Fifth International Symposium on Arctic Research

ISAR-5

The changing Arctic and its regional to global impact:
From information to knowledge and action

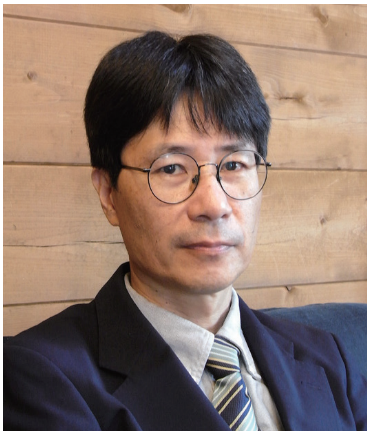
January 15-18, 2018

Tokyo, JAPAN

www.jcar.org/isar-5/

Organizations
Japan Consortium for Arctic Environmental Research
National Institute of Polar Research
Japan Agency for Marine-Earth Science and Technology
Hokkaido University
Japan Arctic Research Network Center (J-ARC Net)

Venue
Hitotsubashi Hall
National Center of Sciences Building 2F
2-1-2 Hitotsubashi,Chiyoda-ku,Tokyo JAPAN



Welcome Word

Fifth International Symposium on Arctic Research

On behalf of the Symposium Organization Committee, it is our great pleasure to welcome you to the Fifth International Symposium on Arctic Research (ISAR-5) held in Tokyo on 15-18 January 2018. The symposium is organized by Japan Consortium for Arctic Research (JCAR) with supports from National Institute of Polar Research, Japan Agency of Marine/Earth Science and Technology, Hokkaido University, and other many institutions.

The Arctic is experiencing rapid environmental and amplified climatic changes, creating significant challenges for people living in this region and various impacts around the globe. We have been trying to elucidate the reasons for these changes in the Arctic and their phenomena, however many open questions still remain on the roles of clouds, aerosols, sea ice, greenhouse gases, land processes, ozone depletion, solar activity, and other factors involved in Arctic change. Arctic change has impacts on the global climate as well as ecosystems and human societies in higher-middle latitudes. A better understanding of these processes is needed, so that improved information can be given to society and stakeholders including decision makers in particular.

ISAR-5 consists of plenary, breakout and poster sessions. The plenary session includes keynote speeches and session presentations, in which a representative paper of each breakout sessions is presented, so that attendees can listen to presentation of other than your field of expertise. This is important because of inter-disciplinary nature of Arctic research.

We hope you will have a fruitful discussions in ISAR-5 and take a successful step toward your goal.

Teruo Aoki
Chair, ISAR-5 Symposium Organizing Committee

Organizations

Organizer
Japan Consortium for Arctic Environmental Research (JCAR)

Co-Organizers
National Institute of Polar Research (NIPR)
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
Hokkaido University
Japan Arctic Research Network Center (J-ARC Net)

Organizing Groups
Center for Computational Sciences, University of Tsukuba
Institute for Space-Earth Environmental Research (ISEE), Nagoya University

Supporters
Science Council of Japan
Tohoku University
Forestry and Forest Products Research Institute
Japan Aerospace Exploration Agency (JAXA)

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Tetsuya Hiyama (Nagoya University)
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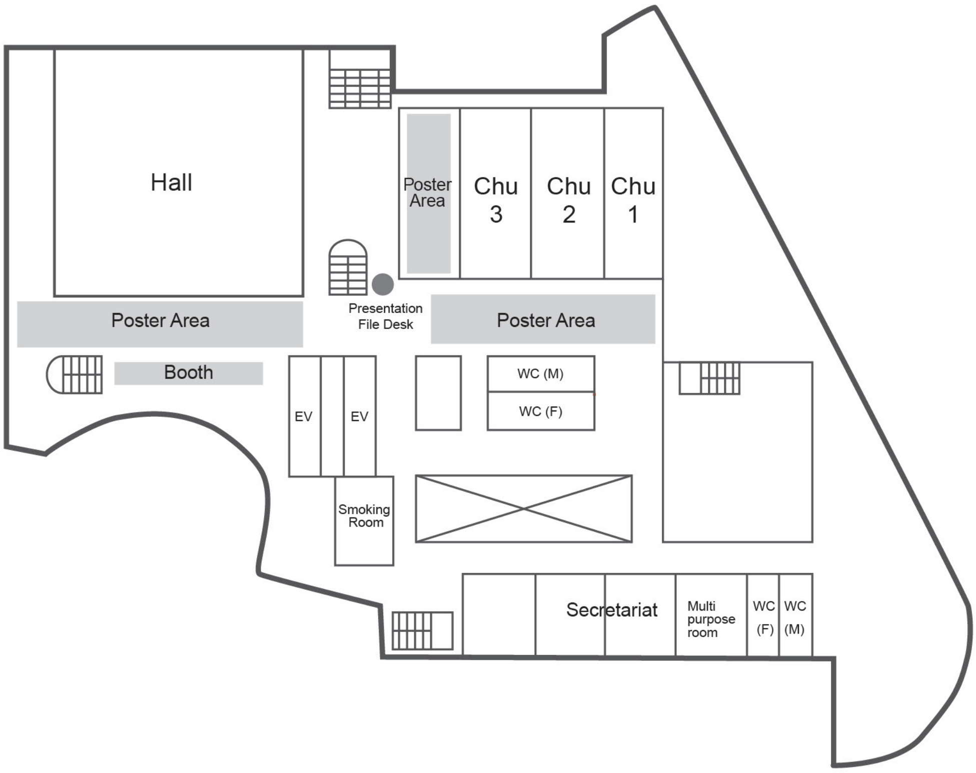
Peter Wadhams (Università Politecnica Delle Marche, Ancona, Italy)
Takashi Yamanouchi (National Institute of Polar Research, Japan)

Floor Map

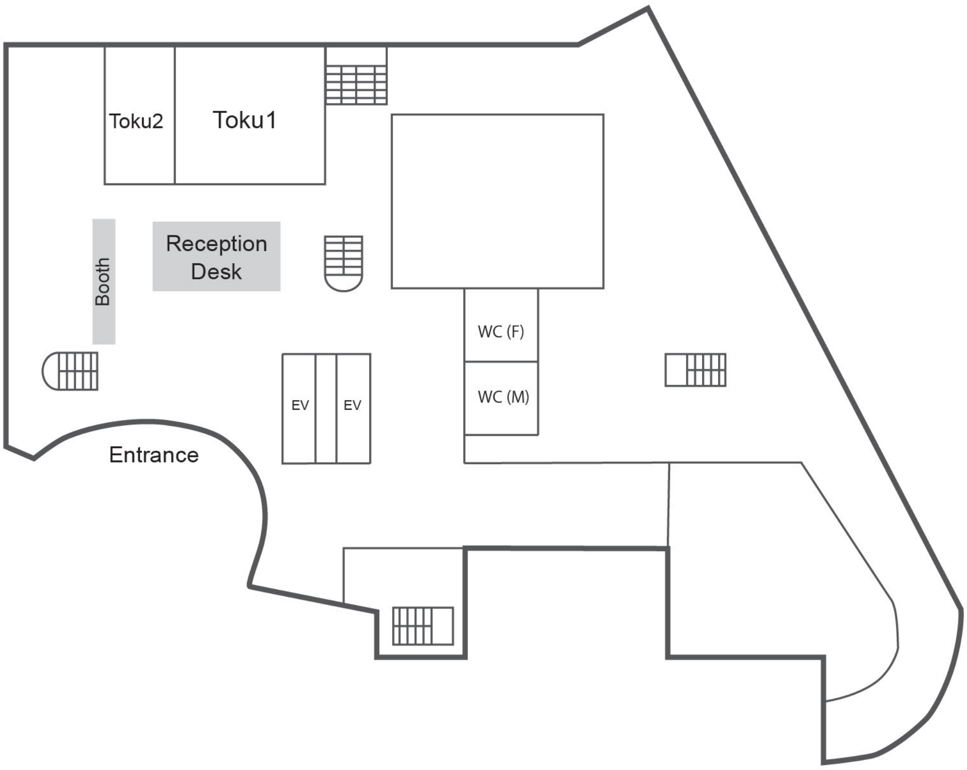
Hitotsubashi Hall

National Center of Sciences Building 2F, 2-1-2 Hitotsubashi, Chiyoda-ku,Tokyo JAPAN

2nd Floor



1st Floor



Program

The Entire Program

Closed Meeting

Date	Time Zone	Hall	Chu1	Chu2	Chu3	Toku1	Toku2	201 Multi room	202 Secretariat	203 Secretariate	VIP room
January 15 Monday	13:00-17:00	Reception Desk Open						Public Lecture Staff Room			
	17:00-19:30	ArCS Public Lecture in ISAR-5 (Japanese)									
January 16 Tuesday	9:00-9:20 9:20-10:20 10:20-10:30 10:40-12:40	Opening Keynote Speech 1, 2 Photo Session Session Presentations SP1						Staff Only			
	12:40-13:30	Lunch									
	13:30-15:00	G6S6	S7S8	G1	S9	S10 13:30-14:30 S12 14:40-15:40 S14 15:50-16:50	G9				
	15:15-16:45										
	16:45-18:15	Poster Sessions (G1, G2, G5, G6S6, G9, S1, S7S8, S9)									
	19:00-21:00	Reception (at TKP Gardencity Takebashi)									
January 17 Wednesday	9:00-10:00 10:15-12:35	Keynote Speech 3, 4 Session Presentations SP2									
	12:35-13:30	Lunch							Ainu Mukkuri WS 12:35-13:30		GCM 12:35-13:15
	13:30-15:00	G2	G5	S1	G7	G8	S15				
	15:15-16:45										
	16:45-18:15	Poster Sessions (G3, G4, G7, G8, S2, S4, S5, S14)									
	18:30-21:00		SAS 18:30-20:20		Geospace research community 18:30-20:00	Northern Region Music Festival 19:00-20:30					
January 18 Thursday	9:00-10:00 10:15-12:15	Keynote Speech 5, 6 Session Presentations SP3								Poster Award Committee 8:30-9:00	
	12:15-13:30	Lunch				SOC-IAC 12:15-13:15			Ainu Mukkuri WS 12:30-13:30		ISIRA 12:15-13:15
	13:30-15:00	G2	S5	S2	S3	G4	S11S13				
	15:15-16:45	S4			G7		G3				
	17:00-17:30	Closing									
	17:30-21:00										

Session Titles

G1	Atmosphere
G2	Ocean and Sea Ice
G3	Rivers, Lakes, Permafrost and Snow Cover
G4	Ice Sheets, Glaciers and Ice Cores
G5	Terrestrial Ecosystems
G6S6	Changes in Sea Ice, Oceans and Ecosystems in the Arctic Ocean
G7	Geospace
G8	Policies and Economy
G9	Social and Cultural Dimensions
S1	Arctic Warming by Natural Variability and/or Human Impact
S2	Synergies for "New Arctic" Climate Prediction, Observation and Modeling
S3	A Complex Adapting Arctic Ecohydrology in the Context of Changing Climate
S4	Biogeochemical Cycles and Biodiversity of Terrestrial Ecosystems under Arctic Warming
S5	Synoptic Arctic Survey – An Ocean Research Program for the Future
S7S8	Arctic Challenge for Ice Observation and Ice Navigation
S9	Understanding the Changing Arctic through Data: Stewardship, Publication, and Science
S10	Sustainable Development in the Russian Arctic: Perspectives from Economic, Environmental and Policy Studies
S11S13	Environmental, Economic, Societal and Geopolitical Dynamics in the Arctic, their Global Drivers and Implications
S12	Greenlandic Reflections of Global Concerns: Ecological, Social and Political Perspectives on the Future
S14	Synthesizing Local Interactions between Permafrost and Human Societies
S15	Technology, Infrastructure and Human Space in the Past and Present of Northern Regions

Opening

January 16 (Tuesday) 09:00-09:20 Hitotsubashi Hall

09:00 Opening remarks
- Teruo Aoki, Chair, ISAR-5 Symposium Organizing Committee
- TBD

Photo Session

January 16 (Tuesday) 10:20-10:30 Hitotsubashi Hall

Closing

January 18 (Thursday) 17:00-17:30 Hitotsubashi Hall

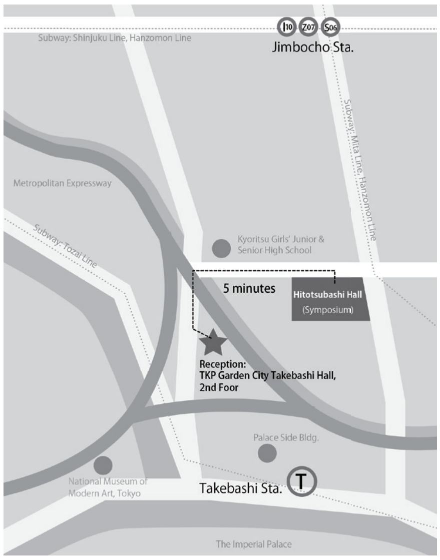
17:00 Closing remarks
- TBD

17:10-17:20 Poster Award
17:20-17:25 About ISAR-6
17:25-17:30 Closing address: Teruo Aoki, Chair, ISAR-5 Symposium Organizing Committee
17:30 Close

Reception

January 16 (Tuesday) 19:00-21:00
Venue: Hall, TKP Gardencity Takebashi
2F, Sumitomo Corporation Takebashi Building,
Hitotsubashi, 1 Chome−2−2, Chiyoda-ku, Tokyo

*The reception requires a registration in advance.
*Please bring your conference name tag with you.



Plenary

Keynote Speeches Hitotsubashi Hall

January 16

1. Kay I. Ohshima	Effects of High Albedo and Brine Rejection of Sea Ice on the Arctic Ocean and its Recent Change
2. Peter Wadhams	A Farewell to Ice - Arctic climate feedbacks and their impact on global warming

January 17

3. Peter Schweitzer	Remoteness and Infrastructure: On the Affordances of the Built Environment in Polar Regions
4. Jacqueline Grebmeier	The Arctic in Transition: Status and Trends in Biological Oceanography to Understand the Changing Marine Ecosystem

January 18

5. Bruce Forbes	Coping with a warming winter climate in Arctic Russia : patterns of extreme weather affecting Nenets reindeer nomadism
6. Tero Mustonen	Community-led Monitoring and Ecological Restoration in the Arctic: History, Power and Resilience

Session Presentations Hitotsubashi Hall

January 16

SP1-G1	Matthew Shupe	Surface Energy Budget Process Relationships for Evaluating Model Performance in Central Greenland
SP1-G6S6	Irene D. Alabia	Distribution shifts of marine taxa in the Pacific Arctic under contemporary climate changes
SP1-S7S8	Natsuhiko Otsuka	Arctic challenge for ice observation and ice navigation
SP1-S9	Øystein Godøy	Towards a virtual research environment for geoscience
SP1-S10	Violetta Gassiy	Benefits sharing as a tool for sustainable development of Arctic indigenous communities in Russia
SP1-S14	Yuichiro Fujioka	Local Knowledge and Perception of Permafrost Degradation in Eastern Siberia: Development of Teaching Materials for Environmental Education

January 17

SP2-G5	Mouctar Kamara	Analyzing long-term growth trends of tree and forest biomass in the circumpolar boreal region.
SP2-G2	Michael Karcher	Forever cyclonic? How stable is the circulation of Atlantic Water in the Arctic Ocean?
SP2-G7	Kazuo Shiokawa	Ground-based instruments of the PWING project to investigate dynamics of the inner magnetosphere at subauroral latitudes
SP2-S1	John E. Walsh	Attribution of Trends of Seasonal Temperatures in Alaska
SP2-S12	Naotaka Hayashi	Seeking a future vision by negotiating environmental changes in North Greenland
SP2-S15	Shiro Sasaki	Weaving techniques in subarctic areas: Their prosperity and decline in Northeast Asia
SP2-G8	Volker Rachold	Arctic Policies and Economy - A German perspective

January 18

SP3-G4	Masashi Niwano	Evaluation of the Greenland Ice Sheet surface mass balance estimated by the NHM-SMAP regional climate model
SP3-S2	Matthew Shupe	Comprehensive Atmospheric Measurements at MOSAiC to Study Cloud-Atmosphere-Surface Interactions
SP3-S3	Daqing Yang	Heat transport from northern rivers to Canadian Arctic coast
SP3-S4	Akihiko Ito	Early detection of changing pan-arctic wetland methane emission
SP3-S5	Leif G. Anderson	Assessing the Carbon Climate in the Upper Waters of a changing Arctic Ocean
SP3-S11S13	Lassi Heininen	The Global Arctic as a New Geopolitical Context – potential influences of Arctic actors beyond the (Arctic) region

January 16, 2018

Hall

9:00- 9:20 **Opening**

9:20- 9:50 **Keynote speech 1** Kay I. Ohshima — Effects of High Albedo and Brine Rejection of Sea Ice on the Arctic Ocean and its Recent Change

9:50-10:20 **Keynote speech 2** Peter Wadhams — A Farewell to Ice - Arctic climate feedbacks and their impact on global warming

10:20-10:30 **Photo session**

10:30-10:40 **Break**

10:40-12:40 **Session presentations 1** **Chair: S. Saito (Hokkaido Univ., Japan)**

SP1-G1	10:40-11:00	Surface Energy Budget Process Relationships for Evaluating Model Performance in Central Greenland: Matthew Shupe, M. Miller, C. Cox, O. Persson
SP1-G6S6	11:00-11:20	Distribution shifts of marine taxa in the Pacific Arctic under contemporary climate changes: Irene D. Alabia J. García Molinos, S.I. Saitoh, T. Hirawake, H. Hirata, F.J. Mueter
SP1-S7S8	11:20-11:40	Arctic challenge for ice observation and ice navigation: Natsuhiko Otsuka, K. Tateyama
SP1-S9	11:40-12:00	Towards a virtual research environment for geoscience: Øystein. Godøy, T. Thorbjornsen, L. Ferrighi, A. Vines, T. Hamre, B. Pfeil
SP1-S10	12:00-12:20	Benefits sharing as a tool for sustainable development of Arctic indigenous communities in Russia: Violetta Gassiy
SP1-S14	12:20-12:40	Local Knowledge and Perception of Permafrost Degradation in Eastern Siberia: Development of Teaching Materials for Environmental Education: Yuichiro Fujioka, H. Takakura

12:40-13:30 **Lunch**

13:30 **Breakout Sessions**

Hall

G6S6 Changes in Sea Ice, Oceans and Ecosystems in the Arctic Ocean

Chair: Amane Fujiwara

G6S6-O01 13:30-13:45
On the Nature of Wind-Forced Upwelling in Barrow Canyon
*M. Pisareva, R. Pickart, P. Fratantoni, T. Weingartner

G6S6-O02 13:45-14:00
Continuous Sea-ice Thickness Measurement in the Northeastern Coastal Chukchi Sea from 2009
*Y. Fukamachi, K. I. Ohshima, A. R. Mahoney, H. Eicken, D. Simizu, K. Iwamoto, E. Moriya, T. Takatsuka, J. Jones

G6S6-O03 14:00-14:15
Observed and anticipated changes in the seasonal cycle of coastal sea ice and their impacts in the Alaskan Arctic
*H. Eicken, O. A. Lee, M. A. Johnson, A. R. Mahoney, P. L. Pulsifer

G6S6-O04 14:15-14:30
Factors influencing Multi-time scale Sea-ice Variations in the Pacific Arctic Region
*J. -H. Kim, K. -H. Cho, X. Zhang, L. Peng, K. Shimada, E. Yoshizawa, Y. Choi, S. -H. Kang

G6S6-O05 14:30-14:45
Causes and Consequences of the Beaufort Gyre Region Freshwater Content Changes (2003-2016)
*A. Proshutinsky, R. Krishfield, W. Williams, M. -L. Timmermans

14:45-15:15 Break

Chair: Yoshiyuki Abe

G6S6-O06 15:15-15:30
Dissolution of $CaCO_3$ in the present and glacial ocean: A comparison of the effects of different dissolution parameterizations
*D. Peya, C. Voelker, G. Lohmann

G6S6-O07 15:30-15:45
Enhancing of Biological Pump in the Chukchi Sea Based on Seven Chinese Arctic Summer Cruises since 1999 and Sediment Cores Records
*J. Chen, H. Jin, Y. Zhuang, H. Li, Y. Bai, Q. Zhu

G6S6-O08 15:45-16:00
The Composition and Origination of Suspended Particles from Water Column in the Shelfs of Chukchi Sea and Northern Bering Sea
*X. Yu, L. Ye, Y. Liu, J. Lei, X. Yao,J. Zhu, X. Jin, W. Zhang

G6S6-O09 16:00-16:15
Inferences on Biological Community Structure of the Distributed Biological Observatory (DBO) from Undersea Video Imagery
*L. Cooper, J. Grebmeier, A. Bayard, H. Bi

G6S6-O10 16:15-16:30
Changes in seabird density relative to water mass around St. Lawrence Island, northern Bering Sea during summer
*B. Nishizawa, H. Hayashi, N. Yamada, H. Ueno, T. Hirawake, Y. Watanuki

G6S6-O11 16:30-16:45
A Step-Wise Progression to Fisheries Ecosystem Science in the Central Arctic Ocean
*J. Grebmeier, H. P. Huntington

Chu1

S7S8 Arctic Challenge for Ice Observation and Ice Navigation

Chair:Peter Wadhams

S7S8-O01 13:30-13:48
Maritime Target Detection and Discrimination in Ice-Infested Arctic Waters based on Generative Adversarial Network Using SAR Images
Y. HE, *D. Tao, J. Zhang, L.Zhu, P. Ding

S7S8-O02 13:48-14:06
The use of AUVs (autonomous underwater vehicles) under sea ice - achievements so far
*P. Wadhams, B. Krogh

S7S8-O03 14:06-14:24
MAPPING SEA ICE FROM ABOVE AND BELOW
*B. Krogh, P. Wadhams

S7S8-O04 14:24-14:42
Estimation of sailing speed through ice covered waters on the northern sea route
*K. Tateyama, H. Okuda, N. Otsuka

S7S8-O05 14:42-15:00
Arctic Marine Access and Ice Navigation Seasons
*L.W. Brigham

15:00-15:15 Break

Chair: Nastuhiko Otsuka

S7S8-O06 15:15-15:33
Development of NSR Transit Simulator "VESTA-ICE"
*S. Uto, T. Matsuzawa

S7S8-O07 15:33-15:51
Sea Route Search Using the Global Dynamic Windows Approach including Ice Concentration
*T. Takagi, K. Tateyama

S7S8-O08 15:51-16:09
Field investigation of sea spray particles impinging on large vessels - Case study of the R/V Mirai
*T. Ozeki, S. Toda, H. Yamaguchi

S7S8-O09 16:09-16:27
R & D Study of Oil Recovery Device for Ice-covered Waters - NMRI-ORDICE
*K. Izumiyama, S. Kanada, H. Shimoda, D. Wako, T. Matsuzawa

S7S8-O10 16:27-16:45
Arctic research and educational collaboration plan between Japan-Norway
A. Yamakawa, *S. Sandven, S. Saitoh, H. Enomoto, Y. Kodama, N. Otsuka

Chu2

G1 Atmosphere

Chair: Mio Matsueda

G01-O01 13:30-13:45
Sensitivity of the Arctic climate forcing due to atmospheric physical parameterizations
*J. H. Yoon

G01-O02 13:45-14:00
Cooling trend over Eurasian continent and Arctic sea ice decline
*K. Nishii, B. Taguchi, A. Kuwano-Yoshida, H. Nakamura, Y. Kosaka, T. Miyasaka

G01-O03 14:00-14:15
Quantification of influence of Arctic sea-ice reduction and natural variability to recent Eurasian cooling
*M. Mori, Y. Kosaka, M. Watanabe, H. Nakamura, M. Kimoto

G01-O04 14:15-14:30
A comparison of climate impacts of the Arctic sea ice loss based on multiple sea ice concentration datasets
*T. Nakamura, K. Yamazaki, K. Hoshi, M. Honda, J. Ukita

G01-O05 14:30-14:45
Is the recent downturn of the summer North Atlantic Oscillation (SNAO) related to Arctic Sea Ice change?
*H. W. Linderholm, T. Ou, J.-H. Jeong, D. Chen, B.-M. Kim

G01-O06 14:45-15:00
Analysis of cloud formation processes for arctic cyclone in the non-hydrostatic icosahedral grid model
*T. Kurihana, H. Tanaka

15:00- 15:15 Break

Chair: Keiichiro HARA

G01-O07 15:15-15:30
Soil CO_2 Measurements in Canada's High Arctic Winter
*R. Layden

G01-O08 15:30-15:45
Terrestrial Biospheric and Oceanic CO_2 Uptake Estimated from Long-term Measurements of Atmospheric CO_2 Mole Fraction, d13C and $d(O_2/N_2)$ at Ny Ålesund, Svalbard
*D. Goto, S. Morimoto, S. Ishidoya, S. Aoki, T. Nakazawa

G01-O09 15:45-16:00
Relationships between wildfire occurrences and environmental factors over the Siberian region
*T. J. Yasunari, K. -M. Kim, A. M. da Silva

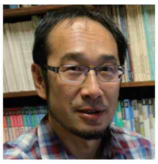
G01-O10 16:00-16:15
Variations of black carbon and dust in Northwest Greenland reconstructed by Continuous Flow Analysis of an ice core
*K. Goto-Azuma, Y. Ogawa-Tsukagawa, Y. Kondo, R. Dallmayr, M. Hirabayashi, J. Ogata, K. Kitamura, K. Kawamura, H. Motoyama, S. Matoba, M. Kadota, T. Aoki, N. Moteki, S. Ohata, T. Mori, M Koike, Y. Komuro, A. Tsushima, N. Nagatsuka

G01-O11 16:15-16:30
Lidar Observed Seasonal Variation of Free Tropospheric Aerosols over Ny Ålesund
*T. Shibata, K. Shiraishi, K. Sudo, S. Iwasaki, M. Shiobara, T. Takano

G01-O12 16:30-16:45
Moistening of the Antarctic upper troposphere observed by balloonborne water vapor measurements
*Y. Tomikawa, M. Kohma, M. Takeda, K .Sato

16:45-18:15 **Poster Session**

19:00-21:00 **Reception** **TKP Takebashi**



Keynote speech 1

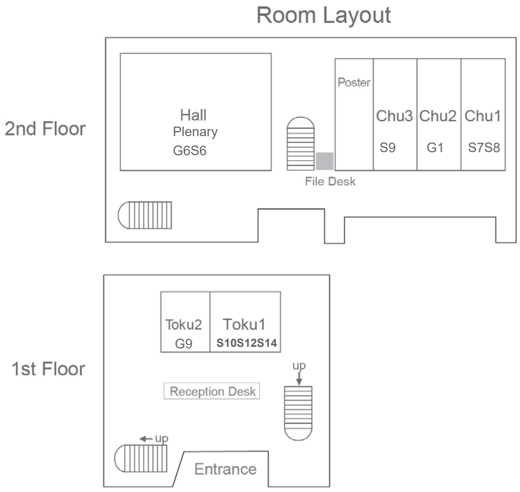
Kay I. Ohshima

Professor in Physical Oceanography
Institute of Low Temperature Science /
Arctic Research Center, Hokkaido University, Japan

Keynote speech 2

Peter Wadhams

Professor Emeritus in Sea Ice Physics
Department of Applied Mathematics and Theoretical Physics, University of Cambridge, UK; and Università Politecnica delle Marche, Ancona, Italy



Chu3

S9 Understanding the Changing Arctic through Data: Stewardship, Publication, and Science

Chair: Øystein Godøy

S09-O01 13:30-13:45
Metadata Management, Interoperability and Data Citation in Polar Science
*M. Kanao, J. Friddell, A. Kadokura

S09-O02 13:45-14:00
Getting Necessary Heritage Data out of Deep Freeze
*E. Griffin

S09-O03 14:00-14:15
The Canadian Consortium for Arctic Data Interoperability: An Emerging Initiative for Canadian Arctic Data Stewardship
*M. Murray, S. C. Vossepoel

S09-O04 14:15-14:30
INTAROS: Integrated Arctic observation system development under Horizin 2020
*S. Sandven, H. Sagen, E. Buch, R. Pirazzini, D. Gustavson, A. B.-Moller, P. Voss, F. Danielsen, L. Iversen, P. Goncalves, T. Hamre, G. Ottersen, M. Sejr, D. Zola, N. Dwyer

S09-O05 14:30-14:45
Arctic Observations, Data and Society: using systems science to enhance Arctic information flow
*P.L. Pulsifer, P. A. Berkman, Y. Kontar, H. Savela, Y. Qiu

14:45-15:15 Break

Chair: Shannon Vossepoel

S09-O06 15:15-15:30
Data Management of Arctic Project in Japan
*H. Yabuki, T. Sugimura, T. Terui

S09-O07 15:30-15:45
Linking People with People and with the Data They Need: Recent Activities at the Canadian Cryospheric Information Network and Polar Data Catalogue
J. Friddell, *P. Pulsifer, G. Alix, D. Church, Y. Dong, D. Fairbarn, D. Friddell, F. Lauritzen, E. LeDrew

S09-O08 15:45-16:00
National ground segment for Sentinel data in Norway
*Ø. Godøy, N. Budewitz, T. Halsne, L. Ferrighi, B. Saadatnejad, L. -A. Breivik

S09-O09 16:00-16:15
Arctic Territory - geological data and modeling
*A. Rybkina, A. Reissell, P. Kabat, A. Gvishiani

Toku1

S10 Sustainable Development in the Russian Arctic: Perspectives from Economic, Environmental and Policy Studies

Chair: Violetta Gassiy, Daria Gritsenko

S10-O01 13:30-13:45
Is their resource curse in the Russian peripheral Arctic regions?
*D. Gritsenko, E. Efimova

S10-O02 13:45-14:00
Contested Russian Arctic: Paradoxes of path-dependency and nation-building
*V. -P. Tynkkynen

S10-O03 14:00-14:15
Participatory Rights - Interplay of Legislation and CSR in Russia
*S. Nystén-Haarala, M. Pappila, A. Kaerki

S10-O04 14:15-14:30
Russian Arctic: Indigenous Communities and Extractive Industries
*L. Suliandziga

14:30-14:40 Break

S12 Greenlandic Reflections of Global Concerns: Ecological, Social and Political Perspectives on the Future

Chair: Naotaka Hayashi, Minori Takahashi

S12-O01 14:40-14:55
Environmental change and its impact on human society in Qaanaaq, northwestern Greenland
*S. Sugiyama, Y. Fukamachi, ArCS Greenland Project members

S12-O02 14:55-15:10
Intercorporeality at the Kayak Competition: Traditional Practices and the Sense of Future in Greenland
*M. Walls

S12-O03 15:10-15:25
Intentions about economic development by the Government of Greenland in a climate change frame
*K. G. Hansen

S12-O04 15:25-15:40
Climate Change and Transformations in the Security Environment
*M. Takahashi

15:40-15:50 Break

S14 Synthesizing Local Interactions between Permafrost and Human Societies

Chair: Hiroki Takakura, Yoshiro Iijima, Tamara Litvineko

S14-O01 15:50-16:02
Melioration in the Permafrost Environment:History and Modernity
*S. Boyakova

S14-O02 16:02-16:14
Thermokarst activating in the recent decades in central Yakutia, Russia
*Y. Iijima, H. Saito, N. Basharin, A. Fedorov

S14-O03 16:14-16:26
Interaction of social and natural factors in economic activities of contemporary Sakha farmers
*M. Goto, S. Boyakova

S14-O04 16:26-16:38
Social Consequences of Changing Permafrost in Yakutia: Gendered Challenges in Churapchinsky region
*S. Grigorev, L.Vinokurova

S14-O05 16:38-16:50
Permafrost and Poverty: the Social Effects of Climate Change in the Republic of Sakha (Yakutia)
*V. Ignatyeva

Toku2

G9 Social and Cultural Dimensions

Chair: Shirow Tatsuzawa

G09-O01 13:30-13:45
Not-Quiteness of the Horse for the Tyva herders
V. Peemot

G09-O02 13:45-14:00
Knowing Salmon: An Ethnography of Knowledge Co-production in Alaska
*S. Kondo

G09-O03 14:00-14:15
Why do Khanty Choose to Wear Fur?: Fur-Wearing Culture and Use of Wild/Domesticated Animals
*Y. Oishi

G09-O04 14:15-14:30
Sound relationship between wildlife and local people - a case study of wild reindeer conservation in East Siberia -
*S. Tatsuzawa, I. Okhlopkov, N. Solomonov, E. Nikolaev, R. Kirillin, E. Kirillin, M. Nicholai

G09-O05 (cancel)
De-extinction Debates and the Ethno-paleontology of Wooly Mammoths in Taimyr
*D. G. Anderson

Discussion 14:45-15:00

15:00-15:15 Break

Chair: Shiaki Kondo

G09-O06 15:15-15:30
Post-Soviet Population Dynamics In the Russian Extreme North: A Case of Chukotka
*K. Kumo, T. Litvinenko

G09-O07 15:30-15:45
Place Names, Landscapes, and Ways of Living from Local Perspectives in Nanvarpak (Iliamna Lake), Alaska
*Y. Kugo

G09-O08 15:45-16:00
Arctic research in the world based on bybliometric analysis
*A. Bancheva

16:00-16:45 Discussion

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9:00- 9:30 **Keynote speech 3** Peter Schweitzer — Remoteness and Infrastructure: On the Affordances of the Built Environment in Polar Regions

9:30-10:00 **Keynote speech 4** Jacqueline Grebmeier — The Arctic in Transition: Status and Trends in Biological Oceanography to Understand the Changing Marine Ecosystem

10:00-10:15 **Break**

10:15-12:35 **Session presentations 2** **Chair: T. Kikuchi (JAMSTEC, Japan)**

SP2-G5	10:15-10:35	Analyzing long-term growth trends of tree and forest biomass in the circumpolar boreal region: Mouctar Kamara, Y. Tamura, Y. Matsuura, A. Osawa
SP2-G2	10:35-10:55	Forever cyclonic? How stable is the circulation of Atlantic Water in the Arctic Ocean?: Michael Karcher, H. Sumata, B. Rabe, T. Kikuchi, A. Behrendt, F. Kauker, R. Gerdes
SP2-G7	10:55-11:15	Ground-based instruments of the PWING project to investigate dynamics of the inner magnetosphere at subauroral latitudes: Kazuo Shiokawa, PWING Team
SP2-S1	11:15-11:35	Attribution of Trends of Seasonal Temperatures in Alaska: John E. Walsh, B. Brettschneider
SP2-S12	11:35-11:55	Seeking a future vision by negotiating environmental changes in North Greenland: Naotaka Hayashi
SP2-S15	11:55-12:15	Weaving techniques in subarctic areas: Their prosperity and decline in Northeast Asia: Shiro Sasaki
SP2-G8	12:15-12:35	Arctic Policies and Economy - A German perspective: Volker Rachold

12:35-13:30 **Lunch**

13:30 **Breakout Sessions**

Hall

G2 **Ocean and Sea Ice**

Chair: Hajime Yamaguchi

G02-O01 13:30-13:48
SMOS-derived thin sea ice thickness in the Arctic and Antarctic
*X. Tian-Kunze, L. Kaleschke

G02-O02 13:48-14:06
Circumpolar Polynya Characteristics in the Arctic -A Multi-sensor Intercomparison for the Period 2002/2003 to 2010/2011
*A. Preußer, S. Willmes, G. Heinemann, K. I. Ohshima

G02-O03 14:06-14:24
Flat first-year ice thickness algorism using AMSR2
*K. Shimada, T. Wada, E. Yoshizawa, K. -H. Cho, H. -S. La, S. -H. Kan

G02-O04 14:24-14:42
Satellite observation of the thickening of sea ice through the ice deformation
*N. Kimura, H. Hasumi, M. Itoh, Y. Fukamachi, T. Kikuchi, E. Moriya

G02-O05 14:42-15:00
Sea Ice Motion and Deformation Measurements Using Satellite Images
*H. -C. Kim, C. -U. Hyun

15:00-15:15 Break

Chair: Hiroyasu Hasumi

G02-O06 15:15-15:33
Inter-Sensor Calibration of Space-Borne Passive Microwave Radiometers for Retrieving Long-Term Sea Ice Trends
*M. Seki, M. Hori, K. Naoki, M. Kachi, K. Imaoka

G02-O07 15:33-15:51
Anomalously low central Arctic salinity in a years of high sea-ice melt and converging atmospheric conditions
*B. Rabe, M. Korhonen, M. Hoppmann, R. Ricker, S. Hendricks, T. Krumpen, A. Ulfsbo, E. Jones, U. Schauer, J. Beckers

G02-O08 15:51-16:09
Water movements in the Arctic Ocean below 1500m statistically confirmed by geochemical data
*M. Ikeda, S. S. Tanaka, Y. Watanabe

G02-O09 16:09-16:27
Effect of different factors on calcium carbonate saturation in the Canada Basin in the last two decades
*Y. Zhang, M. Yamamoto-Kawai

G02-O10 16:27-16:45
Middle Pleistocene to Holocene environmental changes in the northern Northwind Ridge: evidence from terrigenous depositional at ARC06-C22
*R. Wang, W. Zhang, W. Xiao, X. Yu, B. K. Biskaborn, X. Gong, J. Ren, Y. Liu, B. Diekmann

Chu1

G5 **Terrestrial Ecosystems**

Chair: Yojiro Matsuura

G05-O01 13:30-13:50
Top-down and bottom-up CO_2 fluxes at Yakutsk, Siberia
K. Takata, *P. Patra, A. Kotani, T. Ohta, T. Saeki, K. Ichii

G05-O02 13:50-14:10
Carbon cycle of permafrost: main terrestrial and hydrological ecosystems if Eastern Siberia
*T. Maximov, H. Dolman, T. Ohta, P. Anderson, A. Kononov, A. Maksimov, R. Petrov

G05-O03 14:10-14:30
Seasonal change and spatial pattern of monoterpene in a forest soil in a black spruce stand in Interior Alaska
*T. Morishita, T. Miyama, K. Noguchi, Y. Matsuura, Y. Kim

G05-O04 14:30-14:50
Effects of snow cover change on taiga forest ecosystem
*R. Shakhmatov, A. Sugimoto, T. Maximov, S. Hashiguchi

14:50-15:15 Break

Chair: Yojiro Matsuura

G05-O05 15:15-15:35
Simulating topographic controls on the abundance of larch forest in eastern Siberia, and its consequences under changing climate
*H. Sato, H. Kobayashi

G05-O06 15:35-15:55
Change over time in development of root stocks of black spruce growing at upper and lower slopes in interior Alaska
*S. Otake, T. Morishita, Y. Matsuura, K. Noguchi, T. Shirota, R. Ruess, J. Hollingsworth, K. Yasue

G05-O07 15:55-16:15
Warming permafrost accelerates development of soil hummocks and drunken forest
*K. Fujii, K. Yasue, Y. Matsuura, A. Osawa

G05-O08 16:15-16:35
A Late Cretaceous (70 Ma) High Latitude Paleoenvironmental Transect Across Greenhouse Alaska, USA: Investigating the Relationship between Environments and Fossil Vertebrates
*A. R. Fiorillo, P. McCarthy

Chu2

S1 **Arctic Warming by Natural Variability and/or Human Impact**

Chair: Hiroshi L. Tanaka

S1-O01 13:30-13:50
On the Natural Component of Climate Change
*S. Akasofu, H. L. Tanaka

S1-O02 13:50-14:10
Accelerated increase in the Arctic “tropospheric” warming events
*S -Y. Wang, Y. -H. Lin, J. -H. Yoon

S1-O03 14:10-14:30
Future changes in precipitation over the Arctic projected by massive ensemble simulations with a 60-km mesh global atmospheric model
*S. Kusunoki

S1-O04 14:30-14:50
Multi-Decadal Variability in Planetary Albedo
*H. Tanaka, K. Itoh

Questionary 14:50-15:00 H. L. Tanaka

15:00-15:15 Break

Chair: John Walsh

S1-O05 15:15-15:35
Impacts of Climate and Vegetation Changes on Hydrological Processes in a Canadian Northern Research Basin
*K. Rasouli, J. W. Pomeroy

S1-O06 15:35-15:55
Intrusion of Lower Latitude Warm-Moist Air Contributing to the Arctic amplification
*T. Yamanouchi

S1-O07 15:55-16:15
Analysis of the difference between Arctic Oscillation and North Atlantic Oscillation using Self-Organizing Maps
*T. Sunaga, H. Tanaka

S1-O08 16:15-16:20
Maintenance mechanism of a long-lasting polar low observed over the Barents Sea in January 2011
*A. Manda, T. Mitsui, J. Inoue, M. Hori, K. Kawamoto, K. Komatsu

Pannel Discussion 16:20-16:45 J. Walsh and H. L. Tanaka

16:45-18:15 **Poster Session**

Keynote speech 3

Peter Schweitzer

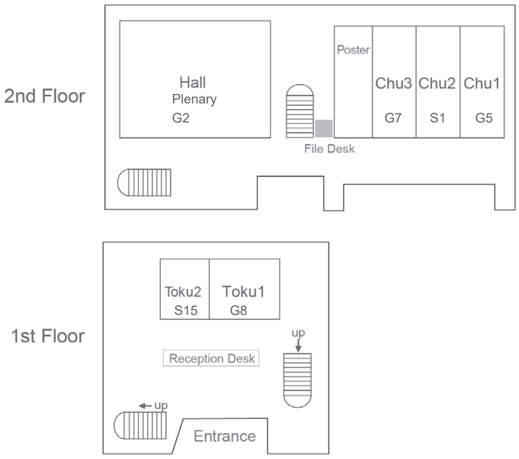
Professor of Anthropology
Department of Social and Cultural Anthropology,
University of Vienna, Austria

Keynote speech 4

Jacqueline Grebmeier

Professor in Biological Oceanography
Chesapeake Biological Laboratory, University of Maryland Center for Environmental Sciences, Solomons, Maryland, USA

Room Layout



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G7 Geospace

Chair: Masaki Tsutsumi

G07-O01 13:30-13:50
Multi-Year Analysis of Arctic Gravity Waves Over Alaska Across the Atmospheric Layers and Into The Near-space Environment
*N. Kim, W. Brittany, D. Eric, N. Michael, C. Richard

G07-O02 13:50-14:10
Gravity Wave Propagation and Dissipation in the Arctic Region and Connection to Vertical Coupling
*E. Yigit

G07-O03 14:10-4:25
Impacts of thermospheric gravity wave on the Ionospheric variability in the Arctic region simulated by GAIA
*Y. Miyoshi, H. Jin, H. Fujiwara, H. Shinagawa

G07-O04 14:25-14:45
Coupling Between Tidal and Planetary Wave Modes in the Mesosphere and Lower Thermosphere
*P. Espy, N. Stray, R. Hibbins

G07-O05 14:45-15:00
Millimeter-wave spectrometer for monitoring minor constituents in the middle atmosphere at Tromsø
*A. Mizuno, T. Nakajima, S. Nozawa, T. Nagahama, T. Kawabata, K. Haratani, H. Iwata, K. Suzuki

15:00-15:15 Break

Chair: Yasunobu Ogawa

G07-O06 15:15-15:30
Temporal and spatial variations of the ionosphere and plasmasphere during geomagnetic storms as seen in global Total Electron Content (TEC) data
*A. Shinbori, Y. Otsuka, T. Tsugawa, M. Nishioka

G07-O07 15:30-15:50
Anomalous ambipolar diffusion observed using meteor radars in the Arctic
*M. Tsutsumi, Y. Ogawa, S. Nozawa, C. Hall

G07-O08 15:50-16:10
Enhanced Polar Outflow Probe (e-POP) Ionospheric Radio Occultation Measurements at High Latitudes
*C. Watson, R. Langley, D. Themens, A. Yau, A. Howarth, T. Jayachandran

G07-O09 16:10-16:25
SuperDARN HOkkaido Pair of (HOP) radars: Powerful tools for monitoring the ionosphere and upper atmosphere in the arctic region
*N. Nishitani

G07-O10 16:25-16:45
China-Iceland Joint Aurora Observatory (CIAO) at Karholl
*H. Hu, H. Yang, Z. Hu

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G8 Policies and Economy

Chair: Shinichiro Tabata

G08-O01 13:30-14:00
International Science, Policy, and Fisheries in the Central Arctic Ocean
*H. Huntington, F. Ohnishi

G08-O02 14:00-14:30
Arctic security: A cooperative move for building human secure transnational society
*H. Kamrul

Book presentation 14:30-15:00
*V. Tynkkynen, S. Tabata, D. Gritsenko, M. Goto

15:00-15:15 Break

Chair: Fujio Ohnishi

G08-O03 15:15-15:37
Economic Development of the Arctic Regions of Russia: Analysis of Regional Budgets
*S. Tabata

G08-O04 15:37-15:59
Modeling the formation of income and resources of the local population of Sakha (Yakutia)
*N. Bochkarev, T. Gavrilyeva

G08-O05 15:59-16:21
Russian climate policy after the Paris Agreement: Perspectives of the North
*N. Stepanova, T. Gavrilieva

G08-O06 16:21-16:43
Perspectives of Carbon Tax Implementation in Russia
*T. Gavrilyeva, A. Nogovitsyn, N. Stepanova

Toku2

S15 Technology, Infrastructure and Human Space in the Past and Present of Northern Regions

Chair: Naoko Iwasaki / Hiroki Takakura

S15-O01 13:30-13:50
The influence of Japanese technology on the Ainu
*N. Iwasaki, Y. Murakami

S15-O02 13:50-14:10
The role of settlements and authority in changes of the traditional nomadic routes in the first half of the 20th century in the Iamal peninsula
*E. Vozhanina

S15-O03 14:10-14:30
Territorial Isolation and the Sustainability of Local Communities: the Case of the European North of Russia
*A. Pozanenko

S15-O04 14:30-14:50
Trying to understand the indirect impacts of Northern mine infrastructure: The Case of the Faro Mine
*C. Southcott

Discussion 14:50-15:00

15:00-15:15 Break

Chair: Peter Schweitzer

S15-O05 15:15-15:35
High Tech for High North: Bringing remote northern communities closer to the rest of the world through information technology
*A. Pestereva

S15-O06 15:35-15:55
Fashioning The New Arctic
*V. Korkina

S15-O07 15:55-16:15
Innovative Arctic: Geography and Dynamics of Patented Innovation in Alaska
*A. Petrov, S. Zbeed

S15-O08 16:15-16:35
GPS tracking of herds in the North: from methodological tool to object of study
*C. Marchina

Discussion 16:35-16:45

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9:00- 9:30 **Keynote speech 5** Bruce Forbes — Coping with a warming winter climate in Arctic Russia : patterns of extreme weather affecting Nenets reindeer nomadism

9:30-10:00 **Keynote speech 6** Tero Mustonen — Community-led Monitoring and Ecological Restoration in the Arctic: History, Power and Resilience

10:00-10:15 **Break**

10:15-12:15 **Session presentations 3** **Chair: H. Enomoto (NIPR, Japan)**

SP3-G4 10:15-10:35 Evaluation of the Greenland Ice Sheet surface mass balance estimated by the NHM-SMAP regional climate model: Masashi Niwano, T. Aoki, A. Hashimoto, S. Matoba, S. Yamaguchi, T. Tanikawa, K. Fujita, A. Tsushima, Y. Iizuka, R. Shimada, M. Hori

SP3-S2 10:35-10:55 Comprehensive Atmospheric Measurements at MOSAiC to Study Cloud-Atmosphere-Surface Interactions: Matthew Shupe

SP3-S3 10:55-11:15 Heat transport from northern rivers to Canadian Arctic coast: Daqing Yang, S. Tank, J. Lung, H. Park

SP3-S4 11:15-11:35 Early detection of changing pan-arctic wetland methane emission: Akihiko Ito

SP3-S5 11:35-11:55 Assessing the Carbon Climate in the Upper Waters of a changing Arctic Ocean: Leif G. Anderson, A. Olsen

SP3-S11S13 11:55-12:15 The Global Arctic as a New Geopolitical Context – potential influences of Arctic actors beyond the (Arctic) region: Lassi Heininen, M. Finger

12:15-13:30 **Lunch**

13:30 **Breakout Sessions**

Hall

G2 Ocean and Sea Ice

Chair: Genki Sagawa

G02-O11 (cancel)
Analysis of the interannual and seasonal variability of upwelling events on the Arctic Ocean continental shelf from 0.08-degree Arctic Ocean HYCOM-CICE
*D. Dukhovskoy

G02-O12 13:30-13:48
The Atlantic water inflow through the Fram Strait in a climate model
*T. Kawasaki

G02-O13 13:48-14:06
Importance of Processes and Coupling for Arctic Sea Ice and Climate Modeling and Prediction
*W. Maslowski, R. Osinski, S. Kamal, Y. Lee, A. Roberts

G02-O14 14:06-14:24
A simultaneous optimization of Arctic sea ice model parameters by genetic algorithm
H. Sumata, *M. Karcher, F. Kauker, R. Gerdes, C. Koeberle

G02-O15 14:24-14:42
A model approach to carbon exchange in the air, sea, and ice of the marine Arctic
*E. Mortenson, N. Steiner, A. Monahan

15:00-15:15 Break

S4 Biogeochemical Cycles and Biodiversity of Terrestrial Ecosystems under Arctic Warming

Chairs:Hideki Kobayashi, Josef Elster, Shin Nagai, Yongwon Kim, Elie Verleyen

S04-O01 15:15-15:30
Study on stable isotopes of precipitation in Hokkaido, North Japan
*X. Li, A. Sugimoto, A. Ueta

S04-O02 15:30-15:45
Multi-year Effect of Wetting on CH_4 Flux at Taiga-Tundra Boundary in Northeastern Siberia Clarified by Stable Isotopes of CH_4
*R. Shingubara, A. Sugimoto, J. Murase, S. Tei, S. Takano, T. Morozumi, M. Liang, G. Iwahana, T. Maximov

S04-O03 15:45-16:00
Perspectives of low-temperature microalgae biomass production in the Arctic
*J. Elster

S04-O04 16:00-16:15
Methane flux measurements over a larch forest in eastern Siberia: emission or uptake?
*T. Nakai, T. Hiyama, A. Kotani, T. Ohta, T. Maximov

S04-O05 16:15-16:30
Accurate detection of spatio-temporal variability of plant phenology in boreal ecosystems by near-surface and satellite remote-sensing
*S. Nagai, T. Morozumi, S. Tei, A. Kotani, H. Ikawa, Y. Kim, H. Kobayashi

S04-O06 16:30-16:45
Seasonal changes in spectral reflectance in an open canopy black spruce forest in Interior Alaska
*H. Kobayashi, S. Nagai, Y. Kim, H. Nagano, K. Ikeda, H. Ikawa

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S5 Synoptic Arctic Survey – An Ocean Research Program for the Future

Chair: Are Olsen

S5-O01 13:30-13:45
Arctic Ocean CO_2 uptake: an improved multi-year estimate of the air-sea CO_2 flux incorporating chlorophyll-a concentrations
*S. Yasunaka, E. Siswanto, A. Olsen, M. Hoppema, E. Watanabe, A. Fransson, M. Chierici, A. Murata, S. K. Lauvset, R. Wanninkhof, T. Takahashi, N. Kosugi, A.M. Omar, S. van Heuven, J. T. Mathis

S5-O02 13:45-14:00
Responses of nutrient and phytoplankton distributions to gale-force winds in the western Arctic Ocean
*S. Nishino, Y. Kawaguchi, J. Inoue, M. Yamamoto-Kawai, M. Aoyama

S5-O03 14:00-14:15
Variations in water mass distributions in western regions of the Pacific sector of the Arctic Ocean from 2011 to 2017
*E. Yoshizawa, K. -H. Cho, T. -W. Park, Y.- S. Choi, K. Shimada, S. -H. Kang

S5-O04 14:15-14:30
Influence of warm-core eddy on dissolved methane distribution in the southwestern Canada Basin during late summer/early fall 2015
*O. T. N. Bui, S. Kameyama, Y. Kawaguchi, D. Sasano, M. Ishii, S. Nishino, N. Kosugi, U. Tsunogai, H. Yoshikawa-Inoue

S5-O05 14:30-14:45
Distributions of trace metals (Mn, Fe, Ni, Zn and Cd) in the western Arctic Ocean in late summer 2012
*Y. Kondo, H. Obata, N. Hioki, A. Ooki, S. Nishino, T. Kikuchi, K. Kuma

S5-O06 14:45-15:00
Radiocesium in the Arctic Ocean after Fukushima Dai-ichi nuclear power plant accident
*Y. Kumamoto, M. Aoyama, Y. Hamajima, S. Nishino, A. Murata, T. Kikuchi

15:00-15:15 Break

Chair: Shigeto Nishino

S5-O07 15:15-15:30
Ensuring Comparability of Oceanic nutrient data in the Synoptic Arctic Survey
*M. Aoyama, E. M. S. Woodward, A. Olsen

S5-O08 15:30-15:45
Rapidly changing western Arctic Ocean sea-ice and ecosystem; Korean research efforts and plan
*S. -H. Kang

S5-O09 15:45-16:00
Korea Arctic Ocean Information System
*J. Chi, H. -C. Kim, S. -H. Kang

S5-O10 16:00-16:15
The Changing Arctic Transpolar System: a Multidisciplinary Russian-German Research Project
*H. Kassens, J. Hölemann, L. A. Timokhov, V. Ivanov

S5-O11 16:15-16:30
Response of dimethyl sulfide production by phytoplankton to change in multiple environmental stressors in the western Arctic Ocean
*S. Kameyama, K. Sugie, A. Fujiwara, S.Nishino

S5-O12 16:30-16:45
Absolute Salinity measurements in the Arctic Ocean
*H. Uchida, S. Nishino, M. Wakita, S. Gary

Chu2

S2 Synergies for "New Arctic" Climate Prediction, Observation and Modeling

Chair: Jun Inoue

S02-O01 13:30-13:45
Seasonal progression of the deposition of black carbon by snowfall at Ny-Ålesund, Spitsbergen
*Y. Kondo, P. R. Sinha, K. Goto-Azuma, Y. Ogwawa-Tsukagawa, M. Koike, S. Ohata, N. Moteki, T. Mori, N. Oshima, E. J. Forland, M. Irwin, J. -C. Gallet, C. A. Pedersen

S02-O02 13:45-14:00
Seasonal differences in the characteristics of ice nucleating particles on Mt. Zeppelin in Ny-Ålesund, Svalbard: A case study in 2016/2017
*Y. Tobo, K. Adachi, N. Nagatsuka, P. DeMott, T. Hill, S. Ohata, Y. Kondo, M. Koike

S02-O03 14:00-14:15
Ship-based Observation and Regional Chemical Transport Model analysis for Atmospheric Black Carbon over the Arctic Ocean
*F. Taketani, T. Miyakawa, M. Takigawa, M. Yamaguchi, S. Kato, Y. Kanaya, Y. Komazaki, P. Mordovskoi, H. Takashima, Y. Tohjima

S02-O04 14:15-14:30
Seasonal variability of near-inertial internal waves in the Northwind Abyssal Plain, Arctic Ocean
*Y. Kawaguchi, M. Itoh, Y. Fukamachi, E. Moriya, J. Onodera, T. Kikuchi

S02-O05 14:30-14:45
Physical Oceanography activities during MOSAiC: a summary from the OCEAN team
*B. Rabe, C. Provost, MOSAiC OCEAN team

S02-O06 14:45-15:00
Year-round surveys for air-sea ice gas flux in the Arctic Ocean
*D. Nomura, E. Damm, B. Loose, B. Delille, A. Fransson, M. Chierici, M. Granskog, J. Inoue

15:00-15:15 Break

Chair: Benjamin Rabe

S02-O07 15:15-15:30
Interaction between YOPP and MOSAiC from observations to modeling
*J. Inoue

S02-O08 15:30-15:45
Impact of extra Arctic radiosonde observations on 5-day weather forecasts over Alaska during August 2015
*M. -H. Lee, J. -H. Kim, H. -J. Song, J. Inoue, K. Sato, A. Yamazaki

S02-O09 15:45-16:00
Effect of the Cycling WRF-3DVAR Data Assimilation of the Ship-borne Arctic Radiosonde Sounding on the Simulation of the Intense Arctic Cyclone in mid-August 2016
*J. -H. Kim, S. -W. Kim, N. -K. Noh

S02-O10 16:00-16:15
Medium-range forecast skill for Arctic Cyclones
*A. Yamagami, M. Matsueda, H. Tanaka

S02-O11 16:15-16:30
Analysis of arctic cyclone of August 2012 using non-hydrostatic global atmosphere and ocean coupled model
*H. Kubokawa, M. Satoh, H. Hasumi, N. Kimura, T. Kawasaki

S02-O12 16:30-16:45
Medium-range forecast skill of summertime sea ice conditions over the East Siberian Sea: Importance of synoptic-scale atmospheric fluctuations
*T. Nakanowatari, J. Inoue, K. Sato, L. Bertino, J. Xie, M. Matsueda, A. Yamagami, T. Sugimura, H. Yabuki, N. Otsuka

16:45-17:00 **Break**

17:00-17:30 **Closing** **Hall**

Keynote speech 5

Bruce Forbes

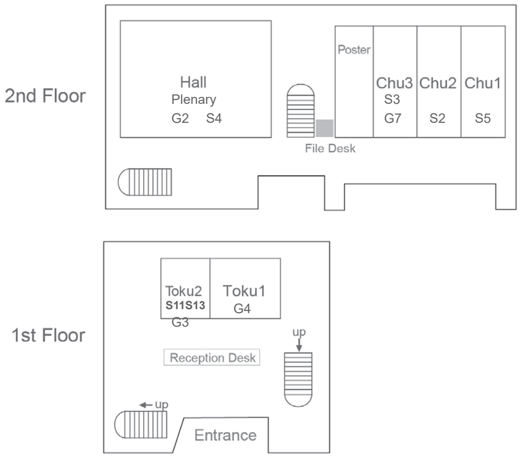
Research Professor
Leader, Global Change Research Group
Arctic Centre, University of Lapland, Rovaniemi, Finland

Keynote speech 6

Tero Mustonen

Director
Snowchange Cooperative, Finland

Room Layout



Chu3

S3 **A Complex Adapting Arctic Ecohydrology in the Context of Changing Climate**

Chair: Hotaek Park

S03-O01 13:30-13:40
Polar Knowledge Canada and the Canadian High Arctic Research Station (CHARS) in Nunavut
*D. J. Scott

S03-O02 13:40-13:55
Spatial variability of streamflow in continuous permafrost environment in Central Yakutia, Russia
*L. Lebedeva, O. Makarieva, N. Nesterova

S03-O03 13:55-14:10
Hydrological changes in the Arctic circumpolar tundra and pan-Arctic large river basins from 2002 to 2016
*K. Suzuki, K. Matsuo, D. Yamazaki, K. Ichii, Y. Iijima, T. Hiyama

S03-O04 14:10-14:25
Permafrost groundwater age of spring discharges around Khangai Mountains in central Mongolia
*T. Hiyama, A. Dashtseren, K. Asai, H. Kanamori, M. Ishikawa

S03-O05 14:25-14:40
Perennial Snowfields in the Central Brooks Range, Alaska: A Landsat Based Time Series of Extent Changes in Gates of the Arctic National Park and Preserve
*M. Tedesche, E. Trochim, S. Fassnacht

S03-O06 14:40-14:55
Active-layer thickness at permafrost larch forests in eastern Siberia
*A. Kotani, M. Nakatsubo, T. Ohta, T. Hiyama, Y. Iijima, T. Maximov

S03-O07 14:55-15:10
The amplified Arctic terrestrial ecohydrological processes under the climate change
*H. Park

15:10-15:15 Break

G7 **Geospace**

Chair: Yoshizumi Miyoshi

G07-O11 15:15-15:35
Energetic electron precipitations associated with chorus waves; Initial observations from Arase and ground-based observations
*Y. Miyoshi, S. Kurita, S. Saito, I. Shinohara, Y. Kasahara, S. Matsuda, Y. Kasaba, S. Yagitani, H. Kojima, M. Hikishima, F. Tsuchiya, A. Kumamoto, Y. Katoh, A. Matsuoka, N. Higashio

G07-O12 15:35-15:50
Ground-based optical observations of pulsating aurora in coordination with ARASE/ERG satellite
*K. Hosokawa, Y. Miyoshi, S. Oyama, Y. Ogawa, S. Kurita, Y. Kasahara, Y. Kasaba, S. Yagitani, S. Matsuda, M. Ozaki, F. Tsuchiya, A. Kumamoto, R. Kataoka, K. Shiokawa, H. Miyaoka, Y. Tanaka, S. Nozawa, M. Teramoto, T. Takashima, I. Shinohara, R. Fujii

G07-O13 15:50-16:10
Role of Space-based and Ground-based Infrastructure in Studies of the Atmospheric Forcing by High-Energy Particle Precipitation and the New Research Opportunity by the EISCAT_3D Incoherent Scatter Facility
*E. Turunen, A. Kero, P. Verronen, Y. Miyoshi, S. Oyama, S. Saito, K. Shiokawa

G07-O14 16:10-16:30
EISCAT radar measurements of energetic particle precipitation during ARASE satellite conjunctions
*A. Kero, P. Verronen, E. Turunen, S. Oyama, Y. Miyoshi

G07-O15 16:30-16:45
Energetic electron precipitation and auroral morphology at the substorm recovery phase
*S. Oyama, A. Kero, C. J. Rodger, M. A. Clilverd, Y. Miyoshi, N. Partamies, E. Turunen, T. Raita, P. T. Verronen, S. Saito

Toku1

G4 **Ice Sheets, Glaciers and Ice Cores**

Chair: Konrad Steffen

G04-O01 13:30-13:45
The role of the North Atlantic Oscillation (NAO) on recent Greenland surface mass loss and mass partitioning
*M. Tedesco, P. Alexander, D. Porter, X. Fettweis, S. Luthke, T. Mote, A. Rennelmalm, E. Hanna

G04-O02 13:45-14:00
Positive feedback effect of NIR albedo reduction on surface melting observed at SIGMA-A on Greenland ice sheet
*T. Aoki, M. Niwano, T. Tanikawa, S. Matoba, S. Yamaguchi, T. Yamasaki, K. Fujita, Y. Iizuka, H. Motoyama, M. Hori, R.Shimada

G04-O03 14:00-14:15
Simulations of the evolution of the Greenland ice sheet under Paris Agreement warming scenarios
*R. Greve, M. Rueckamp, A. Humbert

G04-O04 14:15-14:30
Tracking Crevasse Extent over the Greenland Ice Sheet using ICESat-1
*S. Grigsby, W. Abdalati, W. Colgan

G04-O05 14:30-14:45
Seismic noise as a proxy for glacier dynamics
*E. Podolskiy, F. Walter, S. Sugiyama, M. Funk

G04-O06 14:45-15:00
Seasonal/long-term changes in Rayleigh-wave phase velocity at the bottom of Greenland ice sheet
*G. Toyokuni, H. Takenaka, R. Takagi, M .Kanao, S. Tsuboi, Y. Tono, D. Zhao

15:00-15:15 Break

Chair: Naoko Nagatsuka

G04-O07 15:15-15:30
Japanese activities under EGRIP (East Greenland Ice Core Project)
*K. Goto-Azuma, F. Nakazawa, M. Hirabayashi, N. Nagatsuka, W. Shigeyama, J. Okuno, S. Fujita, H. Enomoto, T. Homma, N. Azuma, T. Saruya, A. Abe-Ouchi, R. Greve, F. Saito, M. Miyahara

G04-O08 15:30-15:45
Reconstruction of nitrogen isotopic composition of nitrate preserved in High-Accumulation Dome at South East Greenland
*S. Hattori, A. Tsuruta, Y. Iizuka, K. Fujita, R. Uemura, S. Matoba, N. Yoshida

G04-O09 15:45-16:00
Composition of salt inclusions in the southeastern Greenland (SE-Dome) ice core analyzed by micro-Raman spectroscopy
*T. Ando, Y. Iizuka, H. Ohno, S. Sugiyama

G04-O10 16:00-16:15
Speciation of calcium in particles trapped in Greenlandic ice core
*C. Miyamoto, Y Iizuka, K. Sakata, Y. Takahashi

G04-O11 16:15-16:30
Effect of solid particles on polycrystalline ice and its relations with rapid deformation of ice-age ice
*T. Saruya, K. Nakajima, M. Takata, T. Homma, N. Azuma, K.Goto-Azuma

Toku2

S11S13 **Environmental, Economic, Societal and Geopolitical Dynamics in the Arctic, their Global Drivers and Implications**

Chair: Lassi Heininen, Matthias Finger

S11S13-O01 13:30-13:45
European cooperation: Poland a strategic link to ensure Artic governance
*D. Garcia-Caceres

S11S13-O02 13:45-14:00
The Role of Non-Arctic States in Regime Building for the Central Arctic Ocean Fisheries Management
*L. Zou

S11S13-O03 14:00-14:15
The Role of non-Arctic Regions in the Globalized Arctic
*J. Saunavaara

S11S13-O04 14:15-14:30
Security as a Key Prerequisite for Stability and Sustainable Environment in the Arctic
*B. Padrtova

S11S13-O05 14:30-14:45
The Arctic and the International Discourse on Climate Change: Which Implications for Arctic Indigenous Peoples
*M. Scopelliti

15:00-15:15 Break

G3 **Rivers, Lakes, Permafrost and Snow Cover**

Chair: Mamoru Ishikawa

G03-O01 15:15-15:33
Changes of streamflow and heat flow in the largest Russian Arctic Rivers
*A. Georgiadi, E. Kashutina, I . Milyukova

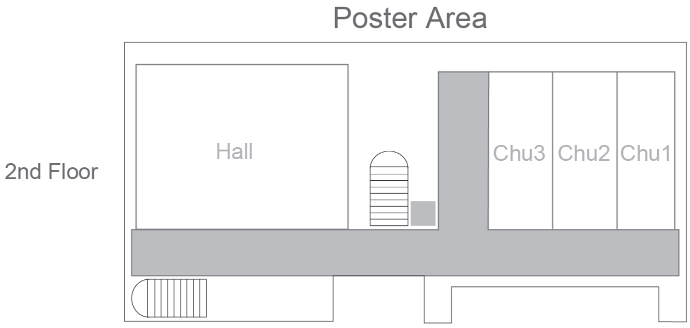
G03-O02 15:33-15:51
Features and extent of the degradation of ice-wedges in Central Yakutia under the influence of modern climate warming
*A. Fedorov , N. Basharin, R. Desyatkin, A. Desyatkin, Y .Iijima , H. Park, G. Iwahana, H. Saito , P. Konstantinov, P. Efremov

G03-O03 15:51-16:09
Engineering-Geocryological Mapping of the Republic of Sakha (Yakutia)
*A. Shestakova

G03-O04 16:09-16:27
Probabilistic modelling of methane emissions from Arctic shelf during Holocene
D. Yumashev, V. Yumashev, N. Shakhova, I. Semiletov, *P. Wadhams

G03-O05 16:27-16:45
Assessment of seasonal snow cover mass in NH and the Arctic during satellite-era (1980-present)
*K. Luojus, J. Cohen, J. Ikonen, K. Veijola, J. Pulliainen, C. Derksen, R . Brown

Poster Sessions



Core Time

January 16 (16:45-18:15)

G1	Atmosphere
G2	Ocean and Sea Ice
G5	Terrestrial Ecosystems
G6S6	Changes in Sea Ice, Oceans and Ecosystems in the Arctic Ocean
G9	Social and Cultural Dimensions
S1	Arctic Warming by Natural Variability and/or Human Impact
S7S8	Arctic Challenge for Ice Observation and Ice Navigation
S9	Understanding the Changing Arctic through Data: Stewardship, Publication, and Science

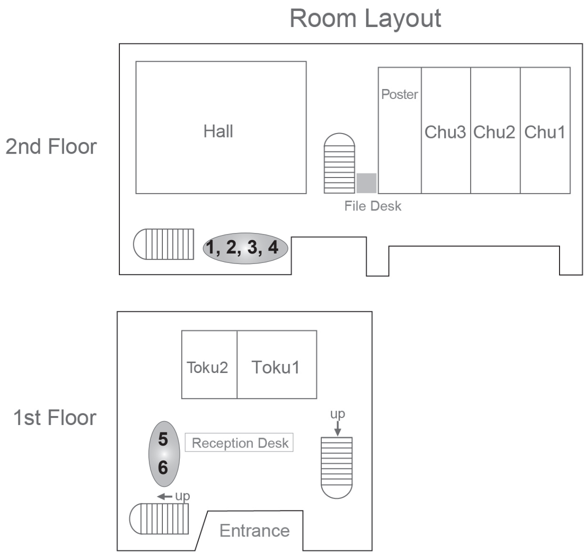
January 17 (16:45-18:15)

G3	Rivers, Lakes, Permafrost and Snow Cover
G4	Ice Sheets, Glaciers and Ice Cores
G7	Geospace
G8	Policies and Economy
S2	Synergies for "New Arctic" Climate Prediction, Observation and Modeling
S4	Biogeochemical Cycles and Biodiversity of Terrestrial Ecosystems under Arctic Warming
S5	Synoptic Arctic Survey – An Ocean Research Program for the Future
S14	Synthesizing Local Interactions between Permafrost and Human Societies

Exhibition Area

1. Japan Arctic Research Network Center Industry-academia-government collaboration support project "Arctic Technology Research Forum to consolidate Opinions from Industry"

   ENGINEERING ADVANCEMENT ASSOCIATION OFJAPAN（ENAA), The University of Tokyo, MITSUBISHI HEAVY INDUSTRIES, LTD. Hokkaido University, National Institute of Polar Research, Japan Agency for Marine-Earth Science and Technology（JAMSTEC）
2. Arctic Data archive System (ADS)
3. Japan Aerospace Exploration Agency (JAXA)
4. Japan Arctic Research Network Center (J-ARC Net)
5. Arctic Challenge for Sustainability (ArCS)
6. Institute for Space-Earth Environmental Research (ISEE), Nagoya University



■G1 Atmosphere

G01-P01
How well do medium-range ensemble forecasts simulate atmospheric blocking events?
*M. Matsueda

G01-P02
Remote tropical influence on a regional Arctic warming over the Barents Sea since the late 1990s
*B. Taguchi, K. Nishii, M. Mori, H. Nakamura, Y. Kosaka, T. Miyasaka

G01-P03
A lag-relationship between the Arctic Oscillation in winter and the summer climate in the Northern Hemisphere
*R. Hoshi, H. Takahashi

G01-P04
Synoptic-scale Fire Weather Conditions in Southern Sakha - Relationship with Warm Air Mass
*H. Hayasaka, K. Yamazaki

G01-P05
Seasonal feedback analysis on polar amplification in warm climate induced by orbit/CO_2 and impact of wetland
*R. O'ishi, K. Kino, A. Abe-Ouchi, M. Yoshimori, M. Suzuki

G01-P06
Temporal variations of the mole fraction, carbon and hydrogen isotope ratios of atmospheric methane in the Hudson Bay Lowlands, Canada
*R. Fujita, S. Morimoto, T. Umezawa, K. Ishijima, P. Patra, D. Worthy, D. Goto, S. Aoki, T. Nakazawa

G01-P07
Observations of atmospheric black carbon at Poker Flat Research Range, Alaska, since April 2016
*P. Mordovskoi, F. Taketani, Y. Kanaya, Y. Kim, H. Kobayashi, T. Miyakawa, M. Yamaguchi, M. Takigawa

G01-P08
The water-soluble species in airborne particles at NEEM
*M. Hirabayashi, K. Satow, K. Goto-Azuma

G01-P09
Clouds with low lidar returns and high cloud radar echoes
*S. Iwasaki, H. Okamoto, K.sato, S. Katagiri, M. Fujiwara, T. Shibata, K. Tsuboki, T. Ono, T. Sugidachi

G01-P10
Seasonal variation of lower stratospheric aerosols observed by lidar above Svalbard, Norway
*K. Shiraishi, T. Shibata, M. Shiobara

G01-P11
Seasonal characteristics of trace gas transport in the Arctic upper troposphere/lower stratosphere
*Y. Inai, R. Fujita, T. Machida, H. Matsueda, Y. Sawa, K. Tsuboi, K. Katsumata, S. Morimoto, S. Aoki, T. Nakazawa

■G2 Ocean and Sea Ice

G02-P01
Mapping the spatial-temporal Changes of sea Ice in the Bohai Sea using Landsat Archive
*W. Tan

G02-P02
An improved method for Antarctic Sea Ice Concentration Estimation from Passive Microwave Data
*T. Liu, X. Song

G02-P03
Ice-ocean albedo feedback in the Arctic Ocean shifting to a seasonal sea ice zone
*H. Kashiwase, K. I .Ohshima, S. Nihashi, H. Eicken

G02-P04
Spectral albedo of sea ice at Qaanaaq fjord in northwest Greenland
*T. Tanikawa, T. Aoki, M. Niwano, M. Hosaka, M. Hori

G02-P05
Under-ice turbulent microstructure and upper ocean vertical fluxes in the Makarov and Eurasian Basins, Arctic Ocean, in 2015
M. Janout, *B.Rabe, R. Graupner, J. Hoelemann, H. Hampe, M. Hoppmann, M. Horn, B. Juhls, M. Korhonen, A. Nikolopoulos, S. Pisarev, A. Randelhoff, J. P. Savy, N. Villacieros

G02-P06
Sea-ice thickness from moored ice-profiling sonar in the Canada Basin, Arctic Ocean
*M. Itoh, Y. Fukamachi, N. Kimura, R. Krishfield, T. Kikuchi, E. Moriya, J. Onodera ,N. Harada

G02-P07
Sea Ice Variability in the Mid-twentieth Century from MRI-ESM2
*T. Aizawa, M. Ishii, S. Yukimoto, H. Hasumi

G02-P08
Short-term sea ice forecasting during extreme Arctic cyclone in August 2016
*L. W. A. De Silva, H. Yamaguchi

G02-P09
Ice-Band Pattern Formation in Winter Marginal Ice Zone
*R. Saiki, H. Mitsudera, A. Manome, N. Kimura, J. Ukita, T. Toyota, T. Nakamura

■G5 Terrestrial Ecosystems

G05-P01
Long-term monitoring carbon balance at a black spruce forest in interior Alaska.
*M. Ueyama, H. Iwata, H. Nagano, Y. Harazono

G05-P02
Seasonal variation of photoassimilate allocation in xylem of black spruce in interior Alaska.
*T. Saito, M. Dannoura, A. Kagawa, K. Noguchi, R. Ruess, J. Hokkunsworth, K. Yasue

G05-P03
Underground competition may be occurred among Picea mariana trees in central Alaska.
*T. Shirota, K. Yaue, S. Otake, T. Saito, T. Tanabe, M. Dannoura, Y. Matsuura, K. Noguchi, T. Morishita, R. Ruess, J. Hollingsworth

G05-P04
Climate responses of radial growth of Larix sibirica and Pinus sibirica growing in Mongolian permafrost.
*K. Yasue, K. Fukushima, Y. Matsuura, K. Shichi, T. Shirota, N. Baatarbileg

G05-P05
The annual change of defoliation intensity by Lymantria disper and its size dependency of Larix sibirica in Mongolia.
*S. Okaniwa, T. Shirota, K. Inoue, Y. Fujioka, T. Tanabe, K. Yasue, T. Okano, N. Bataarbileg, B. Oyunsanaa

G05-P06
Arctic willow ecology and its feedback to river conditions using C, N stable isotope.
*R. Fan, T. Morozumi, S. Takano, R. Shingubara, S. Tei, T. Maximov, A. Sugimoto

G05-P07
Time-lag effect of forest productivity response to climate change over the circum-Arctic deduced from satellite images and tree rings.
*S. Tei, A. Sugimoto

G05-P08
A statistical downscaling framework for mapping global to regional environmental impact.
*K. S. Mwitondi

G05-P09
INTERACT goes viral: an advanced community steps into a global role
*M. Johansson, T. Callaghan

G05-P10
Soil organic carbon storage regime in circumpolar forest ecosystems.
*Y. Matsuura, K. Ono, J. Toriyama, K. Fujii, N. Makita, T. Morishita

G05-P11
Biodiversity studies through international collaborative initiatives in ArCS (Arctic Challenge for Sustainability).
*M. Uchida, A. Mori, A. Takahashi, Y. Watanabe, S. Imura, Y. Tanabe, M. Tsuji, R. Kaneko, J. -B. Thiebot, R. Kitagawa, S. Masumoto, J. Uetake, S. Tatsuzawa, T. Osono, M. Hasegawa, M. Tojo, T. Hoshino, M. Hirota, W. F. Vincent, Y. Iimura, H. Doi, S. Matsuoka, T. Naganuma, M. Higuchi, E. Harada, M. J. Naud, Y. Sawa, T. Ikeuchi, I. M. Okhlopkov, N. G. Solomonov, J. Bety

G05-P12
Diversity of fungi along primary successional and elevational gradients near Mount Robson, British Columbia.
*T. Osono, S. Sakoh, Y. Ogisu, S. Matsuoka

G05-P13
Bacteria community differences between glacier and glacier foreland soil, and their transportation in Ny-Ålesund, Svalbard.
*J. Uetake, M. Uchida, Y. Tobo, S. Kreidenweis, M. Kosugi

G05-P14
Annual development of mat-forming filamentous algae Tribonema sp. in hydro-terrestrial habitats in the Arctic.
M.Jimel, *J. Elster

■G6S6 Changes in Sea Ice, Oceans and Ecosystems in the Arctic Ocean

G6S6-P01
The Laptev Sea region of freshwater influence: Oceanography and ecosystem
*M. Janout, J. Hoelemann, D. Bauch, G. Laukert, D. Piepenburg, A. Novikhin, F. Martinov, V. Povashny, A. Wayte, B.Rabe

G6S6-P02
Oligotrophic trend in the Pacific Arctic Ocean over the last three decades
*Y. Zhuang, H. Jin, J. Chen, H. Li, S. Gao, Y. Bai, Z. Ji, Y. Li, J. Ren

G6S6-P03
Spring phytoplankton bloom at Bering Strait in 2017
*H. Abe, M. Sampei, T. Hirawake, H. Waga, S. Nishino, A. Ooki

G6S6-P04
Pigment indicated Phytoplankton communities in the West Arctic Ocean in summer season
*H. Jin, Y. Zhuang, H. Li, J. Chen, Y. Bai, Z. Ji, Y. Zhang, F. Gu

G6S6-P05
Sea ice history of the Pacific Arctic Region: Evidence from fossil diatom records
*J. Ren, J. Chen, L. Ran, H. Jin, R. Wang, Y. Bai, Y. Zhuang, Z. Li

G6S6-P06
Settling particle flux and the possible influence of surface atmospheric forcing in the southern Northwind Abyssal Plain
*J. Onodera, N. Harada, E. Watanabe

G6S6-P07
Seasonal changes in population structure of four dominant copepods collected by a sediment trap moored in the western Arctic Ocean
*K. Tokuhiro, Y. Abe, K. Matsuno, J. Onodera, A. Fujiwara, N. Harada, T. Hirawake, A. Yamaguchi

G6S6-P08
Spatial and inter-annual changes of zooplankton community structure in the western Arctic Ocean during summers of 2008-2015
*Y. Abe, K. Matsuno, A. Yamaguchi, T. Hirawake

G6S6-P09
Horizontal and vertical distribution of appendicularian community and population structure in the Bering and Chukchi Seas during summer of 2007
*M. Maekakuchi, Y. Abe, K. Matsuno, T. Hirawake, A. Yamaguchi

G6S6-P10
Nitrogen isotope ratio of Amino acid in zooplankton, Calanus Hyperboreus in the Western Arctic Ocean, as a Biotracer
*H. -M. Won, B. -H. Choi, M. -S. Kim, H. -S. Yu, S. -Y. Ha, S. -H. Kang, K. -H. Shin

G6S6-P11
The Pacific Arctic Region: A Window into Shifting Benthic Populations in Response to Ecosystem Change
*J. Grebmeier

G6S6-P12
Hyperborean microphytobenthos (Vaucheria sp.) of coastal tidal flats, central Svalbard
*J. Elster, C. E. Souquieres, J. Kviderova

G6S6-P13
Fate of particulate matter in the epi-benthic layer around the Bering Strait during autumn
*M. Sampei, H. Abe, S. Nishino, A. Ooki, H. Waga, T. Hirawake

G6S6-P14
The threat of biological invasions spreading as an element of anthropogenic pressure in Arctic development
*E. Mironenko, A. Ugujuan, L. Aghajanyan, O. Mironwnko

■G9 Social and Cultural Dimensions

G09-P01
Applying national climate scenario: future hot weather projection and its population exposure in South Korea.
*C. Shim, J. Han

G09-P02
Daggers and the Change in Value of Copper: An Analysis of Northern Athabascan Culture from the 18th to 20th Century
H. Noguchi, *S. Kondo

G09-P03
Investigation for annual route changes of reindeer migration in Siberia using satellite remote sensing
*G. Suzuki, T. Sakka, T. Tashiro, H. Kawamata, S. Tatsuzawa, Nobuyasu Naruse, Yukihiro Takahashi

G09-P04
International Cooperative Study and Actions for Conservation of Asian Black Brant Brant brant orientalis
*Y. Sawa, T. Ikeuchi, S. Tatsuzawa, I. Bysykatova, D. Ward, C. Lei, K. Ushiyama, T. Shimada, C. Tamura, A. Ishioroshi, A. Isaev, M. Uchida

G09-P05 (cancel)
An Ethnoarchaeological Survey of Hunter-Herder Hearths across Eurasia
*D. G. Anderson, K. Milek

G09-P06
The Finns in Siberia in 1917: Collaboration and Inclusiveness in the Community-Driven Heritage Project
*V. Peemot

■S1 Arctic Warming by Natural Variability and/or Human Impact

S1-P01
Atmospheric water cycles in the Arctic and Antarctic during the past four decades
*K. Oshima, K. Yamazaki

S1-P02
Maintenance mechanism of a long-lasting polar low observed over the Barents Sea in January 2011
*A. Manda, T. Mitsui, J. Inoue, M. Hori, K. Kawamoto, K. Komatsu

■S7S8 Arctic Challenge for Ice Observation and Ice Navigation

S7S8-P01
Navigable speed related to ice condition along the Northern Sea Route
*N.Otsuka, K. Izumiyama, K.Tateyama

S7S8-P02
Development of Online Arctic Sea Route Search System on ADS
*T. Sugimura, T. Terui, H. Yabuki, H. Yamaguchi

■S9 Understanding the Changing Arctic through Data: Stewardship, Publication, and Science

S09-P01
Activities of the Polar Environment Data Science Center
*A. Kadokura

S09-P02
Introduction on "Polar Data Journal"
*A. Kadokura, Y. Minamiyama, M. Kanao, T. Terui, H.Yabuki, K. Yamaji

S09-P03
Operation of the infrastructure system in Arctic Data archive System
*T. Terui, T. Sugimura, H. Yabuki

S09-P04
IUGONET Tools and Services for Upper Atmospheric Research
*Y. Tanaka, N. Umemura, A. Shinbori, S. Abe, M. Nose, S. UeNo

■G3 Rivers, Lakes, Permafrost and Snow Cover

G03-P01
Predicting the effects of climate change on stream water temperatures across pan-Arctic river networks: a conservation perspective
*J. Garcia-Molinos, K. S. Christoffersen, J. Culp

G03-P02
Long-term trends of snow cover extent and duration in the Northern Hemisphere derived from imagery collected by polar orbiting optical satellites
*M. Hori, K. Sugiura, K. Kobayashi, T. Aoki, T. Tanikawa, M. Niwano, H. Enomoto

G03-P03
Observed asymmetric warming in the sub-arctic regions (Mongolian Plateau) and on the Qinghai-Tibet Plateau from 1961 to 2011
*T. Wu, Q. Wang, B. Dorjgotov

G03-P04
Multiple-scaled permafrost observations over Mongolia
*M. Ishikawa, Y. Iijima, A. Dashtseren, Y. Jambaljav, S. Miyazaki

G03-P05
Suprapermafrost taliks in the Shestakovka River watershed, continuous permafrost environment, investigated by GPR and ERT techniques
*L. Lebedeva, K. Bazhin, I. Khristoforov

G03-P06
Identification and Mapping of Permafrost Using Satellite Images in the Mountainous Regions of Cryolithozone (on the Example of the Elkon Mountain in Southern Yakutia)
*S. Kalinicheva

G03-P07
Effect of surface snow albedo on surface air temperature in northern high-latitude regions
*M. Abe

G03-P08
Quantifying Permafrost Extent and Condition at Department of Defense Installations in the Arctic
*C. A. J. Edlund, D. Prigge

■G4 Ice Sheets, Glaciers and Ice Cores

G04-P01
Annual variation of bare ice extent on the Greenland Ice Sheet from 1979 to 2016
*R. Shimada, M. Hori, N. Takeuchi, T. Aoki

G04-P02
Floods of a proglacial stream in Qaanaaq, northwestern Greenland
*D. Sakakibara, M. Niwano, S. Fukumoto, S. Sugiyama

G04-P03
Glacier-ocean interaction: oceanographic observations in fjord near a calving front of Bowdoin Glacier, northwest Greenland
*N. Kanna, S. Sugiyama, D, Sakakibara, Y. Fukamachi, D. Nomura, S. Fukumoto, S. Yamasaki, E. Podolskiy

G04-P04
Greenland Ice Sheet Monitoring Network (GLISN) project and global seismology
*S. Tsuboi, G. Toyokuni, M. Kanao

G04-P05
Deglaciation history of the Greenland ice sheet inferred from Glacial Isostatic Adjustment modelling
*J. Okuno, H. Miura

G04-P06
Design of a climate/ice-sheet coupled model (MIROC-IcIES) for Greenland ice-sheet simulation
*F. SAITO, A. Abe-Ouchi, R. O'ishi

G04-P07
Changes in the Greenland Ice Sheet 1980-2014: Model results versus observations
*S. Svendsen, S. A. Khan, S. Vijay, R. Forsberg

G04-P08
Sea surface temperature changes during the Last Glacial Maximum: A model-data comparison
*A. Hossain, X. Zhang, G. Lohmann, C. Voelker

G04-P09
Multibeam bathymetric and sediment profiler evidences for pockmarks and ice grounding scours on the Chukchi borderland and Beaufort Sea
*M. Uchida, A. Shibahara, K. Mantoku, H. Ota, M.Itoh, K.Shimada

G04-P10
Sea ice variability for past 155kyr including the last interglacial (Eemian) on the Chukchi Sea; Implication for future warming Arctic
*M. Uchida, H. Kumata, R. Stephan, K. Mantoku, C. Amano, Y. Kuroki, M. Utsumi, M. Itoh, S. Nishino, K. Shimada

G04-P11
General characteristics of a high-accumulation dome ice core, southeast Greenland
*Y. Iizuka, S. Matoba, R. Uemura, K. Fujita, S. Fujita, S. Hattori, S. Yamaguchi, H. Ohno, A. Hori, C. Miyamoto, T. Suzuki, O. Seki, T. Ando

G04-P12
Dust analysis in a high-accumulation dome ice core, southeast Greenland
*T. Amino, Y. Iizuka, S. Matoba

G04-P13
Fluctuations of total metal concentrations recorded in an ice core from southeast dome, Greenland
*C. Sasaki, T. Suzuki, M. Hirabayashi, S. Matoba, Y. Iizuka

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Information

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- • Lunch
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January 16 2018

Keynote
Session presentation

Effects of High Albedo and Brine Rejection of Sea Ice on the Arctic Ocean and its Recent Change

Kay I. Ohshima

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Sea ice strongly affects the ocean, atmosphere and climate, through its high albedo, heat insulating effect, and brine rejection. Here I discuss how such characteristics of sea ice can affect the Arctic Ocean and its recent change. Until recently, the Arctic Ocean has been characterized by a thick multiyear ice cover that persisted throughout the summer. Particularly after the 2000s, however, the Arctic Ocean has shown major reductions in summer ice extent, thinning of sea ice, and a shift from perennial to seasonal sea ice, which makes the Arctic (Northern Sea) Route possible.

Associated with such change, "ice-ocean albedo feedback" has received increasing attention as a major factor in sea ice retreat of the Arctic Ocean. This feedback is owing to a large difference of surface albedos (the ratio of reflected to incident solar radiation) between “black” open water and “white” sea ice: once the ice concentration is decreased, the heat input to the upper ocean is enhanced because of larger absorption of solar radiation in the increased open water area, leading to a further decrease in ice concentration through the sea ice melt by the oceanic heat. Analyses of satellite data and a simplified ice-upper ocean coupled model reveal that divergent ice motion in the early melt season triggers ice-ocean albedo feedback which subsequently amplifies summer sea ice anomalies [1]. The magnitude of divergence controlling the feedback has doubled since 2000 due to a more mobile ice cover, which can partly explain the recent drastic ice reduction in the Arctic Ocean [1]. These results suggest that ice motion in the early melt season may possess predictive skill in seasonal sea ice forecasts in the Arctic Ocean.

Brine rejected during sea-ice formation in coastal polynyas is the main source of dense water. In the Southern Ocean, such dense water is the precursor of Antarctic Bottom Water (AABW), the densest water mass which occupies the abyssal layer of the global ocean. In the Arctic Ocean, dense water originating from the ice production in the coastal polynyas is considered to intrude the subsurface and maintains the cold halocline layer (CHL), which is a major subsurface water mass in the Arctic Ocean. Recent satellite-derived global mapping of sea ice production [2] demonstrates that ice production in Antarctic coastal polynyas is particularly high, which is consistent with the AABW formation. By contrast, Arctic polynyas generally show much lower ice production, because the surrounding land suppresses the divergent ice motion. Instead, fairly high ice production occurs in the Anadyr polynya in the Bering Sea. This provides a possibility that the inflow from this polynya to the Arctic Ocean contributes to the CHL formation.

I thank Drs. H. Kashiwase, S. Nihashi, K. Iwamoto, Y. Fukamachi and H. Eicken for their cooperation and support.

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A Farewell to Ice - Arctic climate feedbacks and their impact on global warming

Peter. Wadhams

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The recent rapid retreat and thinning of Arctic sea ice is the latest stage of a process which has been detectable since 1950 and is now reaching the stage where the summer ice cover will soon disappear completely. This is a direct result of global warming, but in its turn the retreat of the ice has feedback effects on other aspects of the climate system, which make the total impact of ice retreat much greater. I discuss the main feedbacks. They include (1) an albedo feedback – as sea ice and snow on land retreat, the average albedo of the Earth is reduced, and this is now equivalent in climate forcing to adding 50% to our emissions of CO_2; (2) a sea level feedback – the retreating sea ice creates a warmer atmosphere around Greenland in summer, speeding its melt rate and thus increasing the rate of global sea level rise; (3) a methane feedback – increasing quantities of methane are being emitted from the continental shelves of the Arctic Ocean, and this could accelerate to create a methane pulse with major climate implications; (4) a weather feedback – extreme weather changes seem to be related to the ice retreat and these threaten global food supply; (5) a weakening of the Atlantic thermohaline circulation due to a loss of sea ice from the Greenland Sea, which will reduce the warming rate of western Europe while increasing that of the tropical Atlantic and thus increasing the intensity of hurricanes. I discuss new techniques such as AUVs for mapping the thinning ice and marine cloud brightening for slowing warming, but I propose that the only real solution to the accelerated warming is direct air capture of CO_2. Much of this material is covered in my recent book "A Farewell to Ice".

<u>Reference</u>

Wadhams, P. (2016). *A Farewell to Ice. A Report from the Arctic.* London, Allen Lane. US edition 2017, New York, Oxford University Press.

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Surface Energy Budget Process Relationships for Evaluating Model Performance in Central Greenland

Matthew D. Shupe*, Nathaniel B. Miller, Christopher J. Cox, Ola P. G. Persson

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The Greenland Ice Sheet (GIS) plays important roles in the global climate system, impacting sea-level rise, northern hemisphere circulation patterns, and potentially the ocean thermohaline circulation. Variability in the GIS mass budget is of utmost importance and is the result of numerous processes including surface melt, runoff, and precipitation. Within the context of a warming Arctic, surface melt is increasing dramatically. It is therefore essential to understand the key processes that control variability in the surface temperature and ultimately surface melt. The surface energy budget, comprised of radiative, turbulent, and conductive heat fluxes, represents the balance of energy at the surface and largely determines the surface temperature variability. To represent the surface energy budget and melt in current and future climates, numerical models must be able to accurately represent variability in the surface energy budget, including the partitioning of energy into individual terms and the key atmospheric drivers. This presentation draws upon a comprehensive set of surface and atmosphere measurements made at Summit, Greenland to examine the key terms of the surface energy budget. Variability in surface radiation is found to be largely driven by the solar cycle and by the presence of clouds. Changes in surface radiation elicit responses in the surface temperature, turbulent sensible and latent heat fluxes, and conductive heat flux. Relationships are developed that relate the radiative forcing terms and responding terms as they manifest over a full annual cycle. These relationships are then used to evaluate how surface energy budget processes are represented in model and reanalysis products, including ERA-Interim, CFSv2, and the new CESM.

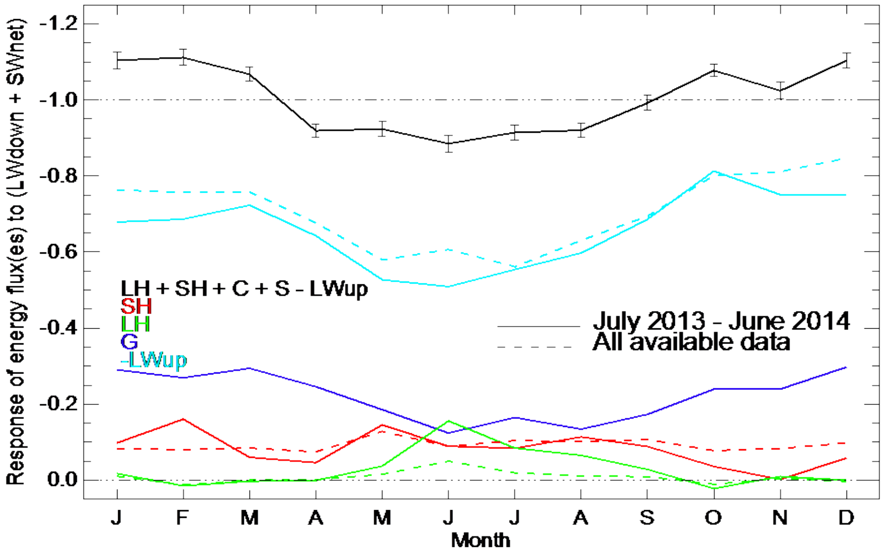

Figure 1. Monthly "slopes" showing the responses of individual energy budget terms to radiative forcing. Here the "forcing" terms are the net shortwave (SWnet) and downwelling longwave (LWdown) radiative fluxes. The "responding" terms are the latent heat (LH), sensible heat (SH), ground heat (G), and upwelling longwave radiation (LWup), which is a proxy for surface temperature.

SP1-G6S6

Distribution shifts of marine taxa in the Pacific Arctic under contemporary climate changes

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[3]Faculty of Environmental Earth Science, Hokkaido University, Japan
[4]College of Fisheries and Ocean Sciences, University of Alaska Fairbanks, USA

Species habitat distributions are strongly intertwined with climate-forced environmental changes. Here, we explored the variations in summer habitat patterns of 21 marine fish and invertebrate taxa in the Eastern Bering Sea using a multi-model ensemble predictions of species distribution from June to July 1993-2016. Using the ensemble model outputs, we examined the rates of observed (biotic velocities) and expected (bioclimatic velocities) habitat shifts across species under distinct climatic stanzas, identified from the regime shift analysis [1] of winter-averaged (January-April) sea surface temperature anomalies extracted at a mooring station (M2; **Fig. 1**). Our analyses revealed that individual taxa responded to climatic changes at differential rates and showed lags in observed distributional responses. In particular, subarctic taxa showed higher habitat sensitivity and exposure to climatic variability than arctic species, as they expand their habitat ranges into suitable sites emerging in the north under warmer climate. Importantly, the actual rates of climate shifts (climatic velocities) were poorly correlated with expected and observed shifts in species distributions across taxa. This stresses the importance of integrating species-specific sensitivity to climatic changes when predicting range shift responses.

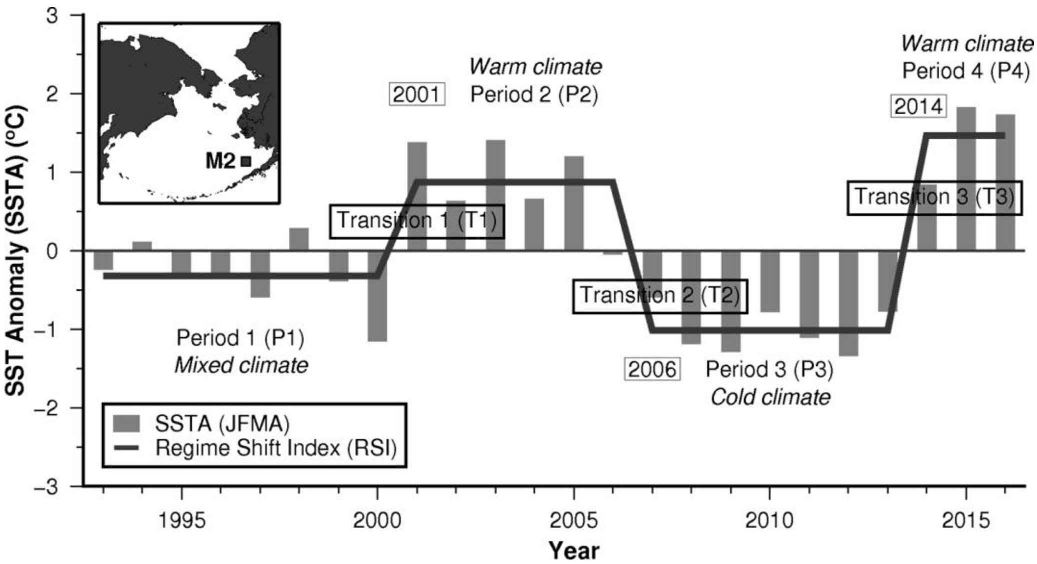

Figure 1. Distinct climatic stanzas in the Eastern Bering Sea during the last 24 years.

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Special session S7&S8, Arctic challenge for ice observation and ice navigation

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Against the background of significant summer sea ice retreat in the Arctic Ocean, commercial and scientific activities are intensifying. Shipping activities along the Northern Sea Route is becoming reality. Year-round crude oil production and shipment has been carried out in the Kara Sea area during the past few years. However, still many risks could be found in navigating ice infested waters along the Northern Sea Route. In order to achieve sustainable shipping along the Northern Sea Route, Tateyama[1], Otsuka[2] and Uto[3] investigates relationship between ship navigability and sea ice condition. Takagi[4] developed navigation route search method in ice covered waters. Ozeki[5] observed the characteristics of sea spray particles which cause ship icing. Izumiyama[6] developed oil recovery device in ice covered waters. And Yamakawa[7] gives the outline of the Arctic research collaboration plan between Japan-Norway, which synthesize recent results from Arctic researches and share the results with stakeholders and the broader public sectors.

Detailed profile of sea ice gives not only scientific but also practical information for both science and industry. However, the actual information of shape and bottom profile of sea ice is very limited and not easy to observe. Song[8] analyses SAR image data by implementing the Generative Adversarial Network (GAN) and achieved maritime target detection in ice infested waters. Wadhams[9] gives latest achievements of under-ice AUVs to observe bottom profile of sea ice. Krough[10] gives the improved sea ice mapping technology of under-ice AUV with Stand-alone USBL Positioning Buoy.

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Towards a virtual research environment for geoscience

Ø. Godøy[1*], T. Thorbjørnsen[2], L.Ferrighi[1], A. Vines[3], T. Hamre[3], B. Pfeil[4]

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Following an evaluation of geosciences in Norway, a pilot project focusing on integration of data, software, publications etc in order to ensure the legacy of science was announced by the Research Council of Norway. This project is looking into traceability between physical samples and their digital representation, data sharing and publication and virtual research environments in support of science. As the project is a pilot project, emphasis is put on understanding the current state within geoscience in Norway, analysing state of the art in communities external to geoscience and to provide recommendations to the Research Council of Norway for future strategies securing the scientific legacy. An important part of this include development of a demonstrator of a virtual research environment supporting geoscience. Within this demonstrator, the project tries to learn from other scientific communities, and to combine geoscientific data and software.

The virtual research environment demonstrator is based on the Galaxy framework and integrates data and software developed by the scientific community. This framework was originally developed for use within Life Sciences, and has been adapted for use in several other fields. It provides a graphical tool for building workflows/pipelines, has good integration with HPC and makes sharing and rerunning workflows/pipelines easy. In addition there is API access. With this, Galaxy can act as a workflow editor and manage connections to HPC for other web services. Within this project, focus has been on integration of software packages in R and Python and application on these on data that are available through geoscientific data catalogs and preferably offer OPeNDAP access for data that has been encoded in NetCDF according to the Climate and Forecast convention. This simplifies data access and manipulation. The current setup offers both predefined software packages and datasets as well as the ability to upload data by the user. Trusted users can also be granted access to upload own software, currently in R. A limitation of the framework, is that it is based on reading and writing to files for each part of the workflow. For large online datasets, it is beneficial to avoid unnecessary downloads, and we have solved this issue for Python by creating tool wrappers that, for each step, only downloads metadata and creates Abstract Syntax Trees. In the final step, only the necessary data are downloaded and the code is evaluated as a whole. However, users can analyse data, store and share work flows and the system is capable of utilising HPC resources or other distributed processing capacities.

Preliminary results following analysis of the software and its user interface indicates that the default user interface lacks some features and the project is now analysing whether it is possible to integrate components of the system in a Drupal based catalogue search and transformation system already capable of performing transformations (e.g. reprojection, subsetting in time, geographical or variable space) on single or multiple datasets.

Benefits sharing as a tool for sustainable development of Arctic indigenous communities in Russia

V. Gassiy[1]

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The future of Russia is inseparably linked with the Arctic, the development of its potential. Today this region gives over 15% of GDP and 20% of Russia's exports - this contribution will grow significantly in the near future [1]. The Arctic is a treasury of Russia. Here, there are not only invaluable natural resources, but also no less valuable people. Evens, Evenks, Dolgans, Yukagirs are many ethnic groups, each with its own unique culture, history and traditions. The Arctic is huge, but past decades subsoil users often invade lands which are sacred for indigenous peoples and deer pastures. As a rule, regional authorities are interested in tax revenues from extraction business, and therefore the dilemma of "culture or production" is decided in favor of the latter. But this does not mean that the question of the price of intervention on indigenous lands of indigenous peoples remains unanswered. Unlike the international practice of developed countries, in which benefits sharing to local residents for lost profits due to industrial development of their original territories in realized, in modern Russia such problems are still unresolved. There is no single calculation formula, nor legislation and regulation support for such payments, so in each specific case it is necessary to consider individually.

At present, in Russia ethnological expertise as a tool for compensating losses of indigenous peoples performs the role of the benefits sharing mechanism adopted in developed countries. It can be stated that it is a new trend in science and practice, and represents a symbiosis of data on the environment, history and culture of indigenous peoples [2]. Unlike environmental, ethnological expertise does not have single "meters". For example, the width and depth of the lake can be measured in meters. But how to measure the sacral value of a lake? Ethnological expertise of projects is carried out by a regional commission which includes various specialists: economists, geographers, biologists, environmentalists, traditional economics activities experts, ethnologists, lawyers. Scientists are engaged in direct field research: how industrial development (gold, diamond, rare earth mining) affects the lives of indigenous communities. This mainly concerns the assessment of economic damage by the territories of traditional nature management, the tribal communities in which such extraction is carried out. It is the only way to protect the rights and interests of indigenous peoples. The main issue is connected with compensation defining. To whom and in what amount compensation will be paid – this question remains open. If these funds are received directly by the tribal communities, what about the other residents, for example, employees of the budgetary sphere (school, mail, hospital) or those who they do not belong to the indigenous groups? Or what if the tribal communities are not registered? How will the interests of other residents of the local community be presented, where there are no work on exploration and mining of mineral resources? These questions have yet to be answered.

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Local Knowledge and Perception of Permafrost Degradation in Eastern Siberia: Development of Teaching Materials for Environmental Education

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Due to the recent global warming, permafrost in high latitude areas has rapidly thawed, resulting in the occurrence of several types of land degradation and one among which is the thermokarst process. Climate factors mainly drive land degradation, on the other hand, social factors are also strongly involved in it. In order to evaluate the climate change in permafrost environment, we need to uncover the permafrost-human relation in various condition. This paper focuses on the sub-arctic permafrost and its interaction among climate, land and people. We will describe the related various events recently emerged in the local environment, and explore the local evaluation, their ways of the perception and knowledge with its historic-cultural background. It would contribute not only the global network of climate change science but also enhance social resilience against land degradation and environmental changes.

The authors as member of the Japanese project of “Arctic Challenge for Sustainability (2015-2019),” develop teaching materials for Environmental Education related on permafrost change in human dimension in eastern Siberia. Environmental Education has been recently expanded into Education for Sustainable Development. To achieve sustainable development, it is important to co-create “new” knowledge by combining scientific and local knowledge. Subsequently, one of the key issues is clarifying the local people’s knowledge and perception of environmental changes. The researchers are required to share their information with local people and officers as stakeholders. This study examined the local knowledge and perceptions of the local Sakha people in the Chrapcha district of eastern Siberia. A field survey was conducted through interviews and focus-group discussions in September 2016.

The results revealed that the Sakha people have rich local knowledge and culturally unique perceptions on environmental changes and land degradation. Historically, they adapted to the local environment to develop livelihoods, mainly agriculture and livestock farming; they also caused changes in the local environment, such as opening the crop field for deforestation and digging numerous artificial ponds to store water for summer droughts. However, they recognized the recent environmental changes; for example, they were aware that the permafrost thawing has broadly proceeded in this area; the forest type before deforestation is related to the speed of permafrost thawing; and the degradation proceeds particularly on abandoned crop fields. In addition, they had their own logic regarding the permafrost thawing process being related to the role of a shielding ice layer in the soil. Furthermore, they understood that the land degradation was a result of intervening climate and social factors, such as the disorganization of sovkhoz and changes in livelihood activities.

The local knowledge and perceptions were typically based on their experiences and information and education acquired, which did not always correspond with scientific knowledge. However, the important point is the awareness of the gap between local and scientific knowledge by sharing information among stakeholders for knowledge co-creation to enhance the resilience for the recent rapid climate changes and land degradations.

January 16

Breakout Session

G6S6

Changes in Sea Ice, Oceans and Ecosystems in the Arctic Ocean

G6S6-O01

On the Nature of Wind-Forced Upwelling in Barrow Canyon

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The Pacific-origin water that flows northward through Bering Strait influences the interior Arctic Ocean. It carries large amounts of freshwater and heat and is also a significant source of nutrients, phytoplankton and zooplankton to the region. During summer months a significant fraction of the transport of Pacific water exits the Chukchi Sea through Barrow Canyon. In addition, eddies and other turbulent features are spawned there that propagate into the basin. Barrow Canyon is also known to be a biological "hotspot" due to its elevated nutrient concentrations, enhanced productivity rates, and high benthic biomass. As such, investigation of Barrow Canyon is crucial for improving our understanding of this important regional ecosystem, including the physical drivers, especially in the changing climate.

Using timeseries from a mooring deployed from 2002-4 near the head of Barrow Canyon, together with atmospheric and sea ice data, we investigate the seasonal signals in the canyon as well as aspects of upwelling and the wind-forcing that drives it. We identified 25 upwelling events, occurring when the Beaufort High is strong and the Aleutian Low is deep. During the warm season most of the events brought winter water to the head of the canyon, while upwelling of Atlantic water occurred during the cold season. Using temporally integrated measures, we explore the relationship between the atmospheric forcing and water column response. While two of the strongest events were associated with particularly strong forcing – both of which brought Atlantic water to the head of the canyon – there was no statistical correlation between the strength of the forcing and the magnitude of the upwelling. This appears to be related to the ice cover in that the strongest upwelling events occurred for partial ice cover, consistent with previous observations on the Beaufort slope, while upwelling during full ice cover was rare.

Continuous Sea-ice Thickness Measurement in the Northeastern Coastal Chukchi Sea from 2009

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The Pacific sector of the Arctic is well documented as an area of rapid sea-ice retreat and shortened sea-ice period by satellite and in situ observations (Johnson and Eicken, 2016). However, there is a deficiency of sea-ice thickness data due to technical and logistical challenges associated with satellite and in situ observations, respectively. For this reason, we have been conducting a mooring experiment of ice-profiling sonar and acoustic Doppler profiler to monitor sea-ice thickness and drift mostly at two locations off Utqiaġvik (formerly known as Barrow) in the northeastern coastal Chukchi Sea since 2009. The area of observation is within Barrow Coastal Polynya (Hirano et al, 2016). At one of these locations about 23 km from the coast, we have obtained continuous data for eight years till 2017 and have processed the data for six years till 2015. Analyzing the data for 2009-10, Fukamachi et al. (in press) showed that mean and modal sea-ice drafts of 1.27 m and 1.2-1.4 m, respectively. The former value is heavily influenced by abundance of thin ice (polynya) and frequency of dynamical thickening process. While the latter can be assumed to represent the first-year sea ice (Mahoney et al., 2015). These and other related values will be evaluated for 2010-15 to examine inter-annual variability of sea-ice characteristics in this area.

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G6S6-O03

Observed and anticipated changes in the seasonal cycle of coastal sea ice and their impacts in the Alaskan Arctic

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Both human activities and ecosystem functions in the Arctic depend critically on the timing of break-up and freeze-up of coastal sea ice. However, in contrast with a large body of work focusing on changes in sea-ice extent and volume, the recent evolution and anticipated future changes in the seasonal cycle of sea ice have received little attention. Focusing on coastal communities in Arctic Alaska, we present research findings on decadal scale changes and interannual variability in the timing of spring break-up and fall freeze-up. An Indigenous sea-ice experts' observation network started in 2006 has been tracking ice conditions, and ice use by people and wildlife. These observations are archived and shared through a database for community ice observations (eloka-arctic.org/sizonet). They indicate substantial interannual variability in the timing and mode of freeze-up and break-up in the region, with significant impacts on people, wildlife, subsistence activities, and ice use by industry. To extend the analysis from the local, km-scale, we developed an algorithm to extract the timing of break-up and freeze-up from passive microwave satellite data, drawing on community-based observations. Data from 1979 to 2013 show break-up start arriving earlier by 5–9 days per decade and freeze-up start arriving later by 7–14 days per decade in the Chukchi and Beaufort Seas. The trends towards a shorter ice season observed over the past several decades point towards a substantial change in the winter ice regime by mid-century with incipient overlap of the end of the freeze-up and start of the break-up season as defined by coastal ice users. Drawing on ice mass balance and ice core measurements at coastal sites, we discuss the implications for ice-associated flora and fauna and people throughout the Pacific Arctic sector.

G6S6-O04

Factors influencing Multi-time scale Sea-ice Variations in the Pacific Arctic Region

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The icebreaker *Araon* has carried out hydrographic surveys in the Pacific Arctic sector since 2010. The main objective of these regularly operated expeditions is to understand the relationship between water mass distribution and sea-ice decline. Multi-year accumulation of the data reveals that the area-mean Pacific Summer Water temperature over the northern Chukchi Sea shelf region is anti-correlated with the sea-ice extent over the central Arctic to the Chukchi Sea. The monthly surface wind distribution over the Chukchi shelf area appears to control the intensity of eastward along-shelf cold current that can suppress (or weaken) the westward flow of warm summer water from the Beaufort Sea. Besides the oceanographic measurements, the basic surface meteorological observations have been made regularly on the *Araon*. Since the 2015 Arctic expedition, the *Araon* began to implement upper-air radiosonde observations at least twice a day as a pilot filed campaign for preparing continuing observations contributing to the Year of Polar Prediction project. The beginning of in-situ upper-air observations in the Arctic represents an enhancement of research on the atmosphere-ocean interaction under storm event. In the 2016 Arctic expedition, the *Araon* came across an extraordinary intense Arctic storm with a minimum central pressure of 968 hPa on 16 August. The *in-situ* atmosphere-ice-ocean observations conducted under the stormy environment made it possible to study the storm's influence on the state of sea-ice and upper ocean. The observational analyses reveal that the storm induced a cold air advection and a net sea-ice surface cooling at the observation site, while the dynamically-enhanced upper ocean mixing and induced upwelling of the warm Pacific Summer Water increased ocean-to-ice heat flux, larger than the net heat loss at the sea-ice surface. Although the relative roles of the dynamics and thermodynamics on the rapid sea ice decline cannot be quantified based on the sole field observations, the storm induced coupled air-ice-sea processes could have accelerated the sea-ice decline during and after the storm event.

Causes and Consequences of the Beaufort Gyre Region Freshwater Content Changes (2003-2016)

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The 2003-2016 hydrographic data collected from research cruises, moorings, Ice-Tethered buoy observations and satellite altimetry in the Beaufort Gyre (BG) region of the Arctic Ocean document an increase of over 6,500km^3 of liquid freshwater content (a 40% growth) relative to climatology of the 1970s. This freshwater accumulation was a result of persistent anticyclonic atmospheric forcing (1997-2016) accompanied by sea ice melt, an anomalous wind-forced redirection of Makenzie River discharge from predominantly eastward to westward flow (Figure 1) supplying the BG region with its fresh water, and fresh water supply from Bering Strait. The fresh water contribution to the BG from Siberian rivers in 2003-2011 was negligible. A slight decrease of freshwater content in the region between 2010 and 2013 was associated with some relaxation of anticyclonic winds; however, in 2015 and 2016, the magnitude of freshwater was greater than ever measured previously due to combination of intensification of anticyclonic winds and fresh water supply from both ice melt and river discharge.

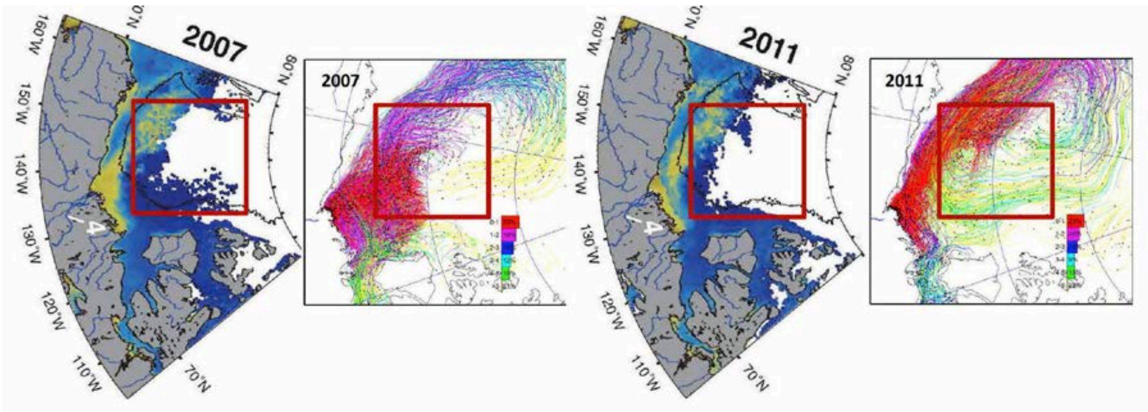

Figure 1. Left panels are 2007 observed flows of terrigenous dissolved organics carbon (tDOT) and trajectories of simulated floats released from Mackenzie River. Right panels is the same but for 2011.

G6S6-O06

Dissolution of $CaCO_3$ in the present and glacial ocean: A comparison of the effects of different dissolution parameterizations

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The production of the calcium carbonate minerals calcite and aragonite, in the ocean is primarily done by different pelagic calcifying organisms: coccolithophorids, foraminifera and pteropods. Corals contribute to the production of $CaCO_3$ in a small portion. The surface ocean is supersaturated with respect to these minerals while the deep ocean is undersaturated. Most of these calcium carbonate minerals produced near the surface ocean sink through the water column and dissolve mainly in the deep ocean below the saturation horizon where the solubility product of the minerals increases due to increased pressure. CaCO3 formation in the surface ocean and dis- solution in the deeper ocean both affect dissolved inorganic carbon and total alkalinity and also the oceanic pCO_2. In this study, a global biogeochemical model (REcoM) is used to analyze the production and dissolution of $CaCO_3$. In REcoM, bio-genic $CaCO_3$ production is restricted to phytoplankton and the dissolution rate of $CaCO_3$ is assumed constant when it sinks through the water column. A comparison between observation and model simulation data of dissolved inorganic carbon (DIC), alkalinity (TA) and saturation state (Ω) is presented in this study. In general, the model does a good job at reproducing the global patterns of DIC, alkalinity and Ω although some regional differences remain. In the case of DIC, model output shows too high concentrations in between 800 m to 1200 m ocean depth. Remineralization of organic matter in this depth of water column would be the possible explanation. Model simulation of alkalinity also shows a higher value than observations in the depth between 1200 m to 2000 m. The possible reason could be that too much dissolution of $CaCO_3$ is happening in this depth range. This research is done to answer two questions: How do these pattern change, when $CaCO_3$ dissolution is made dependent on omega, and how do they change under a glacial climate.

G6S6-O07

Enhancing of Biological Pump in the Chukchi Sea Based on Seven Chinese Arctic Summer Cruises since 1999 and Sediment Cores Records

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With decreasing of sea ice cover there would the potential for deepening of nutricline and an increasing of annual biological pump in the Arctic Ocean because of more nutrients in the euphotic zone will be consumed in an ice free sea or open ocean. Since 1999 (in summers, 1999, 2003, 2008, 2010, 2012, 2014, 2016), seven Chinese Icebreaker Xuelong Arctic Expeditions has been carried out in Chukchi Sea and Canadian Basin where upper ocean nutrients are abundant compared with European sector of the Arctic Ocean. During those cruises, we analyzed nutrients, DO, pH, chl a, opal and HPLC pigments in the water column, which allow us to look the variation of nutricline and biological pump after sea ice retreat since 1999. The results showed that size fractionation of chl a and opal, chl a-maximum depth, phytoplankton communities changed dramatically in the West Arctic Ocean, especially along the longitudinal 170°W section since 1999. A highlight of those changes is deepening of nutricline in summer and increasing of the depth of chl a-maximum in the shelf waters such as Chukchi Sea and ice edge in the deep Canadian Basin since1999. Organic carbon, opal burial and biomarkers records in sedimentary cores in the Chukchi Sea also indicated that increasing of organic carbon burial and relative abundance of diatoms while the contributions of haptophytes decreased since last 250a.

The Composition and Origination of Suspended Particles from Water Column in the Shelfs of Chukchi and Northern Bering Sea

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Abstract Suspended particle samples were collected using PALL filter and the large volume water transfer system (WTS) in surface (depth <1.0m) and water column (depth in 20m to 150m) at 35 stations on the shelfs of the Chukchi Sea and the norther Bering Sea during the Sixth Chinese Arctic expedition in the summer 2016. The particle concentration, TOC, and the $\delta^{13}C$ value of the samples were analyzed. Some of the particle samples and were chosen to examine by the scanning electron microscope (SEM) to reveal the composition. The concentration of suspended particle in surface water between 0.77 $mg.L^{-1}$to 3.39 $mg.L^{-1}$, with the samples collected from the Bering Sea have the higher concentration. The vertical profile of the particle concentration shows the higher values in surface, depth 50 and 100m water column of the northern Bering Sea, surface and 20m of Chukchi Sea. The particles mainly composed by clay materials in surface water with higher TOC content and lighter $\delta^{13}C$ value indicating that organic matter is mostly terrigenous derived in the areas of south of St. Lawrence Island and north of 68°N. The particles contain large amount marine organism from the zone between north of St. Lawrence Island and south of 68°N(near the Bering Strait) with the higher TOC content and heavier $\delta^{13}C$ value indicating that organic matter is mostly marine origination. The particles of water column contain more organism types, like as diatom, foraminifera and bivalves in of Bering Sea, but simplex (diatom)in Chukchi Sea.

Key words: Chukchi and Bering Sea, particles, organic matter, stable isotopes, SEM

G6S6-O09

Inferences on Biological Community Structure of the Distributed Biological Observatory (DBO) from Undersea Video Imagery

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Seafloor imagery of individual stations in the original five transect sampling areas of the Distributed Biological Observatory (DBO) in the Bering and Chukchi seas has been underway since 2008. Video collected in the most recent years has shown the near bottom characteristics of each of the transect lines, with DBO lines 1 and 3 particularly subject to exchange of organic materials in the bottom benthic boundary layer overlying soft muddy sediments. Epibenthos, including high densities of Opilio crab and near bottom fish and euphausids have also been documented at many stations, including near Barrow Canyon and in the Chirikov Basin north of St. Lawrence Island. Sampling at DBO 4 in the northeast Chukchi Sea has shown that brittle stars are overwhelmingly abundant, but a transition occurs to sand dollars and finally filter feeding tunicates, soft corals, and polychaetes in coastal areas with high current flow associated with the Alaska Coastal Current. In some cases such as crabs, sand dollars, and brittle stars, it is possible to quantify the density of these organisms on the seafloor, but improvements in pattern recognition of organisms are needed before video imagery can begin to replace trawling of the epibenthos on a widespread basis. We will show evidence that organisms living near the seafloor such as euphausids that are difficult to sample, but are presumed prey for higher trophic level predators are present in areas where infaunal sampling indicates that sufficient food may not be present although predators such as gray whales are observed feeding.

Figure 1. Polychaete community, Chirikov Basin south of Bering Strait

G6S6-O10

Changes in seabird density relative to water mass around St. Lawrence Island, northern Bering Sea during summer

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The marine ecosystems of the Bering Sea and adjacent Chukchi Sea are experiencing rapid changes due to reductions in sea ice. In the northern Bering Sea, several water masses can be discerned, which are likely to influence the distribution of zooplankton and fish, thereby, distributions of their predators i.e., seabirds. Understanding the link between seabird distributions and water masses is crucial to predicting ecosystem changes and designing effective management plans. To examine seabird distributions relative to water masses we conducted at-sea seabird observations concurrently with CTD measurements onboard *T/S Oshoro-maru* (Hokkaido University) within 200 km area from St. Lawrence Island in the northern Bering Sea during July 2017. Four distinct water masses were identified based on vertical distributions of water temperature and salinity following [1,2]; Alaska Coastal Water (ACW, 2.0–13.0^{o}C, <31.8 psu), Bering Shelf Water (BSW, 0–10.0^{o}C, 31.8–33.0 psu), Anadyr Water (AW, -1.0–1.5 ^{o}C, 32.3–33.3 psu), and Dense Water (DW, <-1.0^{o}C, 32.0–33.0 psu). Seabird density (all species combined) was highest in AW (121.9 birds n.mile^{-1}) and followed in the order as DW (53.4), BSW (30.3), and ACW (10.6). Similar distributional pattern of maximum chlorophyll *a* concentrations in water column was also observed (1.3 ± 0.7 mg m^{-3} in AW, 1.2 ± 0.8 in DW, 1.0 ± 0.5 in BSW, and 0.5 ± 0.1 in ACW). Surface omnivores such as Northern Fulmar *Fulmarus glacialis*, Black-legged kittiwake *Rissa tridactyla*, and Folk-tailed Storm-petrel *Oceanodroma furcata* occurred throughout the study region (8.9 birds n.mile^{-1} in ACW, 21.3 in BSW, 45.3 in AW, and 15.3 in DW). Divers, however, showed stronger relationships with water masses. Planktivorous divers such as Crested Auklet *Aethia cristatella*, Least Auklet *A. pusilla*, and Parakeet Auklet *A. psittacula* were absent in ACW, and their density in AW (46.1 birds n.mile^{-1}) was much higher than those in BSW (4.8) and DW (1.1). Also, the density of krill-eating short-tailed shearwaters *Ardenna tenuirostris*, which was most abundant migrant species in this region during summer, was highest in AW (21.0 birds n.mile^{-1}). These results may be explained, in part, by that large zooplanktons such as krill is more abundant in AW than those in the other water masses [3]. On the other hands, the density of piscivorous divers such as murres (Common Murre *Uria aalge* and Thick-billed Murre *U. lomvia*) and puffins (Horned Puffin *Fratercula corniculata* and Tufted Puffin *F. cirrhata*) was highest in DW (19.1 birds n.mile^{-1}) and followed in the order as AW (8.9), BSW (3.5), and ACW (0.9). Our study suggests that planktivorous divers and piscivorous divers, which are tightly associated with specific water mass, might be more affected than surface omnivores by climate-induced changes in water masses in seasonal sea-ice regions of the northern Bering Sea.

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G6S6-O11

A Step-Wise Progression to Fisheries Ecosystem Science in the Central Arctic Ocean

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The international waters of the central Arctic Ocean have been ice covered throughout human history until recent years (Fig. 1). The loss of summer sea ice removes the physical barrier to fishing vessels. In 2015, the five Arctic coastal states (Canada, Denmark/Greenland, Norway, Russian Federation, United States of America) signed the Oslo Declaration, pledging not to fish in these waters until there is sufficient scientific information to support robust management of the fisheries and ecosystem of the region. They also invited five distant-water fishing jurisdictions (the European Union, Iceland, Japan, People's Republic of China, Republic of Korea) to join further negotiations to develop an international agreement based on the same principles. When the agreement is concluded, the next question will be developing the necessary scientific information to monitor fish stocks in the central Arctic Ocean and understand ecosystem dynamics well enough to create a fisheries ecosystem management plan, should fishing ever take place in these waters. The expense and difficulty of conducting oceanographic research in the high Arctic makes international cooperation necessary, but it will still be hard to justify extensive fisheries research in a region with no fishing. Accordingly, we propose a step-wise approach in which basic monitoring is undertaken to detect ecosystem component status and any significant changes, at which point research and monitoring can be increased to better track fish stocks [1]. This approach will facilitate determining if and when more intensive efforts are needed to gather data on fish population dynamics, specific ecosystem components, and the likely outcomes of different levels of fishing activity in the region. Such a pathway provides a plausible approach to fisheries-related research in the central Arctic Ocean and is likely to produce information of great interest and value to other fields as well.

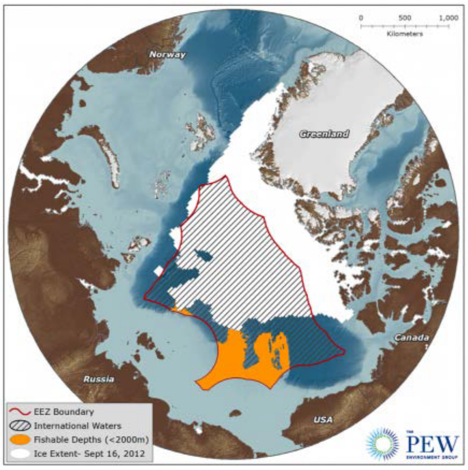

Figure 1. Arctic Exclusive Economic Zone (EEZ) boundary, 2012 summer sea ice extent, and fishable depths. Source: Pew

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January 16

Breakout Session

S7S8

Arctic Challenge for Ice Observation and Ice Navigation

Maritime Target Detection and Discrimination in Ice-Infested Arctic Waters based on Generative Adversarial Network Using SAR Images

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This work discusses the potential of maritime target detection and discrimination in Arctic waters based on recent machine learning method using space-borne synthetic aperture radar (SAR) images. As climate change progresses, the Arctic sea ice is rapidly reducing in its extent and thickness, which makes the Arctic more accessible for shipping, natural resources development, and tourist industry. Thus, for such difficult ice-infested region, the information of various maritime targets, e.g., ships, man-made platforms, oil spills, icebergs, and sea ice areas, becomes increasingly valuable. SAR satellites provide the possibility to monitor the Arctic Ocean regularly as they are capable of producing imagery in all weather conditions independent of daylight. Nowadays, there are many radar remote sensing operations, including Sentinel-1 (ESA), ALOS-2 (Japan), RADARSAT-2 (Canada), etc., offering lots of continuous observation data. Recent years, machine learning and deep learning methods with the ability to learn geometrical information of various images have received lots of attentions. Such methods supported by the available SAR data have great potential for Arctic characteristics studies, and in particular, for information extraction of various targets within the region.

In this study, we utilize the Generative Adversarial Network (GAN) [1] and propose an automatic maritime target detection and discrimination method for ice-infested situations. GAN consists of a generative model and discriminative model: generative model aims at generating as real as the trained images given a distribution sampled from input space; discriminative model is to distinguish whether the input image is generated or real. Both models are trained simultaneously, and compete with each other. It can capture a mapping from feature space into SAR image space automatically. It is also worth noting that there have been some studies on target identification in open sea with other machine learning methods [2] and target detection in sea ice area with statistical analysis algorithms [3]. According to our preliminary results, GAN have the ability to learn various sea clutter features in complicated meteorological and oceanographic conditions. Hence, this study is going to focus on ice-infested Arctic waters. The training and testing satellite scenes may include areas with open water, newly formed sea ice, first-year sea ice (FYI) and multiyear ice (MYI).

The main objectives are: 1) demonstrate the potential and benefits of using advanced intelligent processing methods with SAR images; 2) analysis real Arctic SAR images based on GAN for information extraction of various sea ice areas; 3) achieve improved maritime target detection and discrimination performances in ice-infested waters.

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S7S8-O02

The use of AUVs (autonomous underwater vehicles) under sea ice – achievements so far

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Apart from early short-lived ventures such as the University of Washington's vehicle of 1973, the first use of AUVs under sea ice was an experiment by the present authors in the Greenland Sea in 2002 in which the Maridan vehicle (a Danish vehicle funded by the EU) was used with a sidescan sonar to map the ice underside. Next came a long range AUV study (2004) involving the UK Autosub with multi-beam sonar and transects of up to 175 km in length. This enabled 3-D imagery of large numbers of first-year and multi-year pressure ridges to be obtained, as well as a systematic measure of the shape of the ice underside which permitted its oil containment factor to be estimated. The accompanying on-board ADCP instrumentation mapped upper ocean currents along the track. Following this operation, and following the loss of Autosub under an Antarctic ice shelf, emphasis switched to the use of small AUVs deployed by hand through ice holes or from boats alongside sea ice, and used for mapping relatively small areas of ice. A vehicle used frequently in such studies (2007, 2008, 2014, 2017) has been the Icelandic Gavia, with a Geoswath multi-beam sonar; but difficulties with its navigation system have meant that it has normally been used with a tether, limiting its range. Other vehicles used under ice include the WHOI Sea Bed twin-hulled AUV (2012), but the slowness of this vehicle meant that it could not maintain planned positions or tracks when a sub-ice current was present. The current situation is that both large and small AUVs have been used successfully to map the 3-D structure of the ice underside, but always in an experimental context. The problem is now to determine the best way forward to improve the quantity and quality of data gathering, and to turn the under-ice AUV into a reliable vehicle for routine use. This will be covered in an accompanying paper (Krogh and Wadhams).

S7S8-O03

MAPPING SEA ICE FROM ABOVE AND BELOW

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In order to improve the capabilities of AUVs when operating in the Arctic, and under sea ice in particular, there are a number of requirements that we see as essential for a successful operation. These requirements does not only deal with features of the AUV itself, but also with launch and recovery techniques, positioning under the ice, artificial intelligence for under-ice behavior, the optimal sensor package for mapping the underside of sea ice and the operational scenario as a whole. A key new technology being presented is the Stand-alone USBL Positioning Buoy, which will enable insertion, tracking and retrieval of the AUV to be more rapid and secure, and enable in-mission low bandwidth communication. For mapping the topside of the ice a UAV (Unmanned Aerial Vehicle) which fulfills a similar set of requirements will be described.

S7S8-O04

Estimation of sailing speed through ice covered waters on the northern sea route

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Although sea-ice in the Arctic Ocean is decreasing due to global warming, sea-ice still exists on the Northern Sea Route (NSR) in the summer season. In order to evaluate reduction of the sailing speed by sea-ice along NSR, we compared ships navigation data along the NSR derived from Automatic Identification System (AIS) with ice condition data such as sea-ice concentration and sea-ice thickness estimated from satellite passive microwave radiometer AMSR2 [1] during 2014 to 2016.

As a result, most ship showed decreasing sailing speed with sea-ice condition being severe. Such tendency is the most significant for the ships having Polar Class 6 (PC6). Figure 1 shows hourly sailing speed for PC6 ships and sea-ice thickness estimated from ASMR2 in 0.1m thick interval. PC6 ships showed almost constant speed in the thinner ice area (<0.6m) and decrease with thickness in thicker ice area (>0.6m). This study can be expected to contribute to estimation of the navigable speed in ice covered seas in the future.

This study has been carried out under the support of ArCS, JAXA 1st Research Announcement of Earth observation, and JSPS Grant-in-Aids for Scientific Research (A) Grant Numbers JP26249133 and Scientific Research (C) Grant Numbers JP26340013.

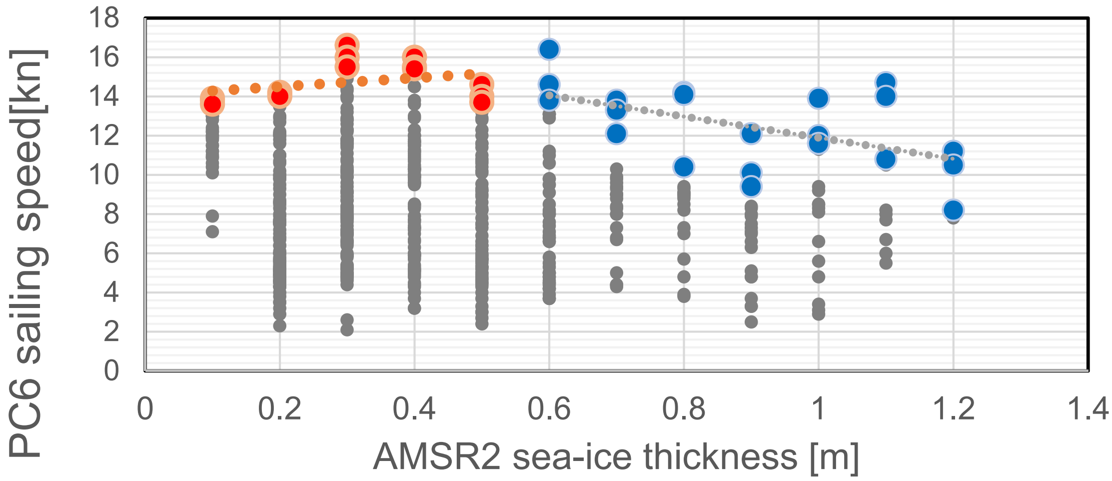

Figure 1. Comparison between ice thickness estimated from AMSR2 and hourly ship speed for PC6 during 2014 to 2016. Red and blue dots mean the highest three points for sailing speeds in thinner ice (<0.6m) and in thicker ice (>0.6m), respectively.

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Arctic Marine Access and Ice Navigation Seasons

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The profound changes of Arctic sea ice in extent, thickness and character provide for increasing marine access throughout the Arctic Ocean. However, Arctic marine operations and shipping are driven primarily by Arctic natural resource development and linkages to global commodities prices as outlined in the Arctic Council's Arctic Marine Shipping Assessment. Most future Arctic commercial voyages will be destinational, as natural resources will be increasingly carried out of the Arctic to global markets. One of the key strategic challenges for future planning is to estimate and quantify the length of the navigation season for regular marine routes. A review of current Arctic marine operations includes a range of feasible navigation seasons: year-round navigation to and from the port of Dudinka (servicing Norilsk) along the western Northern Sea Route (NSR), maintained since 1979; a 6 to 7-month navigation season in the U.S. maritime Arctic; and, a potential 3 to 4-month season in the Canadian Arctic. Uncertainty remains about how long the navigation season will be extended along the eastern Northern Sea Route from the new port of Sabetta on the Ob Gulf to Bering Strait (and into the Pacific Ocean). Also unknown are the feasible lengths of the navigation season for possible trans-Arctic voyages along the NSR, the Northwest Passage and trans-polar routes in the future? One operational factor is the increased use of icebreaking commercial ships such as the LNG carrier *Christophe de Margerie* and the *Norilsk* class carriers that can operate independently on Arctic voyages without icebreaker support. Other factors of importance include: the extended navigation seasons possible with icebreaker escort; the influence of the new IMO Polar Code and the mandatory use of polar ship ice classes for specific ice conditions; and, the overall economics of Arctic shipping when operating ice class ships independently and under escort. This paper will review the overall factors that can lead to a better understanding of the feasible lengths of the navigation seasons along future Arctic marine routes.

Development of NSR Transit Simulator "VESTA-ICE"

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Sustainable use of the Northern Sea Route for commercial shipping requires a lot of technological developments from the aspect of environmental issues. One of the important issues to reduce GHG emission from vessels is optimization of navigation routes which should incorporate with time and space varying ice conditions as well as vessel performance in ice. National Maritime Research Institute has developed an advanced vessel performance simulator in ice named "VESTA-ICE" which is capable of accurate estimation of ship performance such as propulsion power, speed reduction and fuel consumption, taking the main engine characteristics into consideration. Originally "VESTA" was developed as a ship performance simulator in no ice area. Added resistance due to wind and wave as well as the main engine characteristics are physically modeled in this program. Its accuracy has been validated through the extensive validation studies by onboard measurements. The authors incorporated two ice resistance models, Kashitelijan-Poznjok-Ryblin's for small ice floes and Lindqvist's for large ice floes, for performance calculation in ice to extend VESTA to VESTA-ICE. The accuracy of each model is validated through the comparison with the model-scale experiments conducted at the ice model basin of National Maritime Research Institute and the full-scale measurements in the Sea of Okhotsk. It was found that the proposed models are capable of predicting the resistance in floe ice of various sizes and concentrations with reasonable accuracy. Ship performance was estimated by VESTA-ICE from Japan to Norway via NSR. Several routing scenarios were simulated in order to investigate sensitivities of ice conditions for ship performance.

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S7S8-O07

Sea Route Search Using the Global Dynamic Windows Approach including Ice Concentration

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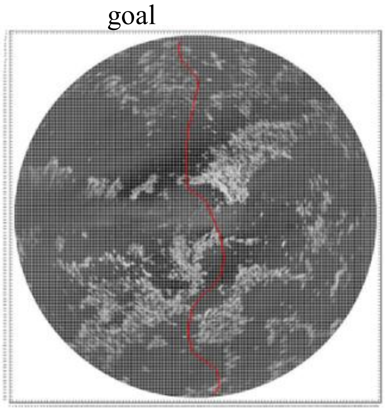
The sea ice has caused significant damage to vessels in the Arctic. There have been over 200 reported damage events over the past 25 years. It is important to avoid the collision with the sea ice, and to select the route to save the fuel and time safety. However, it is not easy to select the best sea route promptly and safely because the shape and the distribution of the sea ice are very complex. In this paper, the selection of the sea route in the ice sea is formulated as the obstacle avoidance problem using the global dynamic windows approach. This approach is a search technique composed of a local and global path-planning algorithm. This approach takes the kinematic and dynamic constraints of the vessels into account using a velocity motion model. In this paper, we propose an objective function used by the global dynamic window approach for searching for a route to safely avoid the sea ice. Finally, it shows that the simulation results applied to the ship radar image are effective for sea ice navigation (Figure.1).

goal



start

Figure 1. Sea route in the sea ice

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S7S8-O08

Field investigation of sea spray particles impinging on large vessels - Case study of the R/V Mirai

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–Marine disasters caused by ship icing occur frequently in cold regions. The typical growth mechanism of sea spray icing is as follows. First, sea spray is generated from the bow of the ship. Next, the spray drifts and impinges upon the superstructure, after which there is a wet growth of ice from the brine water flow. To address icing on the ship, we focus on the impinging seawater spray. We investigated the particle size of seawater spray and made sampling of superstructure ice accretion on R/V Mirai.

The amount of seawater spray and the size distribution of seawater particles were measured by a spray particle counter (SPC) and a marine rain gauge type spray gauge (MRS) . The SPC gives the flux distribution and the transport rate as a function of particle size from 100 to 1,000 μm in diameter. The particles in each class are counted every second. The volume flux of the spray was calculated by class value of particle radius. The amount of seawater spray is measured every minute using the MRS. The smallest measurable unit is 0.1 mm. To reveal the positional relationship of the amount of seawater spray, observations were conducted from three different points on the deck (Figure 1). SPCs were installed one on center of the compass deck and one on the starboard of the bridge deck. The three MRSs were installed one on the compass deck, one on the port and one on the starboard of the bridge deck. They were set on the bulwark behind 42 m from the bow.–

The data of SPCs, MRSs and pitching and rolling angles were obtained continuously through the cruise from Aug. 22 to Oct. 2. The SPCs were able to satisfactorily perform measurements of the particles. A large number of spray particles of large splashes were detected by the two SPCs simultaneously. MRSs detected the time series of accumulated spray volume (incl. precipitation) during the cruse period. The vertical distribution of the amount of sea spray was obtained. Additionally, there was a strong correlation between the amount of sea spray in per hour and the relative wind velocity.

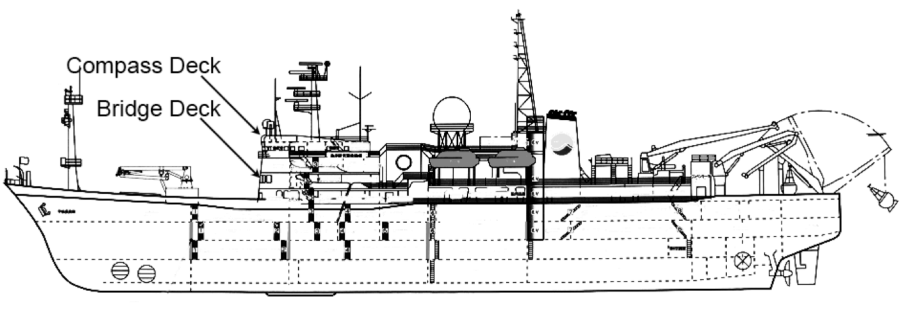

Figure 1 R/V Mirai (8,706 GRT) and location of SPCs and MRSs. Compass deck: SPC and MRS, bridge deck port: MRS, bridge deck starboard: SPC and MRS.

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S7S8-O09

R & D Study of Oil Recovery Device for Ice-covered Waters - NMRI-ORDICE

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National Maritime Research Institute

Large scale oil spilling from ships or other marine facilities such as underwater pipelines could lead to serious impacts on the marine and coastal environments. Ice-covered waters are particularly vulnerable to pollution inflicted by oil spilling. Cold temperatures impair the biological decomposition of oil and the pollutants can be remained in the environment for a prolonged period. Mechanical recovery of oil is an option for the oil spill response operations along with in-situ burning and the use of dispersants. It is the most preferable of the three from the viewpoint of the environment protection.

Mechanical recovery of oil in ice-covered waters should go through two processes. Oil is first separated from the ice and then recovered from the water. The first process requires a method unique to ice-covered waters, while conventional techniques for open water spilling can be applied to the second process with some modifications for cold environments. There have been various studies made of the oil-ice separation methods. Those studies include the international joint research project MORICE and the development of OIS (Oil-Ice Separator) conducted in Finland. The MORICE developed an oil-ice separation method using a Lifting Grated Belt. The belt lifts ice pieces from the water surface while it allows the oil to remain in or fall onto the surface to be recovered. The OIS also uses a grated belt, but, per contra, it submerges ice pieces into the water. The belt is vibrated to make the oil rise to the surface to be recovered. Operation principles of these methods limit their application to relatively small ice pieces.

An R & D study was performed at National Maritime Research Institute (NMRI) of an oil recovery device for ice-covered waters (NMRI-ORDICE) with an objective to develop a device applicable to larger ice floes than the two concepts above. The device uses air bubble-induced streams to separate oil and ice. Series of tests were performed at NMRI's ice tank for a large (6.0 m in length, 5.5 in width and 2.0 m in height) model of the device. The model is consisted of an oil-ice separation channel in the center and oil recovery ducts in the sides. The channel and ducts are separated by gratings that stop the ice while allow oil entering the ducts. There are air-bubbling units located in a 3 by 5 arrangement on the bottom of the separation channel. Air bubbles rising from the unit form a plume to create horizontal stream in the surface. The units can be operated in arbitrary combinations to "drive" oil toward the recovery ducts. The model was tested for various conditions of ice and oil. Ice floes of up to 2 m in diameter were used for the test. Lubrication oils with different viscosity were tested.

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S7S8-O10

Arctic research and educational collaboration plan between Japan-Norway

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Rapid environmental change in the Arctic in the last decades is a global threat, but it provides increasing opportunities for economic activities in the Arctic. Norway's maritime areas in the Arctic account for 60 % of whole Norwegian EEZ (Exclusive Economic Zone). It is also much concerned with Japan. The Arctic is a significant economic activity zone for both countries. Although understanding of the mechanism of climate change and ecosystem is essential for sustainable development in the Arctic, studies are still insufficient. Therefore, it is important to work together and report on activities and results across national borders. The two countries signed a bilateral agreement on science and technology cooperation in 2003. Energy and the environment, marine research, and polar and space research are priority areas of cooperation under the agreement. Norwegian Ministry of Education and Research regards Japan as one of the most significant countries for collaboration on higher education and research in the strategy from 2016 to 2020 [1].

NERSC leads an EU project, INTAROS [2] which is a research and innovation action for 5 years under Horizon2020 (2016-2021). The overall objective is to develop an efficient **Int**egrated **Ar**ctic **O**bservation **S**ystem by extending, improving and unifying existing and evolving systems in the different regions or the Arctic. The project includes 49 partners from 20 countries and NIPR is among them. Sandven, the coordinator of INTAROS, is appointed as a member of International Advisory Board of ArCS [3], which is Japanese national flagship project on the Arctic (2015-2020). NERSC and ARC-HU has agreed with future research and educational collaboration in May 2017. Research and educational collaboration between Japan and Norway has been already commenced. For deeper understanding of the mechanism of the Arctic, it is important to further strengthen the collaboration and maintain long-term partnership.

NERSC, ARC-HU and NIPR will collaborate to synthesize recent results from Arctic researches and share the results not only with academia but also with stakeholders, decision makers and the broader public through joint seminars and workshops. We will also collaborate to cultivate young scientists through joint courses, and support the mobility of students, lectures and scientists between the two countries. Moreover, we will develop and submit competitive research and educational proposals to relevant calls and funding agencies, e.g. the Research Council of Norway, Norwegian Center for International Cooperation in Education, Japan Science and Technology Agency, Japan Society for the Promotion of Science, Innovation Norway and EU Framework Programme for Research and Innovation (Horizon2020), to sustain long-term binational partnership in higher education and research.

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January 16

Breakout Session

G1

Atmosphere

G01-O01

Sensitivity of the Arctic climate forcing due to atmospheric physical parameterizations

Jin-Ho Yoon[1], Bak-Min Kim[2], Jee-Hoon Jeong[3], Philip J. Rasch[4], Hailong Wang[4], Ben Kravitz[4], Catrin Mills[4]

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[2] Korea Polar Research Institute
[3] Chonnam National University
[4] Pacific Northwest National Laboratory

There has been a couple of heated debates about how the Arctic, i.e., reduction of the Arctic sea ice, can play as a climate forcing to influence the midlatitude weather and climate. On the other hand, the traditional perspective on the teleconnection originated from the tropical oceans, which has been widely accepted, could not explain recent changes in winter weather and climate extremes in the midlatitude regions. Here, we are attempting to use the state-of-the-art climate model to examine sensitivity of the Arctic climate forcing compared to the tropical one. Particularly, we are interested in how the atmospheric physical processes could affect the teleconnection pattern, which has not been extensively tested. Our hypothesis is that the Arctic climate forcing is more sensitive to the various physical processes in the climate model, resulting in some inconsistencies in simulated response.

Cooling trend over Eurasian continent and Arctic sea ice decline

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[3]*JAMSTEC, Japan*
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Cooling tendency has been observed over the wintertime Eurasian continent since the 2000s. Many recent studies attribute this cooling trend to the recent decline of Arctic sea ice (e.g., [1]), while other studies argue that the tendency is due to atmospheric internal variability (e.g., [2]). The aim of this study is to evaluate not only the influence of the Arctic sea ice decline, but also that of long-term sea surface temperature (SST) changes, on the Eurasian continent through a set of atmospheric general circulation model (AGCM) ensemble experiments. The first set of experiments (Exp. A) is forced with observed, time-varying SST and sea ice. The second set (Exp. B) is forced with the observed SST and daily climatological sea ice, while the third set (Exp. C) is with climatological SST and the historical sea ice. The climatological SST and sea ice are given to the fourth experiment (Exp. D). Each of experiments consists of 15 ensemble members and the period is from 1982 through 2013. Note that the radiative forcing is fixed to constant values for present-day climate. DJF-mean 2-meter temperatures averaged over (40-60N, 60-120E) is used as winter-mean temperatures over the Eurasian continent.

While, out of 15 ensemble members, only 4 members show cooling trend over Eurasia continent in Exp. A, none of members shows cooling trend in Exp. B, which suggests that observed SST changes alone tend to warm up Eurasia. In Exp. C, 11 out of 15 members show cooling trend, which suggests tendency of the observed sea-ice decline lowering temperatures over the Eurasian continent. We can confirm that model bias should not affect the simulated tendency because Exp. D does not show a particular trend. Our results suggest that the recent sea ice decline has induced cooling over Eurasia to a certain degree, while observed SST change tends to raise temperature over the Eurasian continent, which may have overcome the sea ice effect.

Acknowledgements: This work is supported by ArCS, InterDec project, and the Environment Research and Technology Development Fund (2-1503) of Environmental Restoration and Conservation Agency.

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G01-O03

Quantification of influence of Arctic sea-ice reduction and natural variability to recent Eurasian cooling

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During the recent decades, severe winters are increasing in the mid-latitude central Eurasia, contributing manifestation of cooling trend over there, despite increasing global- and annual-mean surface air temperature [1]. Statistical relationship obtained from observational analyses have suggested that part of this cooling is forced by recent Arctic sea-ice decline. However, numerical modelling studies have shown different conclusion depending on the used model and experimental settings, and whether or not the cause is due to sea ice reduction is controversial [2-3].

In this research, we successfully detected the signature of Eurasian cold winters excited by sea-ice decline in the Barents-Kara Sea, by analyzing observation and four kind of historical large ensemble simulations based on atmospheric general circulation model (AGCM) forced by observed sea surface temperature and sea ice. The sea ice reduction tends to increase occurrence frequency of cold winter in the central Eurasia, but the sea-ice forced effect is underestimated in the AGCM compared with observation. We conclude that this model bias can be a major cause that makes diverse conclusions among modelling studies.

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G01-O04

A comparison of climate impacts of the Arctic sea ice loss based on multiple sea ice concentration datasets

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As part of the effort to understand Arctic climate change and its global impacts, possible impacts of Arctic warming on mid-latitude climate and weather have recently been intensively studied. An issue has arisen as simulated winter atmospheric circulation response to the Arctic sea ice loss largely varies among models and studies, bringing difficulties of evaluation of climate impacts of the Arctic warming. A cause of such uncertainty can be errors from sea ice concentration (SIC) dataset complied based on the satellite remote sensing as well as complexity/non-linearity of the process and imperfection of climate models. Here we performed 3,600-member ensemble simulation of climate impacts of the Arctic sea ice loss using 18 configurations of the boundary condition, namely 6 SIC datasets and 3 definitions of high/low ice years, to estimate the uncertainty of the climate response due to configuration errors. While general responses resemble negative Arctic Oscillation (AO) pattern as shown in Figure 1, individual responses largely vary in amplitudes and horizontal patterns among different configurations. The differences specifically depend on local changes in surface temperature in the North Atlantic region that likely partly controls the quasi-stationary wave response through a modification of the transient eddy activity.

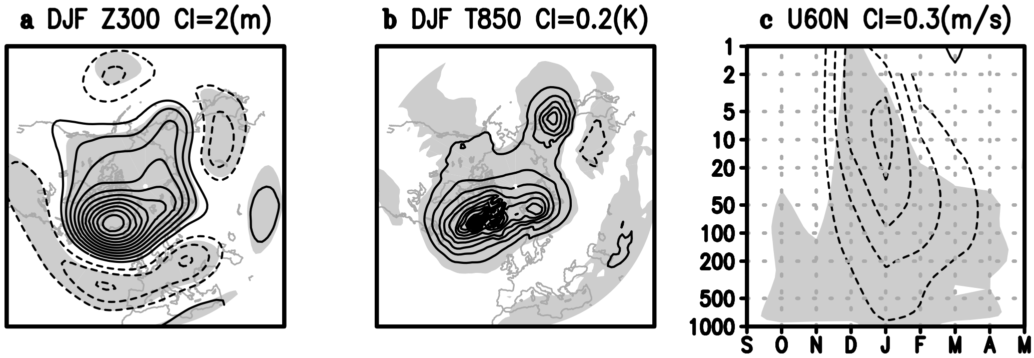

Figure 1. Simulated winter atmospheric responses to sea ice reduction, regardless of differences of dataset and high/low ice year definition. Anomalies of 1.8K sample average of Low-ICE runs minus High-ICE runs are shown for **a,** Z300 in DJF **b,** T850 in DJF and **c,** seasonal evolution of zonal mean U at 60°N. Solid (dashed) line indicate contours of amplitudes of the positive (negative) anomaly, with the zero line omitted. Grey shade indicates statistical significance exceeding 95%.

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Is the recent downturn of the summer North Atlantic Oscillation (SNAO) related to Arctic Sea Ice change?

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[3]*Korea Polar Research Institute, Korea*

The influence of the north Atlantic oscillation (NAO) on climate across the North Atlantic region has been highlighted over the past few decades. So far, most research has focused on the winter season, but recently conclusive evidence of strong links of the NAO to climate variability over Europe, especially Northern Europe, also in summer has been presented [1]. The summer NAO (SNAO) exerts a strong influence on rainfall, temperature, and cloudiness and is related to summer extremes, such as droughts and floods and related phenomena (e.g. forest fires), mainly in Europe but also elsewhere. In its positive phase, the SNAO is associated with anticyclonic conditions over Northern Europe, yielding sunny, warm and dry conditions due to a northerly position of the main storm track. The negative SNAO phase accompanies the southward movement of storm track of about 10 degrees (lat), giving cloudy, wet and cooler conditions over the same region. Moreover, it has been demonstrated that the SNAO is related through teleconnections with climate outside Europe e.g. eastern USA, North Africa and East Asia, Thus, this regional climate pattern is associated with climate variability in both heavily populated, but also sensitive regions.

The climatological impacts of accelerated melting of Arctic sea ice in the last few decades have been the foci of many of studies in recent years. In addition to the local effects of disappearing and thinning sea ice, it has been proposed that the atmospheric circulation over the mid-latitudes can also be affected [e.g. 2]. Although most studies have focused on the dynamically more active winter season, there are also indications of impacts in summer [e.g. 3]. In this presentation, we examine the potential role of changing Arctic sea ice concentration (SIC) on the SNAO, with some focus on the tendency for a shift toward a negative phase of the latter in recent years. Re-analyses data show that over the last five decades, a consistent positive association between winter/spring Arctic SIC, particularly in the Labrador Sea, and the SNAO can be found. However, since the 1990s the strength of this association has weakened considerably, and during the last decade, characterised by accelerated sea ice melting, SIC in the Labrador Sea has been negatively correlated with the SNAO. The nature of the potential SIC-SNAO association is discussed, and using proxy data, we set the current observations in a millennium-long perspective.

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Analysis of cloud formation processes for arctic cyclone in the non-hydrostatic icosahedral grid model

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RIKEN Advanced Institute for Computational Science and University of Tokyo Atmospheric and Ocean Research Institute have co-developed Non-hydrostatic Icosahedral Atmospheric Model (NICAM), whose dynamical core designates the non-hydrostatic equilibrium. This ultra-high resolution model is expected to play an important role for revealing unknown cloud microphysics processes as a cloud resolving simulation model. Numerous studies evaluated the simulation of the cloud convection processes by NICAM in both extratropical and tropical regions, while a small number of researches in the polar region have analyzed these atmospheric phenomena. In one example of previous research related to cloud process in polar region, Aizawa et al. (2014) [1] investigated the three dimensional structure and intensification mechanism of the simulated arctic cyclone (AC) by NICAM with a 7.0 km horizontal mesh resolution, referred as g-level 10. Figure 1 shows an AC at the mature stage which was produced by NICAM in this study. This horizontal structure of AC indicates that it has the quadruple spiral shaped cloud bands without any front. The mature phase of the AC displays anti-clockwise screwing motion as the same stage of cold vortex generally shows. It is meaningful to evaluate the cloud microphysics processes within NICAM in the arctic region through the comparison of model results and observation, and to progress the analysis of the structure of AC by investigating other AC cases.

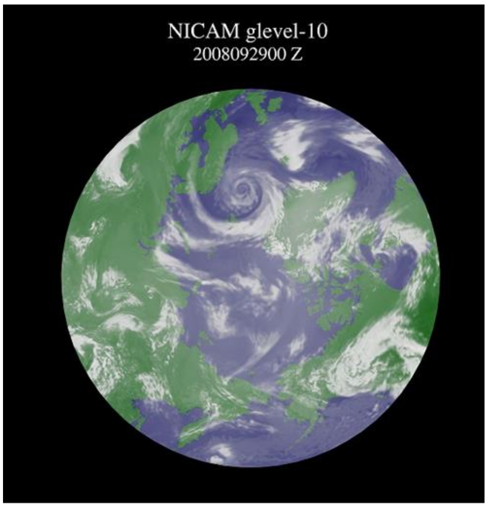

Figure 1. A simulated AC in September 29, 2008 by NICAM g-level 10.

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G01-O07

Soil CO_2 Measurements in Canada's High Arctic Winter

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Arctic permafrost soil holds estimated stores of organic carbon which amount to more than twice the carbon currently in the atmosphere, or almost 1,700 Gigatons [1]. Soil respiration releases CO_2 into the atmosphere and represents an important contribution to the overall carbon cycle, but it is difficult to measure in cold winter months in arctic regions.

We measured the soil CO_2 flux in Inuvik, Canada (68.36° N, 133.72° W) from August 2016 to May 2017 on the grounds of the Aurora Research Institute using Eosense Inc., eosFD CO_2 flux measuring devices. We also monitored the site with a number of temperature sensors (Hobo®) to measure air and ground temperature and we recorded images of the site so that snowfall and snow cover effects could also be examined.

We set out to measure CO_2 flux during winter months at regular intervals of 5 minutes, 10 minutes and 1 hour see Figure 1. Below. We also included a single image taken in early December to show that the equipment was fully snow covered at this point in time.

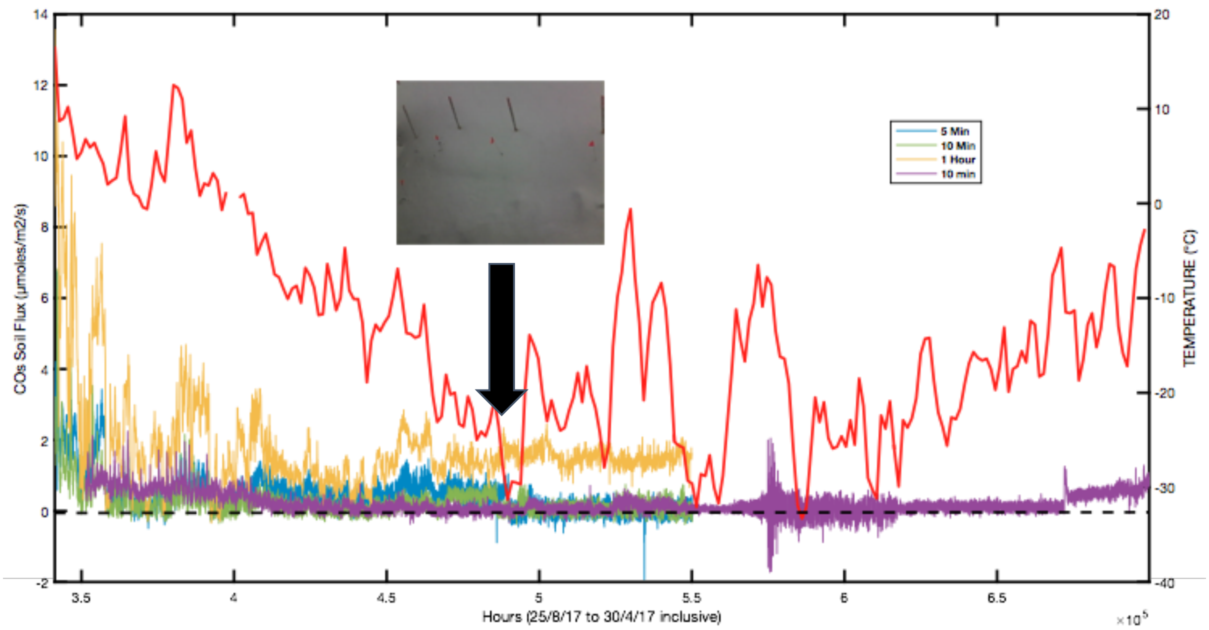

Figure 1. CO_2 Soil Flux from September 2016 to May 2017 in Inuvik, NT, Canada

Flux results were closely correlated with temperature as shown above, (top red line represents air temperature at the Inuvik airport approximately 12 km away) until the devices became covered with snow in late November, 2016. Snow cover insulated the devices, stabilized the flux and may have increased the flux likely as a result of temperature effects. Differences between devices was also dependent on measurement frequency. Further results and discussion will be presented. This work was supported by the National Sciences and Engineering Research Council of Canada (NSERC) and Eosense Inc., Halifax, NS, Canada.

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G01-O08

Terrestrial Biospheric and Oceanic CO_2 Uptake Estimated from Long-term Measurements of Atmospheric CO_2 Mole Fraction, $\delta^{13}C$ and $\delta(O_2/N_2)$ at Ny-Ålesund, Svalbard

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Systematic observations of CO_2 mole fraction, the isotopic ratio $\delta^{13}C$ of CO_2 and oxygen to nitrogen ratio ($\delta(O_2/N_2)$) in the atmosphere have been carried out at Ny-Ålesund (78.92˚N, 11.93˚E, 40 m a.s.l.), Svalbard since 1991, 1996 and 2001, respectively. The CO_2 mole fraction shows a clear seasonal cycle superimposed on a secular increase with an average rate of 2.0 ppm yr^{-1} for the period 1996–2013. On the other hand, $\delta^{13}C$ and $\delta(O_2/N_2)$ decrease secularly at an average rate of −0.020 ‰ yr^{-1} for 1996–2013, and −19.9 per meg yr^{-1} for 2001–2013, respectively. Based on the observed secular trends of the CO_2 mole fraction and $\delta(O_2/N_2)$ (O_2 method), the average CO_2 uptake during 2001–2013 was estimated to be 1.6 ± 0.8 and 2.3 ± 0.5 GtC yr^{-1} for the terrestrial biosphere and the ocean, respectively. By using the observed CO_2 and $\delta^{13}C$ ($\delta^{13}C$ method), the corresponding CO_2 uptake of 1.3 ± 0.6 and 2.6 ± 0.5 GtC yr^{-1} were obtained for the same period. The estimates from the two methods are in good agreement with each other. The terrestrial biospheric CO_2 uptake derived by the latter method showed large inter-annual variability in association with El Niño events. On the other hand, the oceanic uptake increased secularly with less inter-annual variability during 1996–2013 (Figure 1).

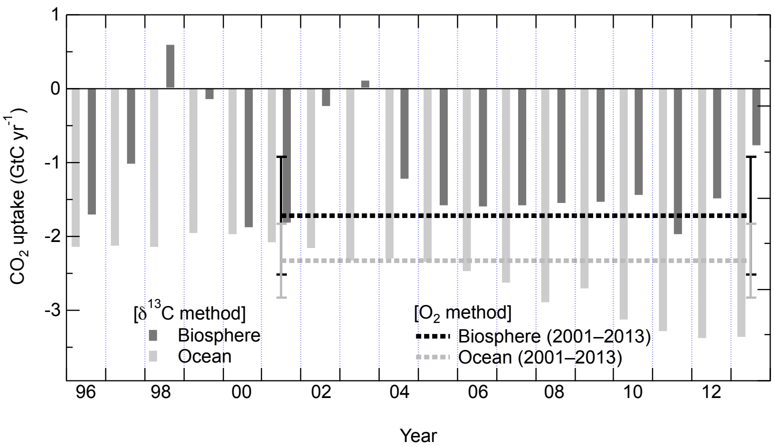

Figure 1. Terrestrial biospheric and oceanic CO_2 uptake estimated using the $\delta^{13}C$ method and the O_2 method for the respective periods of 1996–2013 and 2001–2013

G01-O09

Relationships between wildfire occurrences and environmental factors over the Siberian region

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It is known that smoke from wildfires affect air quality. In Arctic region, wildfires in summer are typical phenomena and those would generate large concerns on air quality at present and in the future. For better future wildfire projection, it is essential to know the factors controlling the cause of wildfires. In this study, we focus on the Siberian region and analyze the relationships between number of wildfires there and several environmental variables such as snow cover fractions, 2-m temperature, geopotential heights, soil moisture, etc., using monthly mean datasets during 2003-2015. For fire pixel counts and snow cover fraction, satellite-based datasets are used. The MODIS Snow Cover data (https://modis.gsfc.nasa.gov/data/dataprod/mod10.php) and the number of fire pixel data (http://feer.gsfc.nasa.gov/) from Terra/Aqua satellite data were used. Those were re-gridded into the horizontal resolutions of NASA's MERRA-2 re-analysis data because we also use the MERRA-2 data (https://gmao.gsfc.nasa.gov/reanalysis/MERRA-2/). The data retrieved by Terra and Aqua were combined.

First of all, we calculated the domain-averaged monthly fire pixel count per the MERRA-2 grid over the Siberia (East) for the time period (firepc), for which the domain defined by Darmenov and da Silva [1] (see their Fig. 4 and Table 4; called data 1) was used. Then, domain-averaged several environmental variables (i.e., atmospheric and land related variables) mentioned above over the region were extracted from the MODIS Snow Cover Fraction (modscf) and MERRA-2 (called data 2). Next, multiple linear regression analyses were carried out for the monthly time series data with the data 1 (no time lag) and time-lagged data 2 from 0 to 4 months under different combinations of the data, after implementing standardizations for each variable. For example, in the case of using the time-lagged modscf, 2-m temperature (t2m) and surface soil wetness (gwettop) together with the inclusions of geopotential height at 500 hPa (h500; no time lag) and observation-corrected precipitation (prectotcorr; no time lag), we could obtain the following multiple linear regression model for the 4-month time-lagged case (modscf, t2m, and gwettop): firepc = 4.378e-01*modscf + 4.405e-01*t2m – 2.503e-01*gwettop + 1.033e+00*h500 – 6.937e-01*prectotcorr + 2.719e-17 ($R^2 = 0.3599$; Adjusted $R^2 = 0.338$). Except for the intercept, all parameters for each variable were significant at the levels of smaller than 0.01. This multiple linear regression model means that fire occurrences can likely be explained with geopotential height at 500 hPa and precipitation on the same month of the wildfire occurrences, and snow cover fraction, 2-m temperature, and surface soil wetness 4 months before the fire occurrences. However, the adjusted R^2 only explain about 34% of variations of number of fires. Therefore, considerations of different factors and/or removing disturbing elements may be necessary to fully explain the cause of fires. More discussion will be held at the day of the presentation.

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Variations of black carbon and dust in Northwest Greenland reconstructed by Continuous Flow Analysis of an ice core

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[3]Hokkaido University, Japan
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[5]University of Tokyo, Japan
[6] Tokyo University of Science, Japan
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An ice core to the depth of 225 m was drilled at the SIGMA-D site, Northwest Greenland, in 2014 under the SIGMA (Snow Impurity and Glacial Microbe Effects on Abrupt Warming in the Arctic) project [1]. The ice core was analyzed to the depth of 113 m with a Continuous Flow Analysis (CFA) system, which was recently built at the National Institute of Polar Research, Japan. The CFA system allowed high resolution analyses of black carbon (BC), stable isotopes of water, dust, electric conductivity, and trace elements (Na, K, Mg, Ca, Fe, and Al). BC was analyzed with a Wide Range SP2, which was recently developed by University of Tokyo [2]. The Wide Range SP2 enabled us to measure BC particles with the size range between 70 and 4000 nm. Dust were analyzed with Klotz Abakus, which detects shading of laser light caused by each particle. Here we report the variations of concentrations and size distributions of BC and microparticles during the past 350 years. Anthropogenic impacts on concentrations, size distributions, and their seasonal variations are clearly seen during the first half of the 20th Century. Dust-derived species Ca, Fe and Al show elevated concentrations during mid-19th Century.

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G01-O11

Lidar Observed Seasonal Variation of Free Tropospheric Aerosols over Ny Ålesund

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[4]*National Institute of Polar Research, Japan*
[5]*Faculty of Engineering, Chiba University, Japan*

Nonstop ground based lidar observations of aerosols and clouds are being conducted at Ny Ålesund (79°N, 12°E), Svarbard, since March 2014. We found by the observations that the backscattering coefficiet of aerosols (BCA) takes highest values in spring and summer (May to July) at the altitudes higher than 2 km, and that such seasonal cycle isn't clear at the altitudes between 0.6 and 2 km. (Fig. 1(a)) We also found that the particle depolarization ratio (PDR) between 0.6 and 5 km takes higest values in winter and spring (January to May), and lowest values in summer and autumn (June to October). (Fig. 1(b)) These seasons for PDR, respectively, correspond to the increasing and decresasing phases of BCA at at the altitude higher than 2 km.

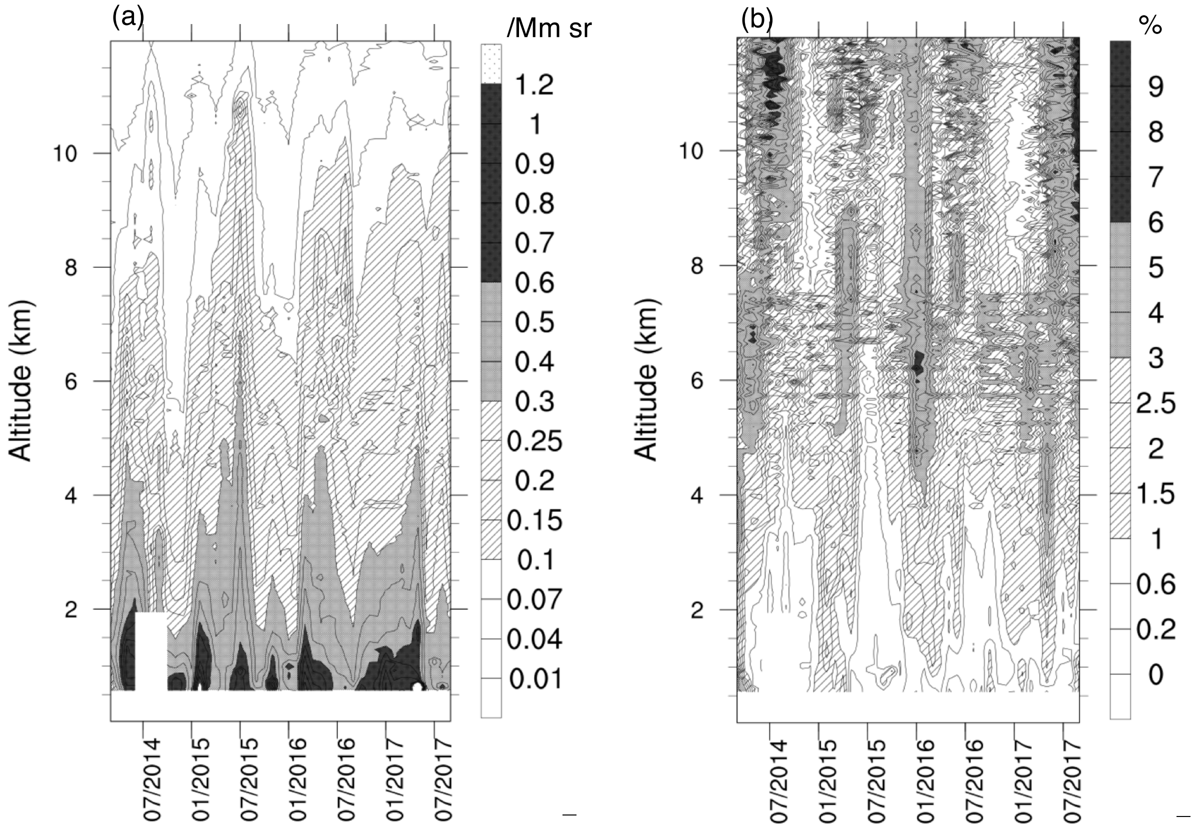

Figure 1. Monthly mean (a) backscattering coefficient (/Mm sr) and (b) particle depolarization ratio (%) at 532 nm observed by ground based lidar at Ny Ålesund.

G01-O12

Moistening of the Antarctic upper troposphere observed by balloonborne water vapor measurements

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An intensive balloon observation was performed at Antarctic Syowa Station (69.0S, 39.6E) in July 2016 using 7 Cryogenic Frostpoint Hygrometers (CFH) and 24 ECC ozonesondes. It aims at examining a fine vertical structure at the Antarctic tropopause and its relationship with the stratosphere-troposphere exchange (STE). High water vapor concentration was observed in the upper troposphere in 2 observations. Trajectory analysis and several kinds of diagnostics showed that the upper troposphere moistening was induced by upward transport of humid air from the lower/middle troposphere. We will discuss characteristics of dynamical processes inducing the transport and contribution of diabatic processes in the presentation.

January 16

Breakout Session

S9

Understanding the Changing Arctic through Data: Stewardship, Publication, and Science

S09-O01

Metadata Management, Interoperability and Data Citation in Polar Science

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[2]*Polar Data Catalogue & Canadian Cryospheric Information Network, University of Waterloo, Canada*

The Polar Environmental Data Science Center (PEDSC) has a task to archive and deliver the data obtained from polar regions by Japanese related activities. Summary information (metadata) of all archived data are available to involved polar communities, with more general interests by public domain. The compiled metadata describe various science research disciplines from both long- and short-term projects in the Arctic and Antarctic, in which their majorities are from Japanese Antarctic Research Expedition (JARE) (Kanao et al., 2014). Inside the portal server for scientific metadata (http://scidbase.nipr.ac.jp/), 380 records have been compiled as of August 2017. A linkage of the metadata between PEDSC and the Polar Data Catalogue, Canada (https://www.polardata.ca/) was initiated since May 2014. The Polar Data Catalogue is a database of metadata and data that describes, indexes, and provides access to diverse data sets generated by the Arctic and Antarctic researchers (Friddell et al. 2014). The records inside the Polar Data Catalogue follow the ISO 19115 standard format in order to provide metadata exchanges with other data centres. These records cover a wide range of disciplines from natural sciences and policy, to health and social sciences. The metadata in the portal server of PEDSC has been provided to the Polar Data Catalogue, by using the Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH). Regarding compiled metadata for all science branches by PEDSC, moreover, a sophisticated system that can automatically attribute the Digital Object Identifier (DOI) are equipped inside the portal server. The DOIs can be requested to "DataCite" through a gateway interface provided by "Japan Link Center (JaLC)", as one of the Registration Agency which can provide the DOIs. After receiving offers to obtain DOIs from the data providers/managers, quality of individual data can be strictly evaluated by involved "data management committee", followed by attributing their DOIs for those with sufficient level of quality for opening/publishing the data into public domain. There are several evaluation terms before assignment of the DOIs; regarding data quality, publishing methodology, long-term maintenance strategy, and their data policy, etc.. In summary, the data managing and serving system combined by both the countries could surely be contribute to advance in rapid data circulation, interoperability, usability by a tight connection between multi-disciplinary polar sciences conducted both in the Arctic and Antarctic research communities.

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S09-O02

Getting Necessary Heritage Data out of Deep Freeze

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Many, if not all, of the natural sciences have remote caches of historical data in analogue formats that would add significantly to our understanding of the evolution of the science in question *if only the older data were readily accessible in modern electronic formats*. The changes which are brought about by such evolution often have very long time-constants, and the data which capture and measure them can therefore span many decades, sometimes centuries. We review very briefly the global situation regarding the status of "*data at risk*", and then home in on the efforts being organized or attempted by those within the Polar communities. This topic is very suitable for a panel discussion, and since it is rather fruitless for the data seekers just to complain about what is lacking, it would be an advantage to include a representative from the World Data Service (or other Data Management organization) who could address the needs of this specific community from the perspective of the data provider.

S09-O03

The Canadian Consortium for Arctic Data Interoperability: An Emerging Initiative for Canadian Arctic Data Stewardship

Maribeth S. Murray[1*] and Shannon Christoffersen Vossepoel[1]

[1]*Arctic Institute of North America, University of Calgary*

The Canadian Consortium for Arctic Data Interoperability (CCADI) is a new and growing initiative that seeks to advance collaboration, nationally and internationally, through the development of a national Canadian arctic data management system that will facilitate information discovery, establish standards for metadata and data sharing, enable interoperability amongst existing data infrastructures, and that will be accessible to a broad audience of users. The consortium is currently composed of a group of Canada's foremost Arctic scholars and Arctic data managers at the University of Calgary (Arctic Institute of North America, Department of Geomatics Engineering, InnoVis), the University of Waterloo (Canadian Cryospheric Information Network and Polar Data Catalogue), Carleton University (Geomatics and Cartographic Research Centre), the University of Manitoba (Centre for Earth Observation Science), Université Laval (Centre d'études nordiques), University of Ottawa (Faculty of Law) Inuit Tapiriit Kanatami, Inuvialuit Regional Corporation, Natural Resources Canada, Polar Knowledge Canada, Cybera Inc., Polar View, and Sensor-Up Inc. This session will provide an overview of the CCADI, its initiatives, and its impact on the national stewardship of Canadian Arctic data.

S09-O04

INTAROS: Integrated Arctic observation system development under Horizon 2020

S. Sandven[1*] and H. Sagen[1]

[1] *Nansen Environmental and Remote Sensing Center, Norway*

INTAROS is a research and innovation action under the H2020-BG-09 call in 2016 and will run from 2016 to 2021. The main objective of INTAROS is to develop an integrated Arctic Observation System (iAOS) by extending, improving and unifying existing systems in the different regions of the Arctic. INTAROS has a strong multidisciplinary focus, including data from atmosphere, ocean, cryosphere and terrestrial sciences, provided by institutions in Europe, North America and Asia. In Japan INTAROS will establish close cooperation with the ArCS programme, which is a major multidisciplinary project running till 2020. INTAROS will furthermore contribute to YOPP and MOSAIC by deploying ice platforms and moorings to increase sea ice and ocean observations from 2018 to 2020. Satellite earth observation (EO) data plays an increasingly important role in such observing systems, because the amount of EO data for observing the global climate and environment grows year by year. In situ observing systems are much more limited due to logistical and technological constraints. The sparseness of in situ data is therefore the largest gap in the overall observing system. At present INTAROS is assessing strengths and weaknesses of selected existing observing systems. This study is undertaken in collaboration with SAON and will be used to identify gaps in the observjng systems from sensors to data dissemination. A long-term goal of INTAROS is to improve the sustainability of the Arctic observing systems. This requires more coordination, mobilization and cooperation between the existing international and national infrastructures (in-situ and space-based observations), the modeling communities and relevant stakeholder groups. INTAROS is also working with community-based observing systems and collaboration between local communities and science communities. An integrated Arctic Observation System should be designed to enable better-informed decisions within key sectors (e.g. local communities, shipping, tourism, fishing), in order to strengthen the societal and economic role of the Arctic region. Information about ongoing activities is found at http://www.intaros.eu.

Acknowledgement. INTAROS receives funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727890.

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S09-O05

Arctic Observations, Data and Society: using systems science to enhance Arctic information flow

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Recent environmental and social change has resulted in an increased focus on the Arctic region by governments and the general public. Much of this interest is generated in the context of the concept of sustainability and the global implications of a changing Arctic. Concurrently, there is a recognition by researchers, Arctic communities and decision makers that Arctic observations and data are not readily available in a usable form to all who need them. This talk provides a review of Arctic data as a complex system of interrelated data resources, technology, funding, human and machine actors and other components that can be seen as an "ecosystem".

To improve the flow of information will require more than simply making data easier to discover and access in its raw form. New approaches to mediating or transforming data to meet the needs of different user communities are needed and increasingly possible. Enhancing the system will require a broad commitment to dialogue across different communities of practice and a recognition of the need to conceive of data and related technologies as a socio-technical system and infrastructure that can interoperate from local to global scales. The talk concludes with a review of existing and emerging projects and programs focused on Arctic data, including the Arctic Data Committee sponsored by the International Arctic Science Committee and Sustaining Arctic Observing Networks program, the Group on Earth Observations Cold Regions Initiative, and the Pan-Arctic Options project.

S09-O06

Data Management of Arctic Project in Japan

Hironori Yabuki[1,2], Takeshi Sugimura[2], Takeshi Terui[2]

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[2]*National Institute of Polar Researchrctic (NIPR)*

Arctic is the region where the global warming is mostly amplificated, and the atmosphere/ ocean/ cryosphere/ land system is changing. Active promotion of Arctic environmental research, it is large and responsible for observational data. Promotion of Arctic research in Japan, has not been subjected to independent in their respective fields.

In the National Institute of Polar Research, perform the integration and sharing of data across a multi-disciplinary such as atmosphere, ocean, snow and ice, land, ecosystem, model, for the purpose of cooperation and integration across disciplines, we build a Arctic Data archive System (ADS).

Arctic Data archive System (ADS), to promote the mutual use of the data across a multi-disciplinary to collect and share data sets, such as observational data, satellite data, numerical experiment data. Through these data sets, clarify of actual conditions and processes of climate change on the Arctic region, and further contribute to assessment of the impact of global warming in the Arctic environmental change, to improve the future prediction accuracy.

A new project of the Arctic research (ArCS :Arctic Challenge for Sustainability) has been started in 2015. ArCS is a national flagship project funded by the Ministry of Education, Culture, Sports, Science and Technology. The National Institute of Polar Research (NIPR), Japan Agency for Marine-Earth Science and Technology (JAMSTEC) and Hokkaido University are playing the key roles in this project, and will continue to carry it out for approximately four-and-a-half years from September 2015 to March 2020. ADS is responsible for the data management of this project.

Linking People with People and with the Data They Need: Recent Activities at the Canadian Cryospheric Information Network and Polar Data Catalogue

J. Friddell[1*], P. Pulsifer[2], G. Alix[1], D. Church[1], Y. Dong[1], D. Fairbarn[1], D. Friddell[1], F. Lauritzen[1], and E. LeDrew[1]

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[2]*University of Colorado Boulder, National Snow and Ice Data Center, Boulder, USA*

Accelerated scientific discovery and an expanded understanding of our world are critical if humanity is to address and overcome the environmental and social challenges we currently face. By improving public access to Arctic data and information, the data management community seeks to facilitate advancements in research and knowledge so that people can have the information they need to make appropriate and beneficial decisions for their lives and the planet. Through activities to coordinate the Canadian polar data community, link with Arctic people and organizations, understand user needs, and improve our technical infrastructure, the Canadian Cryospheric Information Network and Polar Data Catalogue (CCIN/PDC) has been striving to improve and facilitate access to the data in our repository.

CCIN/PDC archive and serve online thousands of descriptive metadata records and millions of data files related to scientific research and monitoring in northern Canada, Antarctic, and other pan-Arctic locations. The data and information in our repository cover natural, social, and health sciences as well as economics, policy, and other fields. In recent years, CCIN/PDC have been engaged in a variety of projects and activities to understand what users need and to make the data in our archive more visible and publicly accessible. In 2015 and 2017, we hosted two Canadian Polar Data Workshops to coordinate the polar data community in Canada, develop a governance structure to facilitate our collaboration, and produce a community position paper to use in advocacy for policy and funding support to data management efforts in Canada. People are enthusiastic to work together and be inclusive of all stakeholders and rights holders in the coordination exercise, but lack of time and capacity have slowed progress, thus we are seeking options for alternate methods to support this effort.

In 2016, we conducted a survey of polar data producers and users to understand their needs for snow and ice data. Among the recommendations were expansion of the contents of the archive; improved web interfaces and access, display, and coverage of the data on our sites; and additional outreach to improve visibility of our collections and tools. On the technical side, we have made many improvements to our software infrastructure, starting with complete redesigns of both the PDC Data/Metadata Input (https://www.polardata.ca/pdcinput/, released late 2016 with new French functionality) and the PDC Geospatial Search applications to address user requests for interface and functional enhancements. Other recent improvements include conversion of our database to a new structure, membership in the World Data System, and approval as Canada's National Antarctic Data Centre.

We thank our many partners and collaborators for their involvement and contributions which make these activities and efforts possible.

S09-O08

National ground segment for Sentinel data in Norway

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The European Space Agency has developed a new series of satellites which are dedicated to specific missions. This is the Sentinels and they are focusing on the operational needs of the Copernicus programme. A number of satellites have been planned and some have been launched, producing data which can be used for both operational and scientific purposes.

The Norwegian Meteorological Institute is, on behalf of the Norwegian Space Centre, developing and implementing the National Ground Segment (NBS) for satellite data. This is initially focusing on easy access to Sentinel data for scientific and operational users. This system is fed by ESA's Collaborative Ground Segment.

NBS is targeting non-expert users as well as expert satellite users. Following this requirement, the NBS setup is designed using lessons learned in data management efforts like the International Polar Year as well as a number of national e-infrastructure projects supported by the Research Council of Norway (including e.g. the Norwegian Scientific Data Network, Norwegian Marine Data Centre and the Norwegian Satellite Earth Observation Database for Marine and Polar Research). This implies that the system is a metadata driven system following the same approach as WMO Information System and INSPIRE, but emphasising the need for semantic translations and dynamic transformation of datasets upon user request. The intention is to be able to integrate these data (and the system) with other data.

The system developed is based on a service oriented architecture where backend services for metadata and data access, visualisation and transformations of data etc are combined through a human interface based on the content management system Drupal. Transformation functionality implemented so far includes reprojection and subsetting of data using web services either integrated in the human frontend (implemented using Drupal) or used directly. Metadata indexing is done using SolR and data are served through the Open Data Protocol or THREDDS Data Servers. The latter allowing aggregation across physical files and accessing the data as data streams (read what you need of a dataset). The underlying design also supports a distributed system where datasets may be served by different physical data centres. Processing of products is done in a HPC environment relying on a Lustre file system, while user services are operated on virtual computers running in a OpenStack environment.

The first version of the system has focused on transformation of data from the native SAFE format to NetCDF. The NetCDF version is pretty close to the Climate and Forecast convention. In the process of transforming data from SAFE to NetCDF, a lossless preprocessing of data is done ensuring that all bands have the same spatial resolution using a nearest neighbour approach. A user that want data in the original resolution in each band may subset data to find the original data. The intention was to perform this transformation on the fly, but so far it has proven too CPU consuming. Thus both SAFE and NetCDF is served currently. Aggregation of products has not been implemented yet, but will be tested for Sentinel-2 data soon. For these data both spatial and temporal aggregation will be evaluated. The spatial aggregation will allow users to access data spanning parts of multiple tiles, while temporal aggregation will allow users to access time series for tiles.

S09-O09

Arctic Territory – geological data and modeling

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The emerging project *"Arctic Territory – geological data and modeling"* aims to provide a comprehensive, multidimensional and interdisciplinary overview of the unique Arctic territory in the geological, economic and political prospective with the special focus on the existing submissions to the United Nations Commission on the Limits of the Continental Shelf (CLCS) on territory beyond 200 nautical miles from the Arctic Coastal States. The first step is a synthesis of the various aspects of Arctic data, based on the open resources and the executive summaries to CLCS from the Arctic Coastal States.

The history of the deep Arctic ocean and its origin is not well known, and a unified geological model of the Arctic is missing mainly due to lack of data. The geological history and current situation remain unresolved, and discussions among scientific and political communities since the beginning of the 20th century are continuing. A systems approach and analytical synthesis of data, including data verification and mining, is needed. The intercomparison of existing geological models of the Arctic territory within a non-political, inclusive and collaborative scientific framework would provide a significant contribution towards sustainable development of the Arctic region. The initial synthesis of existing theories, identification of unified data and intercomparison of models can contribute to establishing scientific dialogue beyond disputes and disagreements.

January 16

Breakout Session

S10

Sustainable Development in the Russian Arctic:
Perspectives from Economic, Environmental and Policy Studies

S10-O01

Is their resource curse in the Russian peripheral Arctic regions?

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Regional development impacts of extractive industries have gained attention in the Arctic context. Yet, the contemporary resource curse debate that examines the linkages between resource extraction and socio-economic development is largely focusing at the national level. This paper contributes to study of resource-based regional development by exploring how the four main interpretations of resource curse ('Dutch disease'; (negative) correlation with economic growth; 'staples trap'; and political rent-seeking) can be understood at the level of an extractive region. We focus on seven Arctic peripheral regions: Murmansk Oblast', Nenetskiy AO, Komi Republic, Yamalo-Nenetskiy AO, Krasnoyarsk Krai, Sakha Republic (Yakutia), and Chukotskiy AO. We find no evidence of systematic negative association between economic growth and the added value of production in extractive industries. In addition, we examine the relationship between a range of indicators of socio-economic development and resource extraction in these seven regions. We conclude that the regions vary in the patterns of their socio-economic development, yet, we cannot attribute the differences to extractive industries alone.

S10-O02

Contested Russian Arctic: Paradoxes of path-dependency and nation-building

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My paper looks at Russia's practices and discourses concerning its Arctic futures. Different strategies defined by Russia and discourses promoted by (para)statal actors and institutions envisage that the Arctic would be turned into an energy powerhouse of the nation, as well as a transport corridor, under Russian control, linking Europe with Asia. These ambitions are scrutinized from three different disciplinary traditions: political economy, politics of identity and culture, and political ecology. With the help of different disciplinary approaches, accompanied with a spatial view looking at the immanent paradoxes of Russia's Arctic visions and practices on different scales (local, national, global), I am able to draw a more nuanced picture of the factors influencing Russia's nation-building efforts via the Arctic, and how historical path-dependencies are linked to these paradoxes. The global "Arctic Paradox", which describes the situation when the changing climate enables the exploitation of new Arctic energy resources and thereby further intensifies climate change, seems to be ignored as the world fixes an intense gaze on the Arctic mineral riches (Gritsenko 2017). The Russian 'Arctic paradox' is of less profound nature than the the global Arctic paradox, as this national paradox is linked to the fluctuating global price of oil and potentially changing ideas about Russia as a Great Power. The Russian Arctic paradox is caused by the need for Russia to be visibly present in the Arctic and along the Northern Sea Route in order to enhance its Great Power status, as well as the fact that Russia has become economically, politically and even culturally chronically dependent on hydrocarbons (Tynkkynen 2016). These factors push the Russian state to promote and finance non-viable oil projects in the Arctic and to do all in its power to influence the price of oil via its energy diplomacy and foreign policy in the global arena in order to make Arctic oil projects profitable and increase budget revenues. At the grass-roots level we see the local Arctic paradox: Hydrocarbon-based workers' towns are well maintained and even indigenous communities are 'subsidised', i.e. compensated for the economic losses produced by the industries, but the long-term economic and sociocultural strategies that reach beyond the time frame of hydrocarbon industries are missing (e.g. Henry et al. 2016). This local Arctic paradox mirrors the general paradox facing Russian society – how to prosper after oil?

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S10-O03

Participatory Rights - Interplay of Legislation and CSR in Russia

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This paper focuses on the role of participatory rights in both Russian legislation and Corporate Social Responsibility (CSR). CSR is usually defined as environmental, social and economic responsibility, which goes further than requirements in legislation. Because of global markets, there is nowadays a growing impact of international soft law standards such as ISO standards, GRI, Global Compact, Ruggie Principles even on Russian oil companies. In Russia participatory rights are weak in legislation, since companies have lobbied to diminish them. However, international standards have elements of participation, especially when it comes to indigenous people. NGOs and international investment banks require international standards to be applied and many Russian oil companies actually report applying them in their annual reports. This paper focuses on the interplay of legislation and self-regulation of oil companies in the light of three cases: oil companies in Komi Republic, Nenets Autonomous Okrug and Sahalin.

Based on our empirical research we claim that even in circumstances of limited democracy direct communication with companies operating in the area seems to be important for the local people. People want to be heard. CSR plays an important role in oil drilling areas. Based on Russian tradition CSR substitutes lacking or either too ambiguous or too declaratory legislation. We also claim that there is development towards strengthening of formal institutions such as law. When legislation is developed to be clearer and less ambiguous, it is more easily resorted to. Law can empower people, but law can also be used as a weapon to silence criticism towards the political and economic elite.

S10-O04

Russian Arctic: Indigenous Communities and Extractive Industries

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The Russian Arctic is a home to numerous indigenous nations totalling about 200.000 people. Yet, despite extensive and vast literature on Arctic studies, it is often limited to the Canadian, European and the US perspectives. In this context, the paper sheds the light on Russian indigenous communities who have been left aside from the critical revision of how the recognition of their rights is understood in country's realities.

Over the past decades the position of the Russian Arctic, due to its enormous resources shifted from a peripheral region to the region of geopolitical significance and has been announced a territory of big and courageous projects. As a result, Arctic resources are of vital importance to the country's energy security and are the driving force of the Russian economy. Under those circumstances, Russian indigenous people who live on territories rich in natural resources, are among the first to face the negative impacts of extractive industries. They are forced to leave their lands and move to the cities where they are subsequently assimilated. Indigenous territories remain polluted and traditional way of life is under threat.

On the other hand, in recent decades many Arctic states have shifted their management strategies in partnership with indigenous communities and perform advanced indigenous policy. As a result, the region has become a unique place where indigenous peoples are engaged in decision-making process together with nation-states. Indeed, Russia appears to be more willing to engage multilaterally in the Arctic than in other regions which raises a question whether the framing the Arctic as a zone of negotiation and cooperation has led to significant impacts on indigenous policy.

The aim of the paper is to analyse the relations between Russian indigenous groups and extractive industries in the Arctic and examine their role in decision-making process affecting traditional livelihood as passive observers, facilitators or triggers of change. From that perspective, the Arctic can be conceived as a potential laboratory for international collaboration and the site for meaningful engagement between the Russian government and Arctic indigenous peoples. On top of that, examination of Russia's multicultural possibilities can be conceived as a clue for the development of modern Russian indigenous studies.

With this in mind, multiple case studies and preliminary results are presented and analysed in the paper. Selection of case studies was based on different facets such as administrative status, economy of the region, competing interests, presence of foreign/international companies in the region and, status of indigenous communities.

January 16

Breakout Session

S12

Greenlandic Reflections of Global Concerns:
Ecological, Social and Political Perspectives on the Future

Environmental change and its impact on human society in Qaanaaq, northwestern Greenland

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Under the frameworks of the GRENE and ArCS Arctic research projects, we have been studying changes in glaciers, ocean and climate in the Qaanaaq region, northwestern Greenland. Our study shows rapidly changing natural environments of the Greenland's coast, and poses possible impacts of such changes on inhabitants in the region. For example, a road connecting Qaanaaq Village and Airport was destroyed in July 2015 and August 2016, which were due to floods of meltwater streams from Qaanaaq Ice Cap (Figure 1). Possibly, flood occurs more frequently in recent years because of increasing amount of ice cap meltwater as well as growing number of heavy rain events. Another example is an influence of ocean environmental change on fishery. Habitat of fish is thought to be changing under the influence of ocean warming as well as increase in freshwater and sediment discharge from glaciers.

In this contribution, we present recent changes in coastal environment in northwestern Greenland and propose possible impact of environmental change on human society. We also introduce workshop held in Qaanaaq Village in 2016 and 2017 (Figure 2). The events were organized to share our study results with local residents, and learn social and environmental changes from local knowledge. The goal of our activity is to provide the indigenous people of Qaanaaq with useful information for their better future. Accurate data and knowledge should help them to adjust their life to the changing environment.

Figure 1. The road destroyed by the flood of an outlet stream of Qaanaaq Ice Cap. Photograph taken on 3 August, 2016.

Figure 2. Workshop held at Qaanaaq Village on 23 July, 2017. Participants discuss study results of the project.

S12-O02

Intercorporeality at the Kayak Competition: Traditional Practices and the Sense of Future in Greenland

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Greenland is a place where the effects of global warming are immediate in their impact on communities. However, from an archaeological perspective, living with environmental impermanence has been a critical feature of the development of Inuit communities through time. In this paper, I consider the importance of traditional practices in mediating how Inuit communities perceive their environment and act together creatively over the long term. My discussion draws on ethnoarchaeological work with a community who build traditional kayaks and have, over the last 30 years, adapted kayak hunting skills in to a national sports competition. Although kayaking is no longer a primary means of subsistence, contemporary popularity of the practice is about more than nostalgia. Traditional kayaking involves many years of careful training to develop the requisite fitness and sensorimotor ability. By kayaking, participants attune themselves to subtleties of the Greenlandic environment that would not be apparent through any other perspective. In this context the community finds meaning in the persistence of the skill because it is an important mechanism of intergenerational experience, and because the physicality of the skill cultivates forms of cultural and environmental knowledge that can only exist through practice. The embodied dispositions and shared subjectivity generated through traditional practices such as kayaking aligns the construction of shared understandings of the future between individuals. As a heritage practice, traditional kayaking in modern Greenland contributes to defining Inuit concepts of modernity that adapt experiences and knowledge developed through generations of hunting live to the present and future.

S12-O03

Intentions about economic development by the Government of Greenland in a climate change frame

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Greenland is still a part of the Kingdom of Denmark. Since 1979 Greenland has had home rule and in 2009 extended home rule was introduced. Since the beginning of home rule Greenland has had full authority of its public economy in areas taken over by the home rule.

Greenland receives an annual block grant from the Danish state at around 3 billion Danish kroners. There is a political consensus about aiming at becoming economically more independent from Denmark. It is acknowledged that only though a higher degree of economical independency Greenland can strive towards more political independency.

The government wishes to base the public economy on incomes from utilizing renewable and non-renewable resources. The political intension is to have the economy based on fisheries, mineral extraction and tourism. So far it is mainly fisheries that contribute to the public economy. At the same there is a strong political focus on ensuring a balanced development between the regions in Greenland.

The paper will discuss and analyze the continuity and changes in the priorities during the last decade of shifting governments. One of the aspects to be covered is to what extent and how climate change has been taken into account in the intentions about economic development by the Government of Greenland.

S12-O04

Climate Change and Transformations in the Security Environment

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The goal of this presentation is to consider the correlation between climate change and the changes in the security environment by taking the inclusion of the US air base in Thule, Greenland in the US missile defense shield in the 2000s as a study case.

On 17 December 2002 Denmark received an official request from Washington D.C. to approve the upgrade of the Thule air base in the Danish territory of Greenland to a missile defense outpost. Denmark opted to postpone the decision on the incorporation of the base in the US missile defense shield, while Greenland, which was directly affected, expressed strong opposition to the inclusion of its territory into the missile defense area. However, later, on 6 August 2004 Greenland signed a comprehensive military agreement called the Igaliku Agreement. By doing so it accepted, to a certain extent, the incorporation of the Thule base into the US missile defense plans. Preceding the Igaliku Agreement, on 14 May 2003 Greenland acquired the right to have a say in matters of own security and defense (Itilleq declaration), and was thus able to act as an autonomous entity and stand shoulder to shoulder with Denmark as one of the signatories of the agreement. The reason Greenland consented to the Igaliku Agreement is that, thanks to the 2003 Itilleq Declaration, it was able to have its views reflected in the agreement.

This presentation seeks to empirically trace the process leading up to Greenland's consent by relying on parliamentary minutes. Our interest lies especially in the process in which Greenland, as a sub-state actor, strengthened its de jure involvement in the field of security through debates on the missile deployment in the 2000s, with *recent changes in the natural environment, i.e., the climate change as a prerequisite*. Such involvement of sub-state actors in affairs that are usually exclusive prerogatives of the state may be a latent factor affecting change in the security conditions in the Arctic region.

January 16

Breakout Session

S14

Synthesizing Local Interactions between Permafrost and Human Societies

S14-O01

Melioration in the Permafrost Environment: History and Modernity

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The climate of Central Yakutia is featured by its sharp continentality, with large annual temperature fluctuations and a relatively small amount of precipitation. The climatology data gives the average annual quantity of the latter of only 200 to 250 mm, which gives grounds to relate the region to the steppe and semi-desert zones. Most affected by the arid climate are the so-called river uluses (districts) of the Sakha Republic (Yakutia): Amghinsky, Megino-Kangalassky, Tattinsky, Ust-Aldansky and Churapchinsky, the area of the traditional settlement of the Yakut people and the development of the agriculture of the Republic.

The Sakha-Yakuts, having managed to adapt to the extreme natural and climate conditions of the North and to build up an effectively productive cattle-breeding, developed their own system of land and water exploitation in the permafrost environment. They have performed the firth irrigation of alas and small-valley meadows, drainage of excessively moist land through the removal of surface waters and artificial drainage (discharge) of thermokarst lakes to form lasting and sustainable meadow lands on their dried bottoms. The procedures were especially active in the 19th century, with the growing aggravation of the land issue in Yakutia. Then, by the orders of the Siberian and Yakutian governors, active work was carried out to drain the lakes, to increase forage lands. Some ulus heads also built on the initiative.

When the collectivization began in the 1930s, a number of attempts were made to conduct the first irrigation in the district. However, the implementation of the 1939-1941 plans to move the Amga River waters into the Tatta River to water nearby areas, was stopped by the Second World War. Unable to cope with the consequences of the worst drought of 1941-1942, the republican leadership decided to move the residents of the most affected Churapcha district to the North. However, made without proper preparation, by purely administrative methods, the resettlement has resulted in thousands of victims, and has become, since then, an unhealed suffering in the historical memory of the Churapcha people.

Now, the population of the Churapchinsky ulus is still in great need of proper water supplies. According to experts' opinion, the actual level of water consumption here is ten or more times lower than in other uluses (districts) of the Republic. Since the 1960s, the planned systematic melioration, mainly irrigation, have been done in the area. On June 16, 1992, the President of the Sakha Republic (Yakutia) issued a decree on the construction of water conduits to supply water to the district. The first main water line from the Lena River to the Myuryu Lake was completed in September 1996. In September 2001, the Lena River - Tuora Kyuel'Lake - Taatta River water line was put into operation. The total length of the both main water lines is 223 km. According to the project, the volume of water pumping every summer through the Lena River - Tuora Kyuel'Lake water line, where we made our field research in 2016–2017, shall be 20 million m^3. However, these water lines have not yet reached their full capacity.

The further comprehensive and objective analysis of the reasons for the insufficient water supply is needed to advance the ulus melioration programs.

S14-O02

Thermokarst activating in the recent decades in central Yakutia, Russia

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The central Lena River basin (central Yakutia: CY) in eastern Siberia is facing extensive landscape changes with thermokarst formation in conjunction with deepening acitive layer of continuous ice-rich permafrost. Water body within the thermokarst depression has monotoniously developed in more than 70 years and particularly active in the last 25-30 years [1]. Dealing with predicted increase in precipitations and temperatures due to climate change requires quantitative knowledge about the spatial distribution of thermokarst and these developments for sustainable land use by local residents [2]. The present study conducted field observations to detect thermokarst developments using small unmanned aerial vehicles (UAVs) and structure-from-motion multi-view stereo (SfM-MVS) photogrammetry in abandoned farm lands (~6 ha) in Churapcha in CY. We obtained ortho-rectified photographs and digital surface models with spatial resolutions with 0.05 m and 0.10 m, respectively. Based on the GIS analyses of the photogrammetry images, more than 600 high-center polygons were developed after 1990s with averaged diameters and areas 8.2 m and 45.1 m^2, respectively. These high-definition data showed the detailed thermokarst development to compare with land use history in this region.

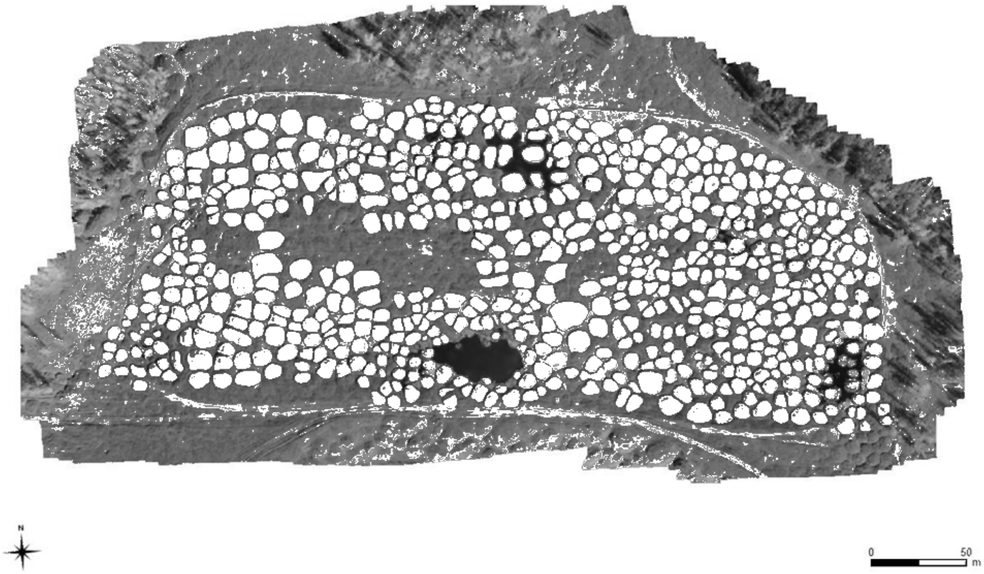

Figure 1. Distribution of high-centered Polygon in abandoned agricultural field, Churapcha

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Interaction of social and natural factors in economic activities of contemporary Sakha farmers

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In this presentation, social arrangement of farm management in the Republic of Sakha (Yakutia) is investigated comparing two cases in different areas in Sakha. One is on the right bank of the Lena in Churapcha ulus, under which is spread thick permafrost layer, and where is suffering from conspicuous thermokarst depression in recent years. The other one is on another side of the Lena, Gornyi ulus, which is lack of permafrost layer and of little thermokarst depression. Comparing the cases of these two areas, we will investigate how the natural and social factors influence the economic activities of farm management of Sakha farmers.

In a few years after the Soviet Union fell, the former state-operated farms as Sovkhoz were dissolved in Sakha. The farm management was brought from under the state control to the sphere of personal tactics. At present, there are two types of farm management. One is the farmers' management, masters of which should register the management to the government, and get the right to receive not only social securities as pension, but also some privileges as subsidies and grants-in-aid, as well as some obligations as audit and payment of taxes. The other type of farm management is the individual household management. The operators of this type can evade the obligations, but in exchange for it, they have to manage without any governmental support. And, which type of farm management to choose is left to the judgement of each person.

Meanwhile, there are some in-between organizations as consumers' cooperative societies and farmers' associations. Each individual farmer has some relations with these in-between organizations. Thus, it is only simplistic to point a transition from socialistic planned economy to capitalistic market economy. Even after the agents of farm management were transferred from state to individuals, each factor of state and individual, organization and market are entangled with each other intricately, and the constellations of each factor are ever changing. Social arrangement of farm management is different in one place from another, thus it should be grasped taking both cultural and natural factors into consideration.

Social Consequences of Changing Permafrost in Yakutia: Gendered Challenges in Churapchinsky region

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This paper presents some results of scientific survey on gender aspects of permafrost changes consequences in Yakutia. Social challenges of regional climatic changes are attracting growing attention [1,2]. On the basis of field materials perception and behavior patterns of rural population during the deformation of habitual habitat had observed. The object of the study is the population of the Churapchinsky region. This region is one of the leading agricultural areas in Yakutia, where the traditional farming is conducting. The economic way of life engaged mainly in horse breeding and cattle breeding, presuppose various models of the life path for rural men and women. Here the Sakha are the ethnic majority, this fact and the preservation of local patriarchal traditions create interesting adaptation model for permafrost' changes.

In Churapchinsky region the ratio of the sexes in the population structure is quite favorable: 49% of men and 51% of women. And we noted that despite the priority of "male professions" (horse breeders and pastoralists) in the local economy, the social roles of women have wide varieties. Social roles that women perform in small rural settlements largely ensure their social stability and contribute to their further development. In the conditions of climate change and permafrost degradation in Central Yakutia, the reaction and experience of further adaptation of rural residents can be interesting for anthropologists. Studies revealing the gendered functions that men and women perform in small rural communities of Churapchinsky region of Yakutia will allow us to more consider the entire range of social challenges faced by the indigenous population of the Arctic.

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S14-O05

Permafrost and Poverty: the Social Effects of Climate Change in the Republic of Sakha (Yakutia)

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In this paper I discuss the topic of climatically conditioned changes in the environment which significantly worsen conditions and quality of life in rural communities of the Republic of Sakha, including 65.3% of the Yakuts who live in rural settlements.

Data from field research in Central Yakutia (2016) confirm that most sensitive to climate change are rural landscapes which are currently experiencing double pressure, anthropogenic and natural. Anthropogenic changes in the environment are associated with the policy of forced sedentarization in the 1930s. "Poselkovanie" (literally "putting in settlements") had as its goal to break the system of dispersed settlement of the Yakuts which was determined by the location of alaases - meadow lands with a source of drinking water. "Alaas" is a natural biotope typical for the plains of Yakutia, the basis for traditional economy - settled cattle breeding and pastoral horse breeding. In the first Yakut villages the construction of residential houses, collective farm offices, schools, hospitals, clubs and livestock farms began. Along with the policy of consolidating collective farms and their transformation into state farms, concentration of people and animals, of machinery and transport and diversification of agricultural production continued. Their consequences gradually became apparent: these are reduction of forest area, decrease in the productivity of meadows, deterioration in the state of water bodies, depletion of soil, a growing number of household waste dumps, etc.

At the present time, natural and climatic changes are added to the anthropogenic changes in rural landscapes, in connection with which the rural area of Yakutia is increasingly perceived as an unsafe environment for human life. This thesis is considered on the example of the village of Churapcha, the administrative center of the Churapchinskiy ulus with a typical agrarian economy and monoethnic population (97% – Sakha). Deep interviews with key informants (young villagers) make it possible to assert that permafrost melting contributes to the impoverishment of people and gradually leads to "climatic poverty" of the most vulnerable groups of the local population. It should be noted that intra-district migration, which increased after the collapse of state farms in the 1990s, led to a significant overpopulation in the village of Churapcha. Today, 46.4% of the population of this district live here, therefore the previous scheme of the resettlement of villagers is changing. Shortage of available land for the construction of residential buildings is filled at the expense of former state farm arables and the airport site which are not suitable for construction as it is precisely on such plots (deforestation, plowing and land reclamation) that the greatest subsidence of the soil occurs and consequently there is a high risk of damage to residential buildings. As a rule, such plots are allocated to young families who are forced to pay mortgage to the bank and almost annually incur burdensome financial and material costs for the purchase, delivery and backfilling of sand, clay and soil to strengthen the foundation of their homes. As a result, poverty is mainly localized in young families with a high proportion of children and minimal incomes, which also negatively affects their health and life. The inequality of rural households provoked by the instability of modern cryogenic processes requires attention from the state and society.

January 16

Breakout Session

G9

Social and Cultural Dimensions

G09-O01

Not-Quiteness of the Horse for the Tyva Herders

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The concept of not-quiteness reflects a multiplicity of meanings of the horse for Tyva herders, for whom the not-quiteness of the horse is explained by its simultaneous closeness to the wilderness and humans [1]. According to herders, the not-quite-livestock position distinguishes horses from other livestock. Horses are 'livestock of the land' in contrary to the cows, sheep and goats that are considered to be 'livestock of the encampment.' This position gives horses—alongside with reindeers and yaks—the autonomy which is uncharacteristic for other types of livestock. Because of the horses' proximity to humans, Tyva herders take on individual relationships with horses in ways they do not with other animals; the herders understand horses to share in an ethical and moral world with humans. A complexity of distinguishing features defines interspecies relationships, including circumstances of the horse's life and death.

Figure 1. Tyva and Kazakh families conduct a ritual of the first milking of mares in summer in Western Mongolia.

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G09-O02

Knowing Salmon: An Ethnography of Knowledge Co-production in Alaska

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Decline of Chinook Salmon (*Oncorhynchus tshawytscha*) since around 2010 has been a serious biocultural issue in rural part of Alaska where wild fish, birds and animals are important food sources. Among many harvested species, salmon is considered as one of the most valued one. It plays a crucial role not only in Native Alaskan groups whose traditional territories include the Pacific drainage areas, but also generally in indigenous societies of North Pacific Rim region. Salmon is what anthropologists Benedict Columbi and James Brooks call *cultural keystone species* [1]. Recognizing the urgency and significance of the issue, local indigenous groups such as Athbascan and Yup'ik peoples have worked with State natural resource managers to find ways to co-manage the salmon, while they have also protested against what they would consider as an unnecessary and unjustifiable non-Native encroachment in the form of subsistence fishing regulations.

Following the ongoing discussions on the relationship between indigenous and scientific knowledge practices [2], this paper deals with the (in)commensurability of knowledge systems as well as the politics of knowledge in the encounter of multiple groups through analyzing the example of salmon management efforts along the Kuskokwim River. My research questions are: (a) What happens when co-management regimes involve multiple indigenous groups that may or may not agree with each other? (b) How are social scientists implicated in such processes of co-management? (c) What are the responsibility and possible contribution by social scientists to environmental issues such as the decline of Chinook Salmon in Alaska?

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Why do Khanty Choose to Wear Fur? : Fur-Wearing Culture and Use of Wild/Domesticated Animals

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This paper examines the reasons why the Northern Khanty, who live in the Taiga area of Western Siberia, choose to wear fur. Today, there are various alternatives to fur, with warm clothes made of synthetic materials available that are suitable for even the coldest climates, including Northern Siberia. Although many Northern peoples of Siberia choose clothes manufactured from synthetic materials over fur, indigenous groups, especially those that inhabit Western Siberia favor fur in everyday life in winter. Although there have been many ethnographical studies of fur clothes worn by the Khanty, these studies have focused on ornamentation of the clothes or sewing techniques used in making the clothes. The underlying reasons why people peal the pelt from animals and use the fur in garments have not been discussed. This paper focuses on cultural reasons for the wearing of fur by the Khanty. It considers differences in attitudes to various living animals and the furs obtained from hunting or breeding and what this means in their life-world. Anthropological fieldwork was conducted in the Khanty-Mansi autonomous region from 2011 to 2012 and in the Yamal-Nenets autonomous region in March and September 2016 to shed light on human–animal relationships, including fur dressing and attitudes to animals. First, the study situates fur use within a subsistence complex and gender division of work. Second, it discusses the aesthetics of reindeer fur and discuss the attitudes of individuals to particular types of reindeer fur. Third, it considers similarities and differences attributed to the values toward particular sacred animals and their furs. The study revealed three major reasons why the Northern Khanty people choose to wear fur, which are not only for the function of protection against cold. First, making and wearing of fur clothes are habits that are embedded in the Khanty's subsistence complex, gender division of work, and local exchange of furs. Second, they find aesthetic pleasure in the strong contrast afforded by the color (black and white) of the fur Third, they believe that the animal remains sacred, even after it has been killed and used for its fur. The contradiction of wearing fur from a sacred beast is overcome by not utilizing fur from only specific parts of the animal [1].

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G09-O04

Sound relationship between wildlife and local people - a case study of wild reindeer conservation in East Siberia-

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In the Arctic region of East Siberia, rapid changes in avian and mammalian faunas have occurred in the past 30 years. Under the global warming condition, many southern species have gone up to the Arctic Circle and new prey-predator relationships have appeared. In addition, habitat selections of migratory or wandering species such as reindeer and polar bears have been destabilised, therefore serious conflicts in indigenous peoples have also increased. Under such circumstances, we began satellite tracking of wild reindeer, and now try to make an adaptive wildlife reserve system with indigenous people.

Yearly procedure is as below; 1. Monitoring wild reindeer by satellite tracking. 2. Tracking data are shared by scientists, representatives of indigenous peoples, hunters, local managers and local government(s).3. Collecting observation data from local indigenous peoples settlements and hunters. 4. Confirmation of wintering range and birthing range. 5. Decision making for reserve range and surrounding hunting range. 6. Summing up of hunting data and evaluation of the system by using of tracking data. Result and Discussion For monitoring, about 30 wild reindeer (*Rangifer tarandus*) were tracked (Argos/Argos, GPS/Argos) in Olenek district of the Republic of Sakha (Yakutia). They migrated in other ways every year, so we defined their birthing grounds and wintering grounds every year.

Our results are as follows; 1) Habitat use: Tracked wild reindeer used only vegetation types with reindeer lichen. 2) Migration and Wintering ranges: All collared reindeer used middle Olenek river area as their summer range, and two contrastive areas as wintering ranges. This means that two sub-populations; a northbound migration group (NMG) and a southbound migration group (SMG) are using same summer range. Although SMG finished their migration for about 500 km, migration of NMG keeps on traveling for over 800 km. 3) Shift in migration range: In 1980s-1990s, this population used only northern area (Safronov et al. 1999). But in these two decades, they have shifted their migration routes. In the north part of this area, ROS (rain on snow) phenomena and the northern up-coming of shrub tree species are already observed in these years. This shift might be caused by lowering of the usefulness of the northern part of this area where is suffered by these global warming induced environmental changes. 4) Problems in their conservation: This population needs genetic analysis, because wintering range of SMG is forested area which is distribution range of another subspecies, forest reindeer (*R. t. fenicus*?) and there also are semi-domesticated reindeer in this area. So, this should be conservation tri-lemma in this overlapping area of three types of reindeer. And more, this migration range shift brought several serious conflicts with local ecosystem and local people (foraging pressure on endangered flora, attraction of carnivore species, mass abduction of and food competition with semi-domesticated reindeer). These may be accumulative effects of the global warming on local ecosystem and local society.

Post-Soviet Population Dynamics
In the Russian Extreme North: A Case of Chukotka

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The purpose of the study is to investigate the situation that emerged in the Extreme North regions as a result of the state policy of the Soviet period, using the example of the demographic trends in the Chukotka as one of the most distal Russian territories with respect to the center of Russia. Previous studies that treated economic factors as the cause of migrant inflow to some region or unfavorable natural conditions as the cause of out-migration of population in a certain region had no purpose of analyzing a separate territory. So, it was impossible to imagine what goes on in a specific territory based on these studies and the peculiarities of each specific region require additional examination. These very tasks were the main target of the given work.

The authors examined the factors affecting the formation and abandonment of urban settlements in the territory. Summing up the examination conducted in the Chukotka, all cases of liquidation of "died-out" urban settlements are united by several common factors. First of all, each was created based on mining enterprises for the production of gold, tin, tungsten, etc. and each also had weak transportation infrastructure. Besides, it should also be noted that all liquidations of settlements occurred before the year 2000, whereupon no further cases of abolishment or change of settlement status were observed. Overall population itself decreased from 164 thousands to 54 thousands in 13 years from 1989 to 2002, but since then Chukotka lost 3 thousands population only in these 14 years until 2016. These figures clearly show that the demographic situation in Chukotka has almost stabilized.

The period of sharp crisis following the economic transition has ended. Even so, it seems the issue of changing migration flows adversely into the Extreme North or aiming to establish a production base in the region cannot be appropriate tasks. As claimed by Hill and Gaddy (2003), the burden of sustaining the social base of remote regions was an eternal "curse" of the former Soviet Union. Today's Chukotka may be an outstanding example of how to overcome this "curse" and solve the dire problems realistically. The experience of Chukotka is an excellent example for interpreting the errors made by the governmental policy for resource development in harsh climatic and natural conditions of remote northern regions.

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G09-O07

Place Names, Landscapes, and Ways of Living from Local Perspectives in *Nanvarpak* (Iliamna Lake), Alaska

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This paper will focus on Central Yup'ik *Nanvarpak* (Iliamna Lake) place naming practices, how the Central Yup'ik people have observed and shared their geographic information in the Iliamna Lake area of southwest Alaska. Building on the rapport I established during previous fieldwork, I conducted oral history fieldwork using a community-based participatory approach in five Iliamna Lake communities in 2016 and 2017. Some residents recognized during the study that many places have multiple names based on several local perspectives. One impact of developing an understanding of local Yup'ik place names is that it can be a tool for local residents to recognize changes in their landscape so they may travel safely to harvest natural resources such as fish, caribou, moose, and berries.

A goal of the project is for communities to maintain the place name data and to pass on their practices for the future generations. Using and maintaining local and Indigenous place names might be a tool for Indigenous people to sustain their ways of living, their languages, and their local ecological systems in a changing environment.

G09-O08

Arctic Research based on Bibliometric Analysis

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Arctic research and development is one of the perspective topics in science in the world as well as in Russia [1]. In this regard the public activity of the global scientific society is presented in this paper. The bibliometric analysis method is used based on data of SciVerse Scopus (SCOPUS) with 10-years period (2007-2016). For the analysis, firstly, main areas in the field of Arctic research were determinated (for example environmental monitoring, permafrost dynamics, exploration of the resources, indigenous people and others). Secondly, key words for these areas were formulated (for request in database). Thirdly, filters of request were indicated. In the result, the following indexes have been analyzed: total number of publications for 10 years; 10-years dynamic; ranking of the countries in public activity (Fig. 1 and Fig. 2. show the results with the examples of two areas of research). The most perspective areas of research and the most active countries were found and classified according to the approach, proposed by [2].
Acknowledgement: the research is partly supported by Russian Geographic Society.

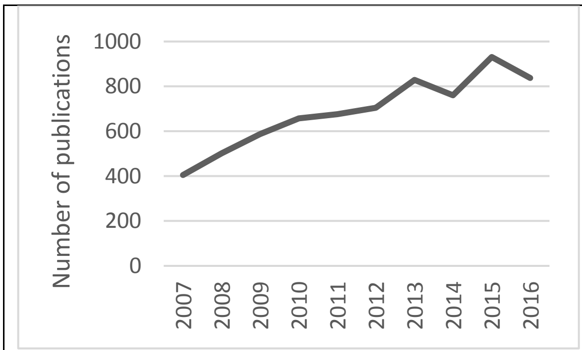

Figure 1. Monitoring of natural hazards (countries-leaders: USA, Canada, China)

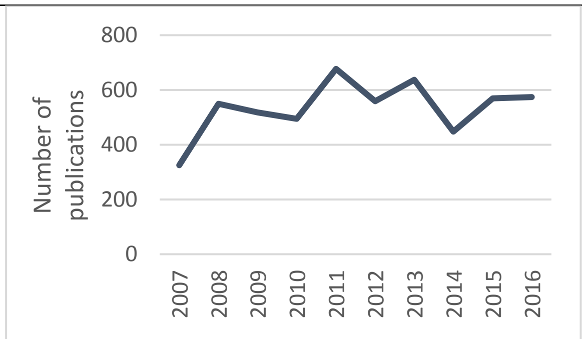

Figure 2. Marine exploration of resources (countries-leaders: USA, Norway, Canada)

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January 17 2018

Keynote
Session presentation

Remoteness and Infrastructure: On the Affordances of the Built Environment in Polar Regions

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Public and academic discourses about the Polar regions typically focus on the so-called natural environment, the threats it faces and the values attached to it. While these discourses and inquiries continue to be relevant, the focus of this presentation is on the affordances of the built environment and infrastructure in polar regions. This means to focus on the opportunities and constraints emerging from interactions between people and infrastructure. At the same time, it requires to take the ongoing industrial and infrastructural buildup of the Arctic seriously. Acknowledging that the "built environment" is not an invention of modernity, this presentation focuses on large-scale infrastructural projects of the 20th century, which marks a watershed of industrial and infrastructural development in the North. During the 20th century, the Soviet Union was at the vanguard of these developments. Thus, a large part of this presentation is devoted to a discussion of Soviet and Russian large-scale projects, without ignoring developments elsewhere in the circumpolar North. The main focus within the broad realm of the built environment is on information and transportation infrastructures, the latter being represented by case studies of the Baikal-Amur Mainline (BAM) and the Northern Sea Route. The concluding section will argue for increased attention to the interactions between humans and the built environment, serving as a kind of programmatic call for more anthropological attention to infrastructure and the built environment not only in arctic regions but in Antarctica as well.

The Arctic in Transition: Status and Trends in Biological Oceanography in the Changing Marine Ecosystem

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The Arctic Ocean complex, extending from its extensive continental shelf seas to the deep basins, is experiencing rapid changes in sea ice extent and duration, warming seawater conditions, and changes in the phenology (or timing) of biological processes. The inflow shelves, such as the northern Bering and Chukchi Seas in the Pacific Arctic are shallow (<100m), seasonally productive waters that experience strong pelagic-benthic coupling of organic matter to the sea floor, but that coupling varies in intensity. By comparison, the deeper (average 200 m) Barents Sea in the Atlantic Arctic is also experiencing environmental change, with earlier retreat of sea ice retreat, but compared with the North American Arctic has seen increased migration of commercial fishes into more northern waters. The inner shelves of the Arctic, such as the Beaufort and Laptev seas, are also influenced by reduced sea ice coverage and freshwater inflow, with impacts on shelf and slope biological processes. The reduction of sea ice seasonally into the Arctic Basin has stimulated upwelling events during wind events, so shelf-basin exchange processes may become even more critical in connecting the high Arctic ecosystem to lower latitudes. Appropriate shipboard field measurements and observations throughout the food chain and associated physical-chemical parameters provide essential, seasonal insights of the marine ecosystem, both in observational and process modes. Continuous measurements using chemical and biological sensors on stationary moorings are also providing year-round time series observations of chlorophyll, nutrients, carbon cycling, zooplankton, fish and marine mammals that provide connectivity to shipboard observations. Similarly, the use of autonomous gliders and saildrones with biochemical sensors are providing high-resolution measurements during the open water, productive season. Satellite observations and field video collections via drop cameras and remotely operated vehicles are also providing insights on the undersea world of the opening Arctic system. I will provide highlights of the current status and trends in biological studies in the Arctic through case studies that are broadening our understanding of the timing and extent of key biological processes. The variable ecosystem response is critical to understanding the changing marine ecosystem of the Arctic.

Analyzing long-term growth trends of tree and forest biomass in the circumpolar boreal region

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Boreal forests are likely to be strongly affected by global environmental changes with factors such as increase in air temperature, drought intensity and frequency, atmospheric CO_2 level etc. [1]. Therefore, they are considered to be more vulnerable than temperate and tropical ecosystems. However, assessing the potential impact of climate change in the boreal region requires long-term data, which are relatively rare and limited in geographical scope. In many parts of the circumpolar boreal region, we often lack empirical information on stand development in the past and studies on long-term changes of forest structure have been few. It is also emphasized that history of stand level changes of aboveground biomass over decades in the arctic region has never been examined due to lack of appropriate data. Meanwhile, the stand reconstruction algorithm of [2], which utilizes information of present stand structure (*DBH*, tree height *H*), and detailed data of tree rings from selected sample trees has enable to estimate stands structure in the past and their annual changes (i.e. stand biomass, annual growth, and stand density) during their development. Thus, in this study such stand reconstruction technique was used to estimate the past development of several stands in the boreal region (Scandinavia, Alaska, and Canada). To identify and describe the growth pattern that the stands have been following over the years including growth shifts events, values of the reconstructed development of aboveground biomass were analyzed with the *s*-*w* diagram (a kind of phase diagram). Trends observed in the *s*-*w* diagram showed presence of abrupts shifts of a growth curve to another growth curve, which represent changes in growth patterns of the stands at sudden and dicret time. At the same time, it is generally observed that the parameters of the growth curves were fixed for several decades while the growth followed one curve. Growth-shifts have been detected in all studied plots and nearly at the same time especially around the late 1970s. It coincides to the shift from a cooling temperatture to a more warmer temperature that has continued untill today. This suggests that the boreal have changed their growth patterns in unison in the past century in response to changes in climate. The *s*-*w* diagram represents a growth curve that is biologically more meaningful than those traditionally being used to express growth trends in dendrochronology and allows a more ecologically tractable understanding of growth processes and provides a useful tool for growth analysis.

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Forever cyclonic? How stable is the circulation of Atlantic Water in the Arctic Ocean?

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The circulation of the sea ice and the Polar mixed layer in the Arctic Ocean is dominated by two large-scale circulation systems: the basin-size Beaufort Gyre, which rotates anti-cyclonically in the western Arctic; and the Transpolar Drift, which carries sea ice and surface water from the Siberian shelves to Fram Strait, but also feeds into the Beaufort Gyre. This circulation system is known to change its intensity and exact positioning on seasonal to pentadal timescales. Below the Polar mixed layer and the halocline, the so called 'Atlantic Water layer' is fed by water of Atlantic origin which enters through Fram Strait and the Barents Sea. Based on observations from the 1980s and 1990s this water is understood to move as a boundary current along the slopes of the Arctic Ocean basins. Eventually, after leaving the Arctic Ocean proper, the surface water, the water from the halocline and the water from the Atlantic Water layer, feed into the Meridional Overturning loop in the North Atlantic. This is one important aspect why understanding the dynamics, which govern the modifications of the outflows by processes internal in the Arctic, is important.

Model results, validated by using the radioisotope I^{129} as a tracer for Atlantic derived water, indicate that this predominantly cyclonic circulation pattern may be subject to change. In particular, these model results suggest a change of circulation in the Amerasian Basin. Starting from 2005, the boundary current, which supplies water of Atlantic origin from the Eurasian Basin via the Makaraov basin, to the Canadian Basin and the Beaufort Sea, starts fading and ceases completely after a few years.

In our study we make use of the recently compiled Unified Database for Arctic and Subarctic Hydrography (UDASH), to investigate indications for such changes in the circulation of the Beaufort Sea. In particular comparing the periods 1999-2003, 2004 to 2008, and 2009 to 2015, we find drastic changes in the potential density fields between the first period and the two later ones. These changes indicate a reduced density gradient between the interior and the slope of the Beaufort Sea, a flattening of the geopotential height field. We conclude submit that the changes of the Beaufort Gyre at the surface, in connection with the increase of its freshwater content and a steepening and deepening of the halocline, are responsible for the decoupling of the Atlantic Water Layer between the basins.

Ground-based instruments of the PWING project to investigate dynamics of the inner magnetosphere at subauroral latitudes

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The plasmas (electrons and ions) in the inner magnetosphere have wide energy ranges from electron volts to mega-electron volts (MeV). These plasmas rotate around the Earth longitudinally due to gradient and curvature of the geomagnetic field with time scales of several hours to several tens of minutes. They interact with plasma waves at frequencies of mHz to kHz mainly in the equatorial plane of the magnetosphere, obtain energies up to MeV, and are lost into the ionosphere. In order to provide global distribution and quantitative evaluation of the dynamical variation of these plasmas and waves in the inner magnetosphere, the PWING Project (study of dynamical variation of Particles and Waves in the INner magnetosphere using Ground-based network observations, http://www.isee.nagoya-u.ac.jp/dimr/PWING/) has been carried out since April 2016 with the support by a Grant-in-Aid for Specially Promoted Research of the Japan Society for the Promotion of Science (JSPS). This paper describes the stations and instrumentation of the PWING project. We operate all-sky airglow/aurora imagers, 64-Hz sampling induction magnetometers, 40-kHz sampling loop antennas, and 64-Hz sampling riometers at 8 stations at subauroral latitudes (~60^{o} geomagnetic latitude (MLAT)) around the north geomagnetic pole, as well as 100-Hz sampling EMCCD cameras at three stations. These stations are distributed longitudinally in Canada, Iceland, Finland, Russia, and Alaska to obtain the longitudinal distribution of plasmas and waves in the inner magnetosphere. This PWING longitudinal network has been developed as a part of the ERG (Arase)-ground coordinated observation network. The ERG (Arase) satellite was launched on December 20, 2016, and has been in full operation since March 2017. We combine these ground network observations with the ERG (Arase) satellite and global modeling studies. These comprehensive datasets contribute to the investigation of dynamical variation of particles and waves in the inner magnetosphere, which is one of the most important research topics in recent space physics and the outcome of our research improves safe and secure use of geospace around the Earth. This presentation is based on Shiokawa et al. (2017).

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Attribution of Trends of Seasonal Temperatures in Alaska

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Alaska has warmed more than most regions over the past several decades, with the strongest warming in winter and spring. Alaska has also experienced extreme seasonal temperatures in the post-2000 period, including its two hottest summers, the warmest autumn and the three warmest winters, of which 2015-16 was the warmest of all. In an attribution study intended to determine the reasons for this warming, we have used an automated analog methodology to evaluate the contribution of the atmospheric circulation to the seasonal temperature trends and extremes. The atmospheric circulation explains more than half the interannual variance of the cold-season temperatures, largely through the intensity and location of the Aleutian low. Over the 1949-2017 period, the portion of the temperature anomaly that is not explained by the large-scale circulations shows a systematic trend, manifest as an increase of “excess warmth” relative to the circulation-analog-derived temperatures. The trend in the “excess warmth” corresponds to a warming of 2.1°C in winter and spring, 1.3°C in summer and 0.5°C in autumn. This trend in excess warmth, which is close to the trend simulated by global climate models run with historical and projected greenhouse gas concentrations for the same period, accounts for 55% of the Alaska’s winter warming and 68% of the Alaska’s annual mean warming over the 1950-2017 period. We conclude that more than half of the post-1949 warming in Alaska is attributable to anthropogenic forcing, and that recent record warmth of individual seasons is attributable to a combination of internal variability and anthropogenic forcing.

SP2-S12

Seeking a future vision by negotiating environmental changes in North Greenland

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In North Greenland, local residents have borne witness to recent unusual climatic variability and weather patterns, which affect local residents' livelihoods in many ways. Although local changes are substantial, hunters are tenacious and cope through acute observation of the shifting landscapes, reference to past experience, environmental understandings that they acquired through livelihood, and by constantly adjusting hunting strategies and techniques. Hunters are also substantially impacted by the system of quotas that the government sets throughout Greenland to manage various species of birds and mammals. The specifics of quotas are meant to be adjusted to take into account regional ecological variations, but these may not actually conform to a particular area's ecological situation. These regulations, I shall demonstrate, can risk alienating local hunters from their land and sea. This paper discusses the significance of the relationship to the environment in how Inuit communities in North Greenland envisage a clear future vision of their life.

Weaving techniques in subarctic areas: Their prosperity and decline in Northeast Asia

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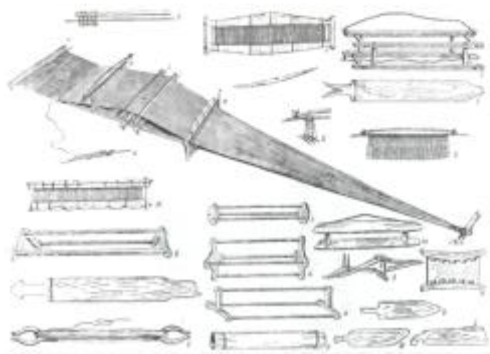
In this report, I discuss the social and technological factors of the maintenance and protection of the original weaving techniques, skills, and tools of the Ainu people, comparing the cases of other indigenous peoples in Northeast Asia.

It is not widely known that the indigenous peoples in Siberia and Northeast Asia (including the Russian Far East, northeastern regions of China, and the northern part of Japan) had their own original weaving techniques and textiles. Although these people tend to purchase rather than make various textile products today, many people imagine that fundamentally they have worn animal skin, fur, and leather since the ethnographic age (the end of the nineteenth century and the beginning of the twentieth century). However, some of them did have original textile clothing and products made by their own materials, tools, and techniques. Examples are ethnic groups such as the Khanty, Mansi, Siberian Tatars, Buriyats, Nanai, and Ainu [1]. When we expand this perspective further to the historic and prehistoric ages, we can find some archeological evidence that indicates that the Neolithic people in Russian Primor'e, Hokkaido, Kuril Islands, and Kamchatka made various textile products of a twined weave structure, and some of the literature also indicates that the Ainu people exported their bark fiber clothes to Japan, the Kuril Islands and even Kamchatka. Obviously, original textile products were widely seen among the people in the subarctic areas in the pre-historic, historic, and ethnographic ages. However, in the present day, only the Ainu retain their tools, techniques and skills, and recognize them as one of the core cultural items that support their ethnic identity. Why did other people lose their original textile culture? Why and how could the Ainu people maintain it?

I have two hypotheses. One is from the technological viewpoint. The Ainu devised several types of looms for making different types of textiles such as that of twined weaving structure and plain structure. Their mechanism and craftswomen's skill were so highly suitable for weaving natural fibers from bark and grass that they were not replaced by modern technology. The other hypothesis is from a social and economic viewpoint. Since at least the eighteenth century, bark fiber clothing called *attus* were exported to Japan, the Kuril Islands, and Kamchatka. Japanese fishermen and sailors loved *attus* jackets for their work wear. Some literature indicates that Ainu craftswomen enthusiastically made this type of clothing to fulfill the demand from Japanese consumers in the mid nineteenth century. Although the demand quickly declined at the end of that century, it can be assumed that such experience contributed to the maintenance of the techniques and skills.



Ainu loom for plain weaving (MAE collection No. 839-184) [1]

Analyzing the literature and museum collections, I discuss these issues and examine the hypotheses.

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Arctic Policies and Economy – a German perspective

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Though not an Arctic nation, Germany operates one of the world's largest Arctic research programs, mainly through the national polar institute, the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI), but also through various other national institutes and authorities as well as through a number of universities. Germany´s strategic approach to Arctic research "Rapid Climate Change in the Arctic - Polar Research as a Global Responsibility" was published by the Federal Ministry of Education and Research in 2015 [1].

Germany is an observer in the Arctic Council, the leading intergovernmental forum for the Arctic that particularly addresses issues of sustainable development and environmental protection. In 2013, the Federal Foreign Office, representing Germany in this political forum, published the "Guidelines of the German Arctic Policy - Assume Responsibility, Seize Opportunities". These guidelines place great importance on science and environment in Germany´s approach to engaging with Arctic nations but also highlight the potential for the economies of Germany and Europe that Arctic resources hold. As a partner with vast expert knowledge in the areas of research, technology and environmental standards, Germany can contribute to sustainable economic development in this region [2].

Other federal ministries, including the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, the Federal Ministry for Economic Affairs and Energy, the Federal Ministry for Transport and Digital Infrastructure, the Federal Ministry for Food and Agriculture and the Federal Ministry for Defense, are attentively monitoring the developments in the Arctic.

In light of the growing political and economic interest in the Arctic, a German Arctic Office as an information and cooperation platform for German stakeholders invested in Arctic science, politics and industry was established beginning of 2017. This presentation will introduce the activities of the German Arctic Office related to Arctic Policies and Economy and - one year after its establishment - analyze the benefits of having such an office for a non-Arctic country.

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January 17

Breakout Session

G2

Ocean and Sea Ice

SMOS-derived thin sea ice thickness in the Arctic and Antarctic

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Thin sea ice thickness has been retrieved from L-band brightness temperatures measured by the Microwave Imaging Radiometer using Aperture Synthesis (MIRAS) on board of Soil Moisture and Ocean Salinity mission (SMOS) of European Space Agency (ESA). Due to the broad swath-width, SMOS has almost daily coverage in both polar regions. The large penetration depth of L-band in the sea ice layer makes it possible to extract information of sea ice thickness up to 1.5 m from brightness temperatures measured by SMOS. The maximum retrievable ice thickness depends on the brine volume in the ice, which in turn depends on ice salinity and ice temperature. The retrieval algorithm described in [1] takes into account variations of ice temperature and ice salinity, that are estimated from the surface air temperature of atmospheric reanalysis data and a model-based sea surface salinity climatology as boundary conditions. Additionally, a lognormal distribution function is assumed to account for the heterogeneity of ice thicknesses within a 40 km large SMOS footprint. The radiation model used in the retrieval is a simple one ice layer model without a snow layer. Furthermore, 100% ice coverage is assumed. Similar ice thickness patterns are found between SMOS ice thickness and Moderate Resolution Imaging Spectroradiometer (MODIS)-derived thin ice thickness in the Kara Sea, as well as that from the assimilation systems- TOPAZ and PIOMAS during the freeze-up periods in the Arctic [1]. A validation campaign in the Barents Sea in 2014 [2] using a helicopter-based electromagnetic induction (HEM) system and an airborne laser scanner (ALS) carried on an aircraft also shows overall good agreement bewteen airborne data and SMOS with a correlation coefficient up to 0.9. The SMOS ice thickness retrieval is strictly limited to cold periods and is not applicable during late spring and summer. Daily SMOS ice thickness charts in the Arctic from 15 October to 15 April since 2010 are available via http://icdc.cen.uni-hamburg.de. The same retrieval method has been applied in the Antarctic within ESA's Climate Change Initiative SICCI project to analyse the seasonality and inter-annual variability of thin first year ice around the Antarctic in the period of 2010-2016. An initial validation and comparison with in-situ measurements from upward-looking sonar (ULS) and HEM shows promising results.

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G02-O02

Circumpolar Polynya Characteristics in the Arctic - A Multi-sensor Intercomparison for the Period 2002/2003 to 2010/2011

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A precise knowledge of wintertime sea-ice production in Arctic polynyas is not only required to increase the understanding of atmosphere – sea-ice – ocean interactions, but also to verify frequently utilized climate and ocean models. In the framework of a JSPS-funded research stay at the Institute of Low Temperature Science (Hokkaido University) in 2016, a high-resolution (~2km) MODIS thermal infrared satellite data set featuring spatial and temporal characteristics of 17 coastal polynya regions over the entire Arctic basin (Preußer et al., 2016) has been directly compared to a comparable data set based on AMSR-E passive microwave data (Iwamoto et al., 2014) for the period 2002/2003 to 2010/2011.
While the MODIS data set is purely based on a 1D energy balance model, where daily thin-ice thicknesses (up to 20cm) are directly derived from ice-surface temperature swath data and ERA-Interim atmospheric reanalysis data on a daily basis, the AMSR-E data set is based on an empirical approach that utilizes a distinct polarization ratio (PR) – ice thickness relationship to infer the thickness of thin ice. In both data sets, the daily mapping of thin-ice thicknesses allows for the derivation of important polynya properties such as areal extent and potential thermodynamic ice production.
It shows that the difference in polynya area and ice production estimates is smaller than expected when using equal reference areas and time-frames, and for certain regions and winter seasons the passive microwave numbers even surpass their MODIS derived equivalents. We note that discrepancies between both data sets originate primarily from sensor-specific differences in the acquired signal (e.g., open water detection), varying spatial resolutions (2km vs. 6.25km) of the used data sets as well as the highly variable influence of cloud cover and associated weather conditions. Hence, a possible bias between both data sets mainly depends on the distribution of thin ice within the footprint of AMSR-E, potential land spill-over effects in proximity of the coastline and the performance of the applied cloud-cover correction scheme (*Spatial Feature Reconstruction* – SFR) in the MODIS data set. However, despite all differences, both data sets are coherent in terms of capturing the general spatial and temporal characteristics of Arctic polynyas for the analysed 9-yr period.

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Flat first-year ice thickness algorism using AMSR2

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After 2008, major sea ice type in the Arctic Ocean has been replaced from multi-year ice to first-year ice except near Greenland and Canadian Archipelago. In the case of first-year ice, fate in summer strongly depends on ice thickness at melt onset. Therefore the monitoring of first-year ice thickness in freezing season is crucially important for forecast/prediction of sea ice distribution in forthcoming summer.

Monitoring of sea ice using satellite data has been developed by mainly two approaches. One is using altimeter data. In this case, sea ice freeboard (thickness) is directly measured regardless of the two sea ice types. This is merit of this method. To obtain 5km resolution data, however, 28 days are required for mapping[1]. This sparse temporal resolution is demerit of this method. Currently, the accuracy of the mapping sea ice thickness data is about 25cm. The other method is using microwave data that reflect the changes in characteristics of near surface sea ice properties dependent on thermodynamic sea ice growth. In this case, near real time daily mapping data with about 10km spatial resolution is able to be provided. But this approach is only applied in cases of "flat first-year ice ", since in cases of multi-year ice influenced by melt water at the surface and rafted sea ice the relation between microwave properties and sea ice thickness would be decorrelated. Here we improve sea ice thickness algorism using microwave data without paying attention to sea ice condition by Krishfield et al. (2014)[2] .

At first of development of algorism, we examine changes in emissivity with frequencies and thickness for "flat first-year sea ice" using AMSR2 and a moored ice profiling sonar data. As the result, emissivity of 18GHz data showed almost no change with thickness, while emissivity of higher frequencies (36GHz and 89GHz) data decreases with thickness for the rage between 0.4m and 1.5m. Since the 89GHz is occasionally influenced by water vapor and other atmospheric noise, we adopt a gradient ratio between 18GHz and 36GHz brightness temperatures to estimate sea ice thickness. The accuracy of the estimated thickness is about 18cm. This is much better than the altimeter derived algorism with about one month temporal resolution.

Our algorism is only applicable to "flat first-year ice". This is weak point. But integration of this algorism and "rafting algorism" using high accuracy sea ice velocity data will overcome this weak point. In other word, integration of proper algorisms based on sea ice dynamics/thermodynamics can improve prediction/forecast of sea ice distribution for scientific and navigation use

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Satellite observation of the thickening of sea ice through the ice deformation

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[4] *Hydro Systems Development, Inc., Tokyo, Japan*

Sea ice thickness changes through both thermodynamic and dynamic processes. Dynamic process involves the ice transport and deformation (rafting and ridging). Mechanisms responsible for this process have been examined by some numerical model studies. However study based on data analysis is very sparse. This study aims to reveal the characteristics of the ice thickening in the Arctic, especially focusing on the dynamic deformation of ice. We prepared daily ice velocity product for 2003-2017, derived from images by satellite microwave sensors Advanced Microwave Scanning Radiometer-Earth Observing System (AMSR-E) and AMSR2 ([1]Kimura et al., 2013). We also use the ice-draft data obtained from moored ice-profiling sonar (IPS) in the Canada Basin.

To examine the change of ice thickness due to the ice deformation, movement of particles arranged over the ice area is calculated using the satellite-derived ice velocity. The spatial inhomogeneity of the particle distribution becomes significant with time (Figure 1). Daily change of ice thickness through the ice redistribution is estimated from the change of the particle density; convergence of the particle promotes the thickening of sea ice due to the ice deformation. We can estimate the contribution of the ice deformation process from the total change of ice thickness observed by IPS. (Figure 2).

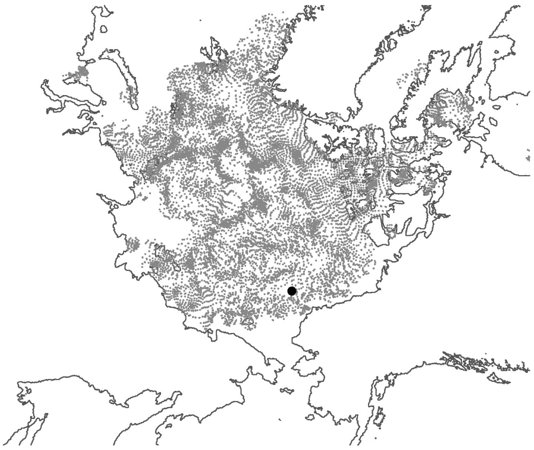

Figure 1. Distribution of migrating particles for July 31 2014, which are arrayed over the ice-covered area on March 1. Black dot shows a mooring location.

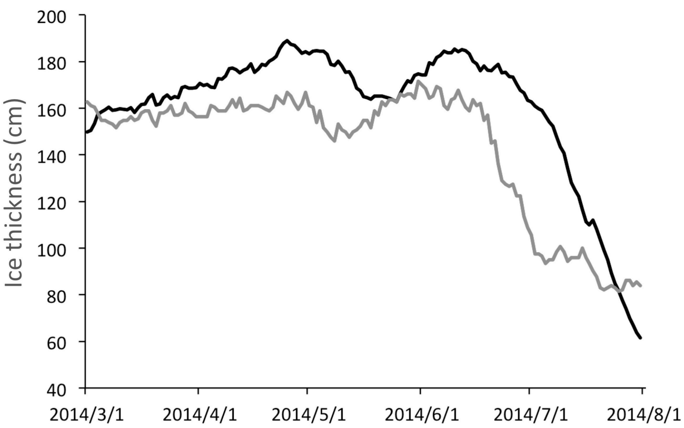

Figure 2. Temporal change of ice thickness, observed by IPS (black), and the change due to ice deformation (gray) estimated by the particle track method. Observed ice thickening during June is due to the ice deformation.

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G02-O05

Sea Ice Motion and Deformation Measurements Using Satellite Images

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This study presents an application of high-resolution optical images from operational satellites, which have become more available in polar regions, for sea ice motion and deformation measurements. The sea ice motion is measured by using a maximum cross-correlation (MCC) technique and multi-temporal high-resolution images acquired on Aug 14–15, 2014 from multiple space-borne sensors on board Korea Multi-Purpose Satellites (KOMPSATs) with short acquisition time intervals. The sea ice motion extracted from the six image pairs of the spatial resolutions were resampled to 4 m and 15 m yields with vector length measurements of 57.7 m root mean square error (RMSE) and –11.4 m bias and 60.7 m RMSE and –13.5 m bias, respectively, compared with buoy location records. The errors from both resolutions indicate more accurate measurements than from conventional sea ice motion datasets from passive microwave and radar data in ice and water mixed surface conditions. In the results of sea ice deformation caused by interaction of individual ice floes, while free drift patterns of ice floes were delineated from the 4 m spatial resolution images, the deformation was less revealing in the 15m spatial resolution image pairs due to emphasized discretization uncertainty from coarser pixel sizes. The results demonstrate that using multi-temporal high-resolution optical satellite images enabled precise image block matching in the melting season, thus this approach could be used for expanding sea ice motion and deformation dataset, with an advantage of frequent image acquisition capability in multiple areas by means of many operational satellites.

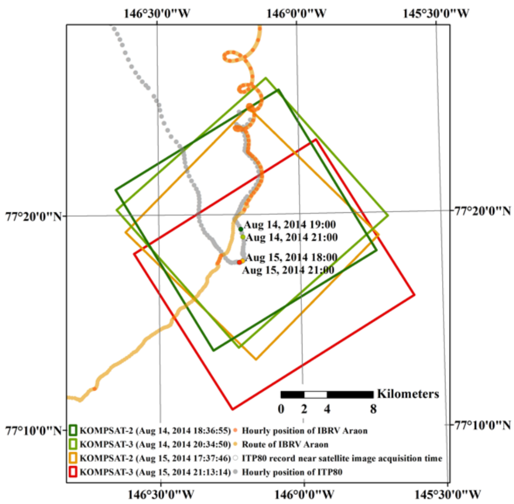

Figure 1. Schematic placements of satellite images used to measure sea ice motion and deformation, and synoptic trajectory of the ITP80.

Acknowledgement:
The authors gratefully acknowledge the KOMPSAT data from the Korea Aerospace Research Institute. The ITP80 data were collected and made available by the Ice-Tethered Profiler Program based at the Woods Hole Oceanographic Institution (http://www.whoi.edu/itp).

G02-O06

Inter-Sensor Calibration of Space-Borne Passive Microwave Radiometers for Retrieving Long-Term Sea Ice Trends

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Monitoring the changes in sea ice cover is important, because they are considered to have significant impacts on Earth's climate. Space-borne passive microwave radiometers (PMRs) have been employed to monitor the spatial and temporal changes in sea ice concentration (SIC) and sea ice extent (SIE), as these instruments can observe both polar regions very frequently regardless of weathers and the time of day or night. Sea ice has been continuously observed by a variety of different space-borne sensors since 1978. In order to retrieve objective trends in SIEs, it is necessary to remove any bias attributable to the differences in the PMR sensors. For example, variations in the incidence angle and instantaneous field of view (IFOV) among the sensors can cause differences in the estimations of sea ice area, particularly at around the edges of sea ice. Since the design lifetimes of satellites are typically five years or so, techniques for standardizing the SIC and SIE data processing among different satellite sensors are essentially required for securing the data continuity during the long-term observation period from 1978 to the present. We have developed an algorithm to conduct sensor-to-sensor calibration using the AMSR-E (one of PMR sensors operated from May 2002 to Oct. 2011) observations as a reference data in order to generate an objective long-term SIE datasets (Fig.1). Retrieved results revealed that sea ice cover in the Arctic has been markedly reduced in recent years; in Sep. 2012, Arctic sea ice has reached its minimum extent. On the other hand, the spatial extent of sea ice in the Antarctic has been increasing and the maximum extent has been observed in Sep. 2014. But the Antarctic extent is the lowest on record in Mar. 2017. As the result, global sea ice extent hits record low in Feb. 2017. Extra long-term sea ice trends for about a half century are expected to be available with extended operation of the AMSR2 mission. AMSR2 is the successor of AMSR-E and has the highest spatial resolution among PMRs so that we will reanalysis our datasets using AMSR2 as a reference data instead of AMSR-E in future.

Acknowledgements. We wish to thank K. Nakagawa, H. Fukushima and R. Okada of Japan Meteorological Agency, K. Cho of Tokai Univ., and J.C. Comiso of NASA for useful suggestions and discussions. Furthermore, we appreciate the programming support provided by K. Sekiya and T. Mutoh of RESTEC.

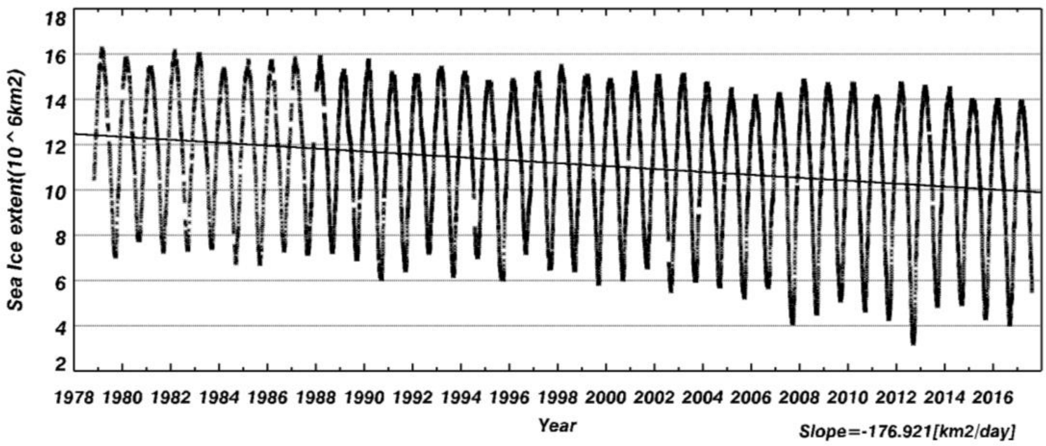

Figure 1. Arctic Sea Ice Extent for 39 years（Nov.1978 - Aug.2017）

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G02-O07

Anomalously low central Arctic salinity in a years of high sea-ice melt and converging atmospheric conditions

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The Arctic Ocean has shown several years of very low sea-ice extent and redistribution of liquid freshwater within the region since the the 1990s. Yet, the mechanisms underlying this variability in the light of decadal trends and oscillations are not fully understood. Using obervations, we show anomalously low salinity in the central Arctic during summer 2015 Values of practical salinity at the North Pole were around 28, whereas they were 30 or more in prior observations since 1992. The freshwater inventory from the surface to the 34 isohaline paints a similar picture with the anomaly continuing into 2016. We find that the freshwater anomaly is likely driven by above average levels of sea-ice melt and Ekman transport from the direction of the Siberian shelves and of the Canada Basin. This is associated with strong freshening of Polar Surface Water and elevated levels of waters of Pacific origin throughout this layer. Our results are part of Arctic-wide changes in sea-ice cover and freshwater distribution on decadal timescales.

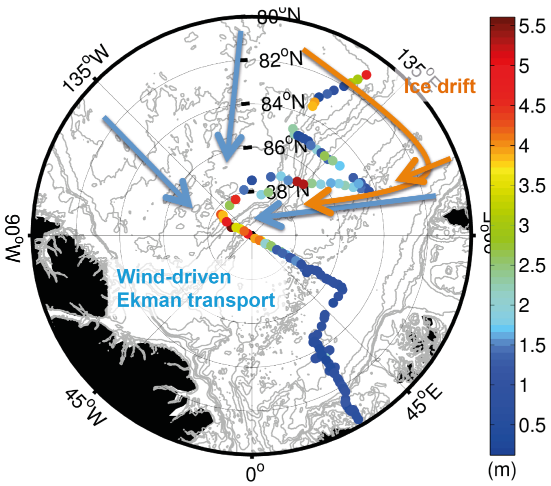

Figure 1. Anomalous Ekman transport and seasonal freshening in the upper Arctic Ocean: seasonal freshwater change during the melt season between the surface and the depth of the winter mixed-layer (colour); Ekman transport from surface wind stress in NCEP-2 reanalysis (blue arrows); ice drift from satellite-based drift products (orange arrows).

G02-O08

Water movements in the Arctic Ocean below 1500m statistically confirmed by geochemical data

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Climatological water mass structures were identified in the Arctic Ocean using the geochemical dataset in the Hydrochemical Atlas of the Arctic Ocean (HAAC), and also a geochemically conserved parameter PO_4^* based on phosphate and dissolved oxygen, as

$$PO_4^* = PO_4 + DO/175 - 1.95 \quad (\mu mol/L)$$

Here, the content of phosphate increases with decline of dissolved oxygen according to remineralization stoichiometry at the rate of P: O_2 = 1: −175. In the upper ocean above 500-m depth, the HAAC shows its reliability through the boundary between the Pacific-origin Water (P-Water) and Atlantic-origin Water (A-Water) with higher and lower silicate, respectively. The boundary between the water masses is located along 135°E-45°W at the surface and rotates counter-clockwise with depth, confirming the anti-cyclonic circulation of P-Water in the surface layer (0 to 200-m depth), and the cyclonic circulation of A-Water in the subsurface layer (200 to 500-m depth).

In the lower ocean below 1500-m depth with the basins separated by the Lomonosov Ridge, the PO_4^* field was statistically analyzed to derive the following results: the Eurasian Basin receives penetration of the Nordic Seas Deep Water with low PO_4^* flowing from the Greenland Sea along the bottom. The routes from the upper ocean to the lower ocean were determined: high PO_4^* is limited to the southern portion of the Canada Basin (Region C), receiving the source water from the upper ocean of the Chukchi and Beaufort Seas, while the other portion of the Amerasian Basin (Region A) receives low PO_4^* water from the upper ocean of the Laptev Sea. The Eurasian Basin (Region E) receives medium PO_4^* from the Barents Sea in addition to the main body originating from the intermediate layer (500 to 1500-m depth). Based on both Welch's t-test and Mann-Whitney U-test, the mean value in Region A is significantly different from the means in Region C and also Region E, at a significance level of 95%.

Name	Region	Depth	PO_4	DO	PO_4^*
	Northern boundary of Chukchi Sea	200m	1.50	280	1.15
	Northern boundary of Laptev Sea	200m	0.75	310	0.57
C	Canada Basin with high PO_4 area	2000-4000m	1.15	295	0.90
A	Amerasian Basin excluding area C	2000-4000m	0.90	285	0.58
E	Eurasian Basin	2000-4000m	0.95	310	0.78
	Northern boundary of Barents Sea	200-500m	0.90	310	0.72
	Greenland Sea Fram Strait	2000m	0.70	310	0.52

Table 1: Phosphate, dissolved oxygen and the tracer values in Regions of the Arctic Ocean

G02-O09

Effect of different factors on calcium carbonate saturation in the Canada Basin in the last two decades

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The uptake of anthropogenic CO_2 drives ocean acidification, with attendant effects on the saturation state of calcium carbonate saturation (Ω). In this study, we analyzed observations between 1997 and 2016 in the Canada Basin and estimated effect of different factors on Ω. It was found that Ω has decreased by ~0.6 from pre-industrial period. In the last two decades, Ω decreased rapidly before 2007 and then slightly rebounded after 2007. Continuous increase of atmospheric CO_2 persistently lowered Ω and accounted for the decrease of Ω ~0.3. Elevated sea surface temperature mitigated ocean acidification and increased Ω significantly in 2008 and 2012 by ~0.1. Melting of sea ice lowered Ω by ~0.4, which was due to dilution of surface water and change in air-sea disequilibrium state. Effect of melting of sea ice was maximum in 2007, when the sharp drop in sea ice coverage occurred that induced a great mount of fresh water discharge into the surface of Canada Basin and enhanced air-sea exchange of CO_2. After 2007, sea ice coverage decline showed an obvious slacken and dilution effect of melting of sea ice decreased. Seawater pCO_2 was getting closer to equilibrium with atmospheric pCO_2 due to enhanced air-sea exchange caused by expanded open water area (and/or weaker phytoplankton activities due to lower nutrients). In the future, anthropogenic CO_2 and elevated sea surface temperature will likely continuously promote and mitigate the ocean acidification, respectively. Dilution effect by sea ice melting will be less significant, air-sea exchange effect can further decrease Ω and until surface seawater pCO_2 equilibrates with atmosphere.

G02-O10

Middle Pleistocene to Holocene environmental changes in the northern Northwind Ridge: evidence from terrigenous depositional at ARC06-C22

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A sediment record from the practically Northern part of the Northwind Ridge off Alaska has been studied. Core ARC6-C22 encompasses marine isotope stages (MIS) 10-1 and reveals changing paleoceanographic conditions, glacial-interglacial terrigenous sediment cycles and land-ocean connections during the late Quaternary.

The core was investigated for clay mineralogy along with grain-size, ice-rafted detritus, color features and bulk chemical compositions. By combination of AMS 14C, magnetism inclinations, XRF Ca & Mn and coarse grain size, and by comparison of similar proxies results from neighbor cores 92AR-P23 and 92AR-P39, the age of core ARC6-C22 since MIS10 was established with stages and Sub-stages cycles.

Before MIS 5 a huge Marine ice sheet existed in the Chukchi Borderland, making the Northwind Ridge a key intersection area for the Ice-rafted debris deposition. In addition, the wind-driven Beaufort Gyre showed zonal swing during glacial-interglacial cycles. IRD, Kaolinite and XRF Ca showed high values during interglacial periods (MIS10, 8,6 and 9d,9b,7d,7b,5b), indicating the Northwind Ridge could receive more debris from Northwest Canada and parts of Alaska with stronger and Parallel direction of Beaufort Gyre. While during the glacial intervals (9e,c,a,7e,c,a,5e) EM1(fine materials), Smectite and illite showed high values, indicating the swing of Beaufort Gyre, and the stronger Pacific water input with longer ice open periods.

After MIS 5, the Marine ice sheet melted due to the global warming and sea level increased. The ice-rafted debris deposition central disappeared, and the terrigenous materials form northeastern Canada and Alaska to the Northwind Ridge during glacial periods turn to be week. The interglacial periods (MIS5c, a,3,1) are characterised by high Smectite and low fine material, showing the growing influence of terrigenous input from the Siberia and the Chukchi Sea.

January 17

Breakout Session

G5

Terrestrial Ecosystems

G05-O01

Top-down and bottom-up CO_2 fluxes at Yakutsk, Siberia

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Carbon dioxide (CO_2) fluxes by different methods vary largely at global, regional and local scales. The net CO_2 fluxes by three bottom-up methods (tower observation, biogeochemical models, and a data-driven model), and an ensemble of atmospheric inversions (top-down method) are compared in Yakutsk, Siberia for 2004-2013 (Table 1). The region is characterized by highly homogeneous larch forest on a flat terrain. The ecosystem around Yakutsk shows a net sink of CO_2 (0.06 kg-C m^{-2} mon^{-1} by tower observation). The monthly-mean seasonal cycles agree among the four methods within the range of inter-model variations. The peak-to-trough amplitude of the seasonal cycle is greater for the inverse models than bottom-up methods. The interannual variability estimated by an ensemble of inverse models is more similar to the tower observation (+/-xx %) than those by the biogeochemical models and the data-driven model. The inverse models and tower observations captured a reduction in CO_2 uptake after 2008 due to unusual waterlogging.

Table 1. List of data and models used in this study.

Approach	Method (Abbrev.)	Models (Abbrev.)	Scientist-in-charge
Bottom-up	Tower Observation (TWR)	N/A	A. Kotani & T. Ohta
	Data-driven model (SVR)	Site-SVR (SVR 3km)	K. Ichii & M. Ueyama
	Biogeochemical model (GTM)	BEAMS (GTM-1)	T. Sasai
		Biom-BGC (GTM-2)	K. Ichii
		CHANGE (GTM-3)	H. Park
		JULES-c_ver1.0 (GTM-4)	E. J. Burk
		SEIB-N (GTM-5)	H. Sato & S. Tei
		STEM1 (GTM-6)	T. Ise
		VISIT (GTM-7)	A. Ito
		LPJ-Lv1.0 (GTM-8)	R. O'ishi
Top-down	Atmospheric Inversion model (INV)	GELCA-EOF (INV-1)	D. Belikov & R. Zhuravlev
		ACTM (INV-2)	T. Saeki and P. K. Patra
		NICAM-TM (INV-3)	Y. Niwa
		NIES-TM (INV-4,5,6)	T. Saeki

Acknowledgements. This study was supported by the GRENE Arctic Climate Change Research Project, and the Low-carbon research program at National Institute for Environmental Studies. Special thanks to the bottom-up (GTMIP) and top-down modelling group members for supporting this analysis.

G05-O02

Carbon cycle of permafrost: main terrestrial and hydrological ecosystems of Eastern Siberia

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This presentation is compiled from the results of many years time series investigations conducted on the study of carbon cycle in permafrost-dominated forests with different productivity and typical tundra SakhaFluxNet and along Great Lena river basin including Aldan and Viluy tributaries.

According to our long-term eddy-correlation data, the annual uptake of carbon flux (NEE) in the moderate productivity larch forest of the Central Yakutia makes 2.12±0.34 t C ha^{-1} yr^{-1}, in the high productivity larch forest of South eastern Yakutia – 2.43±0.23 t C ha^{-1} yr^{-1}, and in the tundra zone – 0.75±0.14 t C ha^{-1} yr^{-1}.

As our multi-year studies showed, there is significant interannual NEE variation in the Central Yakutia larch forest, while in the Southern Yakutia larch forest and tundra ecosystem variation is more smooth, because the climatic conditions in these zones (close to the mountain and sea) are less changeable than in sharply continental Central Yakutia.

Interannual variation of carbon fluxes in permafrost forests in Northeastern Russia (Yakutia) makes 1.7-2.4 t C ha^{-1} yr^{-1} that results in the upper limit of annual sequestering capacity of 450-617 Mt C yr^{-1}. In connection with climate warming there is a tendency of an increase in the volume of carbon sequestration by tundra and as opposed to decrease by larch ecosystem in the result of prolongation of the growing season and changing of plant successions. This is also supported by changes in land use as well as by CO_2 sequestration in the form of fertilizer.

According our biogeochemical investigation annual flux of carbon from main in Eastern Siberia Lena river hydrological ecosystem is almost 6.2 Mt C yr^{-1} including 28% at Aldan and 14% at Viluy rivers [1].

Study resuslts from eddy-covariance systems and two models (LEA and Invers) showed annual carbon budget of Russia for the last ten years, which equals to 0.659±0.100 B t C yr^{-1}, from which 90-95% falls for forested area.

For estimation of methane emmision, we used 2D landscape-scale model, that included the whole life cycles of thaw lakes: formation, expantion, drainage and possible second formation. According to our data, methane emmision from thaw lakes of Siberia is around 3.73 t g CH_4 yr^{-1}, which is much lower than obtained by other researchers. We expect, that predicted expanding of lakes will highly affect permafrost ecosystems and infrastructure [2].

In case of drastically quick climate warming we may expect, in a matter of decades, irreversible degradation and decay of permafrost forest associations with the replacement of the main forest-forming tree species by edificator species typical for swampland plant associations of the boreal zone and/or cryophilic deserts of Asia.

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Seasonal Change and Spatial Pattern of Monoterpene in a Forest Soil in a Black Spruce Stand in Interior Alaska

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Monoterpene is biogenic volatile organic compound (BVOC) which plays important role of atmospheric chemistry and global warming. Tree leaves are known as main sources of BVOC in forest ecosystems and many studies have been conducted above ground. According to these studies, isoprene and monoterpenes are major BVOC and the amount of annual emission from the forest ecosystems has been estimated. Roots of vegetation, fungi, and microorganism also produced monoterpenes, however, monoterpene dynamics in forest soils is unclear. In addition, although some species of monoterpenes influence carbon and nitrogen dynamics including greenhouse gas (GHG) production and consumption in forest soils, however, mechanism and contribution have been unclear. To clarify the effect of monoterpene on these nutrient dynamics, it is necessary to know what kind of monoterpene existed, the pattern of seasonal change, and the range of each monoterpene concentration in the soil. The purpose of this study is to investigate seasonal and spatial changes of monoterpene in forest soils in black spruce stand (*Picea mariana*) in interior Alaska. This study was conducted in different slope positon in black spruce forest (65^{o}N, 147^{o}W) near Fairbanks city. Three plots were established on the slope, those are, upper, middle and lower part of the slope. Among the plots, biomass of the trees, the depth of organic layer and active layer, the composition of moss and lichen species on the forest floor are different. In each plot, air in the atmosphere and the soil were taken into sorbent sampling tube (Tenax TA and Carbotrap B, SUPELCO, Sigma-Aldrich Co.), after that, all tubes were brought to Japan and monoterpene species and the concentration were determined by ATD-GC/MS (Agilent 7890B/5977A) and ATD-GC with FID (Shimadzu GC1700). Seasonal changes of monoterpene concentration in atmosphere and soil were unclear. Total monoterpene concentration in the atmosphere was less than 10 ng L^{-1}, on the other hand, the concentration in the soil exceeded sometimes more than 1000 ng L^{-1} in summer at the site. α-pinene was the most abundant which accounted for 50 % of the total monoterpene, and the total concentration of monoterpene was higher at upper slope (ca. 400 ng L^{-1} in summer) than at lower slope (ca. 100 ng L^{-1} in summer) may be due to the difference of vegetation species on the forest floor and size of the trees. The composition of monoterpenes were not different among the plots and season. Litter and root of vegetation, moss, lichen, microorganism and fungi could be sources of monoterpenes. In this study, the monoterpene concentration was higher in F horizon where fine root was concentrated than in mineral soil, and the composition of detected monoterpene in the soil resembles that from leaves of trees aboveground. Therefore, fine root of black spruce is considered as the main source of monoterpene.

Effects of snow cover change on taiga forest ecosystem

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The air temperature already increased for 2-3 degrees in Siberia (and will continue to rise in the future [1]. Increasing air temperatures and winter precipitation may affect vegetation through change in snow cover onset and its depth because these snow parameters possibly affect soil moisture and soil temperature, alter nutrient availability in the following growing season [2].

To understand effects of changing snow cover depth on taiga forest ecosystem, snow manipulation experiment was conducted in winter of 2015 in taiga forest dominated by Larix cajanderi at Spasskaya Pad experimental forest (the Republic of Sakha, Russia). Snow from 20 x 20 m plot was transported to another plot with the same area and spread out evenly.

Boreal and temperate forests with thin organic layer are more susceptible to freezing disruption [3]. Our results show that after snow manipulation, soil temperature decreased significantly at Snow- plot for soil layers from surface to 80 cm. In spring, advanced snowmelt of reduced snowpack increased summer soil temperature, but decreased soil moisture. Changes affected phenology of larch trees by slowing the speed of needle elongation and decreased nutrient availability in soil and thus decreased nitrogen content in needles in July, although did not affect needle length and nitrogen content in August. We suggest this may be results of reduced nitrogen availability in soil and inability of plant to uptake soil nitrogen due to lowered soil moisture or frost-induced fine-root damage caused by increased frequency of freeze-thaw cycles during snow-free period.

At Snow+ plot, small trees needles at Snow+ plot were significantly longer during early growing season, but at the end of summer the difference in needle length was not significant. Increased nitrogen content of soil and mirroring increase of needle nitrogen content suggest higher nutrient availability and increased uptake of these nutrients with 20% higher soil moisture at Snow+ plot and insulating properties of increased snowpack reduced frequency of freeze-thaw cycles Higher nitrogen content of needles at Snow+ and larger soil ammonium pool in July may be a result of higher winter soil temperature due to increased insulation by snow cover which led to higher microbial activity [4]. Lower needle nitrogen content and soil ammonium at Snow- was observed because soil decomposer communities were disturbed by extreme soil frost in winter or freeze thaw cycles in spring [5].

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G05-O05

Simulating topographic controls on the abundance of larch forest in eastern Siberia, and its consequences under changing climate

Hisashi SATO & Hideki KOBAYASHI (JAMSTEC)

In eastern Siberia, larches (*Larix* spp.) often exist in pure stands, constructing the world's largest coniferous forest, of which changes can significantly affect the earth's albedo and the global carbon balance. Our previous studies tried to reconstruct this vegetation, aiming to forecast its structures and functions under changing climate.

In previous studies of simulating vegetation at large geographical scales, the examining area is divided into coarse grid cells such as 0.5 × 0.5 degree resolution, and topographical heterogeneities within each grid cell are just ignored. However, in Siberian larch area, which is located on the environmental edge of existence of forest ecosystem, abundance of larch trees largely depends on topographic condition at the scale of tens to hundreds meters. In our preliminary analysis, we found a quantitative pattern that topographic properties controls the abundance of larch forest via both drought and flooding stresses in eastern Siberia.

We, therefore, refined the hydrological sub-model of our dynamic vegetation model SEIB-DGVM, and validated whether the modified model can reconstruct the pattern, examined its impact on the estimation of biomass and vegetation productivity under the current and forecasted future climatic conditions.

G05-O06

Change over time in development of root stocks of black spruce growing at upper and lower slopes in interior Alaska

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Root stock records the soil environmental change in past. In order to examine the soil environmental change, we reconstructed lateral root development as well as root stock radial growth using dendrochronological techniques. The research sites were the upper and lower positon of a north facing slope on permafrost of interior Alaska. The upper slope is characterized by thinner organic layer and bigger tree size. Belowground parts of four black spruce trees were excavated both sites. Disk samples of cross section were taken from the base of all lateral roots and from ths stems at every 10 cm in depth. The annual ring widths were measured and cross-dated. The rooting depths and age of the lateral roots were identified. The fire scars of older trees indicated the forest fire occurred summer of 1905. The sample trees of this study were regenerated after the fire. The results of tree ring analysis of root stock revealed that root stock consist of tap root and main stem, and a large portion of root stock was main stem, not tap root. The abrupt radial growth reduction occurred earlier in deeper position. Newer lateral roots tend to formed in shallower layer. These two changes were observed only in lower slope. Both upward changes should attributed to increase in organic layer and decreasing temperature in deeper position. Upward shift of the position with abrupt radial growth reduction is faster compared to the upward shift of the position with new root emergence. This implies decreases of the region, between the position with abrupt radial growth reduction and new root emergence, where belowground part of tree can grow. Ability for carbon accumulation of the forest may decrease in this process.

G05-O07

Preparation of your Abstract for ISAR-5

Warming permafrost accelerates development of soil hummocks and drunken forest

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On warming permafrost, black spruce trees lean in all directions to form “drunken” forest1. Development of drunken forest requires soil movement caused by ice melt-freeze cycles and rolling permafrost table2. Two hypotheses of tree leaning are loosing soil foundation induced by permafrost melting in warm summer and/or mound rising (hummock formation) by freezing soil in winter2, 3. However, no evidence can clarify whether tree leaning is influenced by climate warming or within a natural phenomenon of hummock formation. Here we show the evidence that tree leaning and soil hummock development are accelerated by climate warming. We found using tree ring records that trees leaning events synchronize with development of soil hummocks, which can be recorded in lignin-deposited tree rings of leaned tree trunk. We identified that mound rising by freezing soil in winter, rather than loosing soil foundation in summer, is a direct reason for tree leaning. Hummock formation has shifted from episodic events until 1960 to continuous lifting in the warmer fifty years. Our results demonstrated that drunken forest is not a simple symptom of permafrost degradation, but that natural process of rising mounds is altered by warming even in continuous permafrost zone. Soil change is generally a slow process, but rapid hummock formation has the risk to increase fire susceptibility of dry lichen-covered mounds and shorten fire-regeneration cycles of drunken forest and residence time of ecosystem carbon stored.

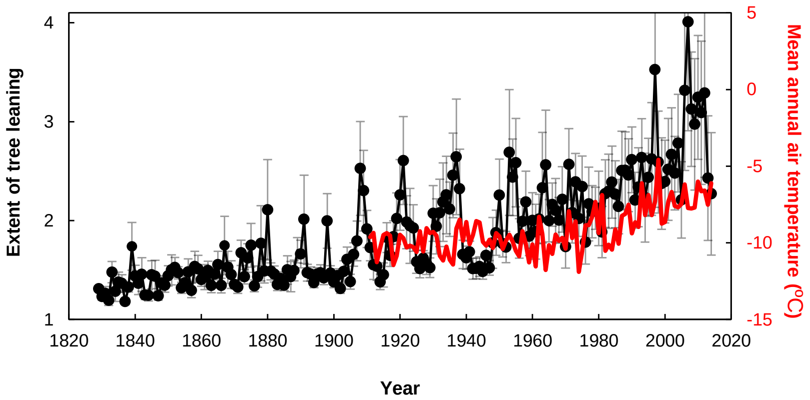

Figure 1. Time-series trends of tree leaning and air temperature in drunken forests near Inuvik

G05-O08

A Late Cretaceous (70 Ma) High Latitude Paleoenvironmental Transect Across Greenhouse Alaska, USA: Investigating the Relationship Between Environments and Fossil Vertebrates

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Recent work on the Chignik Formation (Campanian-Maastrichtian) in Aniakchak National Monument, SW Alaska, extends a high-latitude greenhouse transect from the Alaska Peninsula to the North Slope, across ~ 28° of latitude. The Chignik Formation consists primarily of nonmarine alluvial-coastal plain deposits, dominated by sinuous meandering fluvial channels, with abundant crevasse splays, small lakes and ponds, and a few thin peat swamps. There is also evidence for tidal influence on some of the distal deposits, as well as marginal marine and shallow marine deposits. Dark grey to reddish siltstones with root traces, siderite nodules, organic fragments, plant fossils, and coalified logs represent poorly drained floodplain soils. In some cases, standing tree trunks are present rooted in ancient soils. The vertebrate fossil record consists of tracks and traces, of which 93% of the document sites can be attributed to the ichnogenus *Hadrosauropodus*, a footprint attributed to hadrosaurs. These hadrosaurs ranged in size from full-grown adults to juveniles. In addition to hadrosaurs, there are rare occurrences of tracks that are attributed to ankylosaurs and osteichthyans. The Lower Cantwell Formation in Denali National Park, consists primarily of axial braided rivers, alluvial fans, floodplains, ponds and small lakes. A rich invertebrate and vertebrate ichnofauna is known from the LCF that includes adult and juvenile forms of hadrosaurs and ceratopsians, where hadrosaurs constitute approximately 73% of the ichnofauna. The Prince Creek Formation, North Slope, consists primarily of small distributary channels, crevasse splays, small ponds and abundant paleosols. Large trunk channels fed this delta plain distributary network. The paleosols suggest generally poorly drained conditions punctuated by periods of drying that were probably related to the seasonal light regime. The PCF has produced thousands of skeletal dinosaur remains, based on bonebed frequency, hadrosaurs constitute approximately 83% of the herbivorous dinosaur fauna. These three formations represent different sedimentary environments and landscapes, containing different dinosaur and plant communities. The Prince Creek Formation, located at 75-85° N paleolatitude, had a MAT of ~ 5-7 °C and MAP of ~ 500-1500 mm yr^{-1}. The Lower Cantwell Formation, located at a paleolatitude of 65-75° N had a MAT of ~ 7-8 °C and a MAP of ~ 350-1550 that decreased by an order of magnitude during a period of elevated temperature in the Middle Maastrichtian. These data suggest that moisture played a significant role in the relative percentages of herbivorous dinosaurs across this transect in an ancient Arctic greenhouse world.

January 17

Breakout Session

S1

Arctic Warming by Natural Variability and/or Human Impact

On the Natural Component of Climate Change

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Abstract

Climate change consists of both natural change and man-made change. However, as far as global warming is concerned, it is not possible to identify and determine the man-made component without subtracting the natural component from observed temperature change. As a first approximation, one of the methods to infer the natural component is to learn the past climate change. Based on the past temperature change and various past natural phenomena (including the retreat of glaciers), it is shown that the temperature change from about 1850 to 2017 can be understood mostly in terms of the combined effect of a linear increase of 0.5°C/100 years (probably, "recovery" from the Little Ice Age [LIA]) and a quasi-periodic oscillation (probably, the Pacific Decadal Oscillation [PDO]). The reason for the predicted high temperature in 2100 and the failure of predicting the present halting of global warming (2000-2017) may partly due to the lack of efforts of subtracting the natural component. It is urged to learn causes of the past climate change first before predicting future change.

S1-O02

Accelerated increase in the Arctic "tropospheric" warming events

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Rapid Arctic warming events disrupt mid-latitude weather patterns and oftentimes produce extreme deviations from normal weather conditions. The atmospheric origins of these Arctic warming events have been identified as developing in the troposphere and the stratosphere. Historical cases of tropospheric warming and stratospheric warming in the Arctic were identified and validated based upon tropical linkages as documented in previous studies. The analysis indicates a recent and seemingly accelerated increase in the tropospheric warming type versus a flat trend in stratospheric warming type (Figure 1). Tropospheric events develop twice as fast as stratospheric events and are therefore less predictable. With observations of historically-low Arctic sea ice extent occurring alongside the increase of tropospheric warming events, computer simulations provided evidence that the two phenomena are likely linked. Along with observational evidence for enhanced transport of tropical energy helping fuel these Arctic tropospheric warming events, the results suggest that future mid-latitude weather is likely to undergo an increase to extreme, unseasonal weather patterns that are inherently less predictable at the subseasonal timescale.

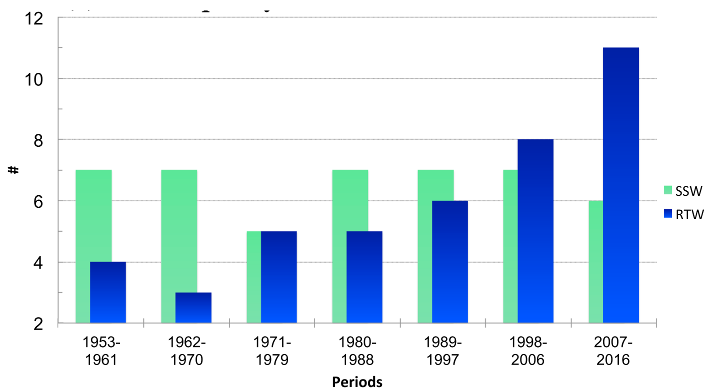

Figure 1. Changes in the frequency of occurrence of Arctic rapid tropospheric warming (RTW) and stratospheric sudden warming (SSW) events. RTW episodes have been increasing, which strongly correlates with sea ice loss.

References

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S1-O03

Future changes in precipitation over the Arctic projected by massive ensemble simulations with a 60-km mesh global atmospheric model

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We conducted massive ensemble global warming projections using a global atmospheric model with high-horizontal resolution of 60-km grid size (MRI-AGCM3.2H). For the present-day climate of 25 years from 1979 through 2003, we forced the model with the observed historical Sea Surface Temperature (SST) with an ensemble size of 100 giving different atmospheric initial conditions and small perturbations in SST. For the future climate, a 25-year integration is conducted, in which the global-mean surface air temperature is 4 K warmer than the pre-Industrial level corresponding to conditions around the 2090s under the Representative Concentration Pathways 8.5 (RCP8.5) emission scenario. In order to estimate the uncertainty, we adopted SST changes projected by 6 coupled models of the Fifth phase of Couple Model Intercomparison Project (CMIP5). For each SST distributions, 15-member ensemble simulations are conducted for different atmospheric initial conditions and small perturbations in SST. Total ensemble size amounts to 90. These series of experiments are called "the database for Policy Decision making for Future climate change" (d4PDF) [1].

Reproducibility of annual precipitation (PAVE) and 5-day precipitation (R05D) over the Arctic by MRI-AGCM3.2H is almost comparable to CMIP5 atmospheric models. Figure 1 shows the dependence of precipitation change on different regions. Increase of PAVE is larger than R05D over the Arctic. This is contrary to global, tropical and mid-latitude averages where increase of R05D is larger than PAVE. This tendency is consistent with previous studies [2, 3].

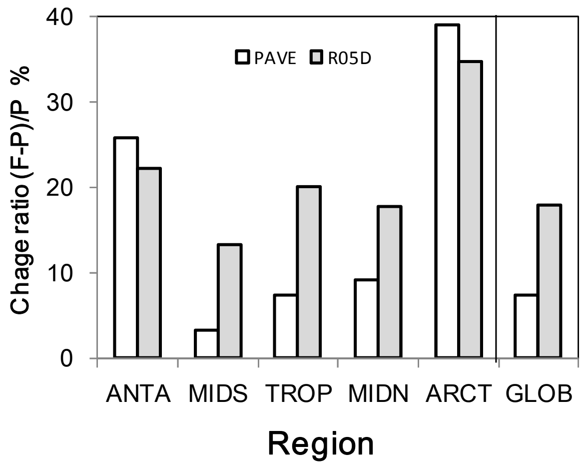

Figure 1. Dependence of precipitation change relative to present-day climate (%) on regions. ANTA: Antarctica (90°S–67.5°S); MIDS: Mid-latitudes in the Southern Hemisphere (67.5°S–20°S); TROP: Tropics (20°S–20°N); MIDN: mid-latitudes in the Northern Hemisphere (20°N–67.5°N); ARCT: Arctic (67.5°N–90°N); GLOB: Global (90°S–90°N).

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S1-O04

Multi-Decadal Variability in Planetary Albedo

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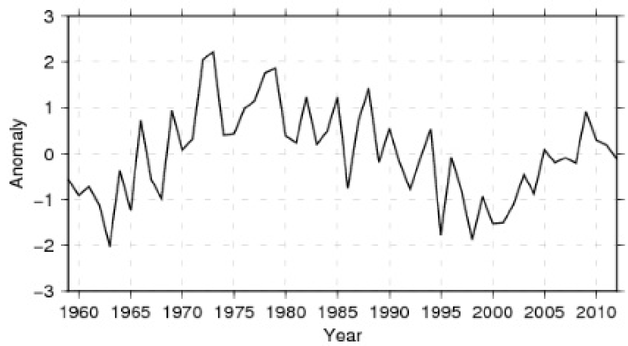
Multi-decadal variability in planetary albedo is investigated using the JRA-55 and ERA-40 reanalysis data by Tanaka and Tamura (2016). As shown in Fig. 1, it is found that the planetary albedo increased for 1958 to 1970, decreased for 1970 to 2000, and increased for 2000 to 2012 with one percent amplitude, which corresponds to 1.0 W/m2. The multi-decadal variability in the planetary albedo is compared with the time series of the AO mode and Barents Sea mode of surface air temperature. It is shown that the recent AO negative pattern showing warm Arctic and cold mid-latitudes is in good agreement with planetary albedo change indicating negative anomaly in high latitudes and positive anomaly in mid-latitudes. Moreover, the Barents Sea mode with the warm Barents Sea and cold mid-latitudes shows long-term variability similar to the planetary albedo change. The natural variabilities of both the AO mode and Barents Sea mode indicate some possible link to the planetary albedo to cause the warming hiatus in recent years.

In this study, a simple energy balance model (EBM) was integrated in time, considering a hypothetical long-term variability in planetary albedo. A natural variability was superimposed on a linear warming trend due to the increasing radiative forcing of CO2. The result demonstrates that the superposition of the natural variability and the background linear trend can offset with each other to show the warming hiatus for some periods. It is also stressed that the rapid warming during 1970 to 2000 can be explained by the superposition of the natural variability and the background linear trend at least within the simple EBM.



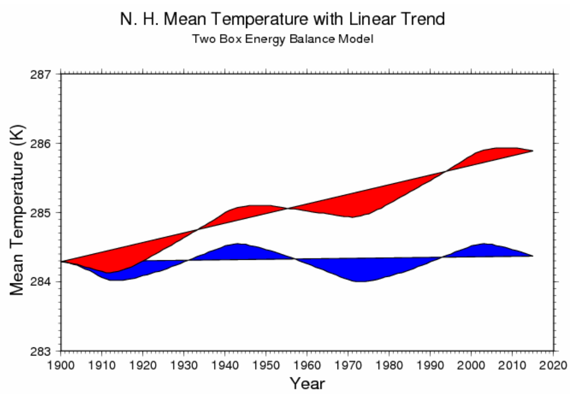


Figure 1. Time change in normalized planetary albedo and a simple EBM simulation

Reference : Tanaka, H.L. and M. Tamura: Polar Science, doi: 10.1016/j.polar.2016.03.002, (2016)

Impacts of Climate and Vegetation Changes on Hydrological Processes in a Canadian Northern Research Basin

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Investigation of climate change impacts on snow and frozen ground processes in Arctic and subarctic regions is of great interest to water resources stakeholders and the climate change research community. Wolf Creek Research Basin (WCRB) in northern Canada, which has an archive of high elevation weather, snowpack, soils, and streamflow data, was selected to analyze the sensitivity and response of cold regions hydrology to climate and transient vegetation changes. A physically based semi-distributed hydrological model was developed from the Cold Regions Hydrological Modelling (CRHM) platform. The model was then perturbed on an annual or a monthly basis. Instead of direct application of regional climate model outputs with large biases when compared against local observations, monthly perturbed climate was reconstructed based on the historical observations and changes in monthly climatology. A sensitivity analysis shows that the impact of warming on peak snowpack and annual runoff can be offset by an increase in precipitation. The increased precipitation needs to be greater than 5% in WCRB to offset the impact of 1°C warming on simulated peak snowpack and greater than 8% to offset the impact of warming by 5°C on annual total runoff. The impact of the same warming and precipitation change at different latitudes will not necessarily be similar and even though northern latitudes will warm up more, they will also have more precipitation and hence will be resilient to changes relative to mid-latitudes. A large decrease in snow accumulation, annual total runoff, and peak streamflow and lengthening of the snow-free period are expected under warming and decreased precipitation. Under monthly perturbed climate, sublimation from blowing snow, snow surface, and snow intercepted on the canopy drops in the study area. Not only climate changes but also vegetation and associated soil changes affect cold regions hydrological mechanisms. Vegetation changes act similarly to climate changes and decrease peak SWE at middle elevations, the spatial variability of peak SWE, and sublimation amounts. However, the impact of climate change is partially offset by the impact of vegetation change on peak SWE at high elevations, peak SWE timing, peak streamflow, ET, annual total runoff, soil moisture, and permafrost degradation. The models used here can be applied to investigate impacts of the combined climate and vegetation changes and to detect snow and streamflow regime shifts due to transient vegetation and soil changes.

Intrusion of Lower Latitude Warm-Moist Air Contributing to the Arctic amplification

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At Ny-Ålesund, Svalbard, two distinct winter atmospheric states are seen in downward longwave radiation (LD) during December 2015 and January 2016 (Fig. 1). After the cold state with the temperature around -10 to -20℃, a warm state with plus temperature appears and LD increases from about 170 to 320-330 W/m^2. This abrupt and large increase of LD might be due to the change of cloud condition, from clear to overcast sky, which was examined from the cloud radar data taken during GRENE Arctic Climate Change Research Project. However, only the cloud change could not explain this large change of LD. Looking at the atmospheric circulation patterns (500 GPH from ERA-Interim; Fig. 2), during the warm state, distortion of tropospheric polar vortex appears with a high pressure ridge (blocking high), and downstream of the ridge, strong low and intrusion of warm and moist air from the Atlantic Ocean influences the warming at Svalbard. This situation is just as pointed out by Yamanouchi and Orbeack (1995) in the past. This analysis period was widely discussed due to the record high temperature in the Arctic (North Pole; Moore, 2016; Kim et al., 2017; Graham et al., 2017; Overland and Wang, 2016).

Mauturilli and Kayser (2016) pointed out the increase of atmospheric water vapor amount in these 20 years at Ny-Ålesund, due to the increase of frequency of southerly winds observed by the aerological observations. Then, longwave radiation and cloud amount increased (Yamanouchi, 2007; Maturilli et al., 2015), and corresponded to the increase of frequency of the warm state introduced above. This intrusion of warm-moist air from the lower latitude is one of the major processes contributing on the Arctic amplification, just as proved using GCM by Yoshimori et al. (2017). The regional feedbacks in the Arctic atmosphere are induced by the change in atmospheric heat transport. The remote forcing due to the surface warming in the lower latitudes is predominant compared to the local response of the Northern high latitudes to the CO_2 increase. The increased moisture transport from lower latitudes warms the Arctic in winter more effectively not only via latent heat release but also via greenhouse effect of water vapor and clouds. So, the surface warming due to anthropogenic CO_2 increase in the lower latitudes is the major origin of Arctic amplification (AA). But still natural variability might also be controlling the effectiveness of AA.

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Yoshimori, M., A. Abe-Ouchi and A. Laine, 2017: Clim. Dyn. DOI 10.1007/s00382-017-3523-2.

S1-O07

Cancelled

S1-O08

Maintenance mechanism of a long-lasting polar low observed over the Barents Sea in January 2011

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This study documents the life cycle of an unusually long-lasting polar low (PL) observed in January 2011, through a comprehensive analysis of in situ shipboard measurements, satellite and reanalysis products, and numerical simulations. Figure 1 shows a sequence of cloud top pressure levels overlaid on sea level pressure. The PL lasted for more than 3 days, which was atypical, since only 10% of PLs lasted more than 1 day [1]. The maintenance mechanism of this PL was analyzed, with special emphasis on condensational heating and related moisture supply. During the development phase, strong condensational heating extended from the low to the upper troposphere and reached its maximum in the middle troposphere. Horizontal moisture transport accompanied with northward migration of a preceding low was important during this phase. During the mature phase, however, low-level clouds played a significant role in maintaining the PL. Evaporation from the sea surface compensated moisture loss caused by divergence of the horizontal moisture transport, and was essential for the moisture supply. The simulated PL decayed rapidly when surface evaporation was switched off after the development phase. These results indicate that increases in horizontal moisture transport and surface evaporation in the Arctic have the potential to affect the lifetime of PLs.

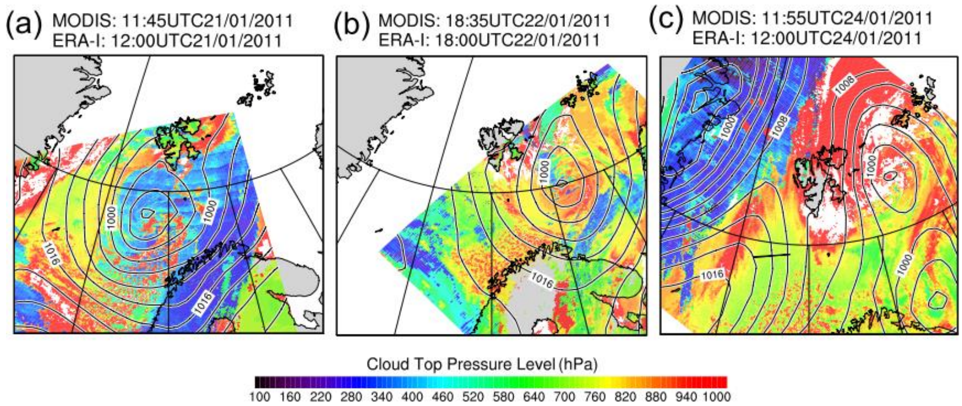

Figure 1. Cloud top pressure level (areas shown in color) overlaid on sea level pressure (contours) in hPa at around (a) 21/12:00, (b) 22/18:00, and (b) 24/12:00.

This work was supported in part by Arctic Challenge for Sustainability and the Japan Society for Promotion for Science through a Grant-in-Aid for Scientific Research (17H02958, 16H04046, and 16H01844).

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January 17

Breakout Session

G7

Geospace

G07-O01

Multi-Year Analysis of Arctic Gravity Waves Over Alaska Across the Atmospheric Layers and Into The Near-space Environment

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A four-year observation period of wave dynamics and coupling across atmospheric layers over Alaska was achieved between 2011-2015. The project was a collaborative effort between Utah Valley University, University of Alaska, Fairbanks, and Utah State University. The study involved measurements from the NICT Rayleigh lidar, the UVU airglow imager, and the PFISR incoherent scatter radar systems, with each instrument contributing knowledge regarding different parts of the wave spectrum and spanning an altitude region from ~40 - 500 km. The overarching objective was to characterize the observed waves and address their variability including impacts of stratospheric weather systems. In the study presented here, four years of data have been analyzed to investigate wave characteristics, year to year and seasonal variability, and correlate the observed wave parameters to stratospheric weather phenomena including the Aleutian low, the polar vortex, and sudden stratospheric warming events. Furthermore, a ray-tracing model has been employed to investigate the source regions of the mesospheric waves and how it relates to the local tropospheric wave sources. The presentation will also briefly discuss new initiatives for upper atmospheric gravity wave dynamics in the Arctic.

Gravity Wave Propagation and Dissipation in the Arctic Region and Connection to Vertical Coupling

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Gravity wave (GW) propagation and dissipation in the middle and upper atmosphere have great implications for the thermal and dynamical structure of the global atmosphere [1]. Here I present simulation of GW-induced coupling in the high-latitudes, using a general circulation of the atmosphere extending from the lower atmosphere to the upper thermosphere. A state-of-the-art whole atmosphere GW parameterization [2] is used in order to incorporate the effects of subgrid-scale GWs. GWs demonstrate substantial latitudinal variability in terms of propagation and dissipation conditions and impact the diurnal migrating tide in the middle atmosphere and thermosphere. At Arctic latitudes, GWs encounter often favorable propagation conditions, owing to an interplay of background circulation and wave dissipation as illustrated in Figure 1, where GWs propagate up to 300 km at a Northern Hemisphere high-latitude.

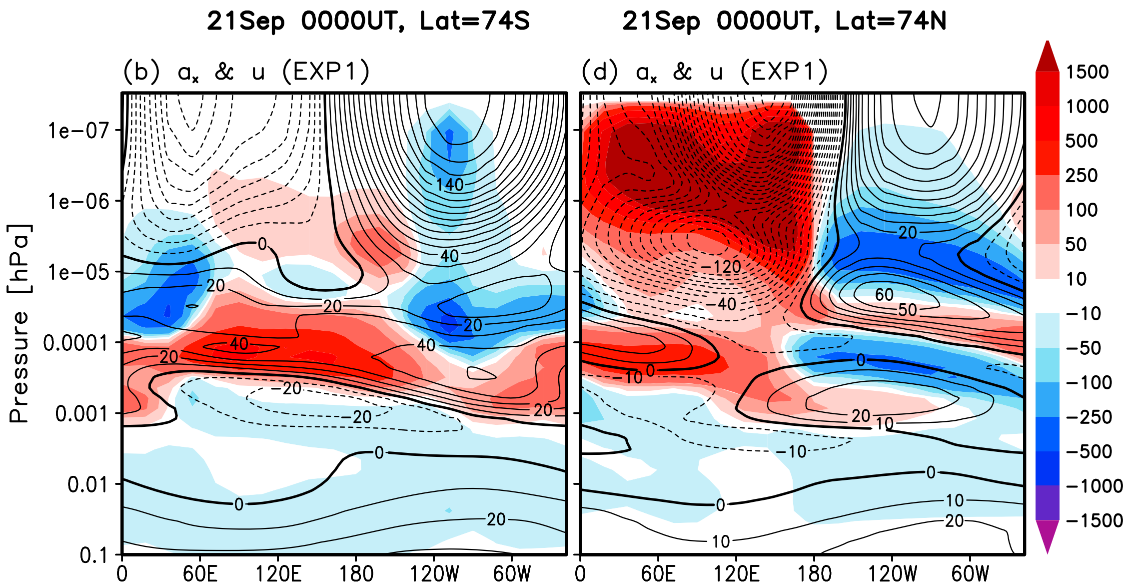

Figure 1. Gravity wave propagation and effects (shaded, in m/s/day) and zonal wind (contour, in m/s) at two representative high-latitudes at September equinox as simulation by the Coupled Middle Atmosphere Thermosphere General Circulation Model-2 incorporating the whole atmosphere GW parameterization [2].

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G07-O03

Impacts of thermospheric gravity wave on the Ionospheric variability in the Arctic region simulated by GAIA

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[2]*NICT, Japan*
[3]*Seikei University, Japan*

It has been recognized that gravity waves (GWs) play an important role on the variability in the Thermosphere-Ionosphere system. In this study, impacts of thermospheric GWs on the variability in the ionosphere are examined using a whole atmosphere-ionosphere coupled model (GAIA: horizontal resolution 100km). The GAIA contains the region from the ground surface to the upper thermosphere, so that we can simulate excitation of GWs in the lower atmosphere, their upward propagation into the thermosphere, and their impact on the Thermosphere-Ionosphere system. Furthermore, the GAIA includes coupling processes between neutral atmosphere and plasma. This means that GAIA can simulate ionospheric variability excited by the thermospheric GWs propagating from the lower atmosphere. We investigate behaviors of ionospheric variability simulated by GAIA. In particular, we focus four attention on the ionospheric variability in the Arctic region. The relation between the ionospheric variability and thermospheric GWs are discussed in detail in this study.

G07-O04

Coupling Between Tidal and Planetary Wave Modes in the Mesosphere and Lower Thermosphere

P.J. Espy[1,2*], N. Stray[1,2] and R.E. Hibbins[1,2]

[1]*Norwegian University of Science and Technology (NTNU), Trondheim, Norway*
[2]*Birkeland Centre for Space Science, Bergen, Norway*

Individual spatial modes from tidal and planetary waves are known to structure the ionosphere. However, wind observations from a single station, even those that image over scales much smaller than these waves, produce a time-series from which only the net period and phase of the total superposed spatial wavenumber components can be derived. Thus, neither the amplitudes of the individual wave modes nor the interactions between them can be observed. While satellite data can give both temporal and spatial components, the time and spatial information is generally not separable without assuming stationarity.

Here, hourly mean meteor wind data from a longitudinal chain of 8 high-latitude northern hemisphere SuperDARN radars have been combined in order to provide the spatial tidal and planetary wave components as a function of time. This has been used to extract the migrating and non-migrating components of the semidiurnal tide, as well as the S1 and S2 planetary wave components in the lower thermosphere meridional wind between 1995 and 2016. Since these measurements can separate the individual wave modes, they will provide a valuable resource for future observations from the EISCAT 3D system.

We find that the semidiurnal tide is dominated by the migrating (W2) component, though small but significant W1 and W3 contributions to the semidiurnal tide occur, especially around the equinoxes. Similarly, the S1 planetary wave amplitudes in the northern hemisphere are generally largest, but there are periods where the S2 mode becomes dominant. Due to their large amplitudes in the northern hemisphere, these planetary wave modes can couple into individual tidal components and may enhance their presence in the ionosphere. Data analysis and validation will be presented, together with initial results on the inter-annual variability of the tidal and planetary wave components and their possible coupling to the ionosphere

G07-O05

Millimeter-wave spectrometer for monitoring minor constituents in the middle atmosphere at Tromsø

A. Mizuno[1*], T. Nakajima[1], S. Nozawa[1], T. Nagahama[1], T. Kawabata[1], K. Haratani[1], H. Iwata[1], and K. Suzuki[1]

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Since 2012, we have been carried out the ground-based millimeter-wave monitoring of nitric oxide (NO) at 250.796 GHz and ozone (O_3) at 235.709 GHz at Syowa station in Antarctica in collaboration with the Space and Upper Atmospheric Sciences Group of NIPR. The main objective of the monitoring is to study the influence of energetic particle precipitation (EPP) related to the solar activity on the polar atmosphere. We have detected several significant events of short-term (several days) sporadic enhancement of NO related to EPPs (e.g., Isono et al. GRL, 2014, Isono et al. JGR, 2014), but the enhancements are apparently different between the polar night period and the midnight sun period because the NO chemistry is not only sensitive to the EPPs but also UV radiation. To study the short-term NO enhancement process in more detail, we planned to make comparative analyses based on the simultaneous observations from both the northern- and southern-polar regions and decided to install a millimeter-wave spectrometer at the EISCAT site in Tromsø, Norway.

The basic feature of the millimeter-wave spectrometer is almost the same as the one operating at Syowa, i.e., equipped with a 4K-cooled low-noise superconductive receiver for 250 GHz band and a digital FFT data processor with an instantaneous bandwidth of 1 GHz. We started development of the infrastructure in September 2015 in cooperation with UiT The Arctic University of Norway. We put an observing container just next to the Sodium Lidar facility operated by Dr. Nozawa. All the instruments for the millimeter-wave spectrometer were transported to the site by October 2016, and the assembly and adjustment of the spectrometer system were completed in March 2017. The results of the test observation of NO and ozone were well, but at that time, we could not start the continuous monitoring because of air-conditioning problem, i.e., the temperature of the observing room rose too high. To solve this problem, in the end of September 2017, we made a hole and put a ventilator on the roof of the observing container to evacuate the hot air, and the hot air is guided by a duct to the zenith window on the roof to blow out the snow on the window. We will start the continuous monitoring in October 2017.

In the presentation, we will report the latest progress of the spectrometer system and the measurements. Also, we will mention our future plan of updating of the instruments which enable multi-line or multi-frequency millimeter-wave spectroscopy.

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G07-O06

Temporal and spatial variations of the ionosphere and plasmasphere during geomagnetic storms as seen in global Total Electron Content (TEC) data

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[2]*National Institute of Information and Communications Technology, Japan*

The global structure of the ionosphere and plasmasphere is drastically changed during geomagnetic storms, and the response of the ionosphere and plasmasphere to geomagnetic disturbances is very complicated. Previous studies showed (1) a large enhancement of Total Electron Content (TEC) in the equatorial and middle-latitude regions within a few hours during a severe geomagnetic storm [Mannucci et al., 2005], and (2) appearance of storm-enhanced electron density (SED) from middle to high latitudes [Foster, 1993]. However, these studies did not investigate detailed temporal and spatial variations of the ionosphere and plasmasphere with high time resolution during geomagnetic storms on the basis of global TEC data analysis. In this study, we clarify the temporal and spatial variations of the ionosphere and plasmasphere during geomagnetic storms with the global TEC data. In this analysis, we used the geomagnetic Kp and SYM-H induces and global TEC data. These data are provided by World Data Center for Geomagnetism, Kyoto University, and Dense Regional And Worldwide INternational GNSS-TEC observation (DRAWING-TEC) project, NICT [Tsugawa et al., 2007], respectively. We first produced a global distribution of the 10-day quiet-time average TEC in a month of investigated storm events. As a next step, we created a global map of difference of TEC (d-TEC) in between the storm-time and geomagnetically quiet periods, and investigated the global variation of the d-TEC during the main and recovery phases of geomagnetic storms. After the sudden commencement identified as a step-like increase of the SYM-H index, d-TEC began to increase in the middle-low latitudes (30-55 degrees) of the morning sector (9-10 h, LT: local time). As geomagnetic storms grow, the enhanced d-TEC region expanded to the afternoon sector (15 h, LT) within 4-5 hours. 4 hours after the start of the main phase, the decreased d-TEC region with a line structure in a longitudinal direction, which is identified as an ionospheric trough, appeared in the afternoon sector (14-17 h, LT). The location moved equatorward with a wavy structure with a scale of 500-1000 km in a longitudinal direction associated with the development of geomagnetic storms. On the other hand, in the high-latitude region (more than 60 degrees, GMLAT) of the morning sector (10-12 h, LT), a plume-like structure of d-TEC appeared, which corresponds to the SED phenomenon.

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G07-O07

Anomalous ambipolar diffusion observed using meteor radars in the Arctic

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[3] *The Arctic University of Norway, Norway*

Ambipolar diffusion coefficients are estimated through radar echo decay rates of ionized meteor trails. Information of neutral atmosphere temperature in the lower thermosphere can be further deduced from the ambipolar diffusion coefficient when electron and ion temperatures can be assumed the same with the neutral atmosphere temperature [1-3]. We found that the ambipolar diffusion in the polar mesopshere was sometimes anomalously enhanced in Arctic meteor radar observations. Comparison with collocated Na lidar and EISCAT radars in Tromsoe showed that such enhancements were not observed in neutral temperature field, and that enhanced electric field in the lower thermosphere seemed responsible for enhancing electron temperature through Farley-Buneman instability [4] and subsequent anomalous ambipolar diffusion. This further indicates that meteor radar observations in polar regions have a potential to give a certain measure of electric field in the lower thermosphere and even the upper mesosphere, which is very difficult to observe without an incoherent scatter radar.

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G07-O08

Cancelled

G07-O09

SuperDARN HOkkaido Pair of (HOP) radars: Powerful tools for monitoring the ionosphere and upper atmosphere in the arctic region

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The Super Dual Auroral Radar Network (SuperDARN) is a network of HF radars deployed under the international collaboration between about 10 countries. As of September 1, 2017 there are total of 36 SuperDARN radars, 23 in the northern and 13 in the souther hemispheres, continously monitoring the ionosphere and upper atmosphere in the high- and mid-latitude regions. Among them, the Hokkaido Pair of (HOP) radars, located in Hokkaido, Japan, are the radars located at the lowest geomagnetic latitude, having part of field of views in the arctic region (Figure 1). Using this unique geographic location, the radars have been yielding a lot of scientific results, covering the area ranging from the magnetosphere / ionosphere to the thermosphere / upper mesosphere, since their deployment (Hokkaido East in 2006 and Hokkaido West in 2014) and total of 34 papers, with HOP radars data playing important roles, have been published in international peer-review journals. Main scientific achievements of the HOP radars are as follows:

1) Clarification of detailed characteristics and their interpretation of sub-auroral / mid-latitude ionospheric responses to Interplanetary Magnetic Field (IMF), solar wind parameter changes and substorms
2) Clarification of detailed characteristics of magnetohydrodynamic (MHD) waves in the ionosphere and magnetosphere
3) Clarification of detailed characteristics and their interpretation of Large-Scale / Medium Scale Traveling Ionospheric Disturbances (LSTIDs / MSTIDs)
4) Clarification of characteristics of ionospheric disturbances due to the 2011 Tohoku Earthquake, including the finding of disturbances propagating up to 6 km/s
5) Clarification of characteristics and their quantitative modeling of sudden ionospheric changes due to solar flares

Summary of the latest scientific achievements and future perspective will be presented.

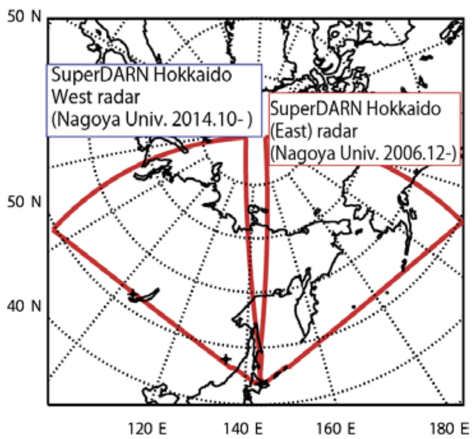

Figure 1. Field of view of the SuperDARN HOP radars.

G07-O10

China-Iceland Joint Aurora Observatory (CIAO) at Karholl

Hongqiao Hu*, Huigen Yang and Zejun Hu

Polar Research Institute of China, China

Iceland, with magnetic latitude of 66°, located under auroral oval, is a good ground-based platform for magnetotail dynamics observation, especially for substorm observation. Under cooperation with Icelandic Centre for Research (RANNIS) and Icelandic institutions, PRIC is establishing the China-Iceland Joint Aurora Observatory (CIAO) at Kárhóll, Northern Iceland. The scientific objectives of CIAO are to establish a permanent observatory of aurora, for space physics research, for space weather monitoring, and for aurora and geo-science outreach. In this talk, CIAO will be introduced.

January 17

Breakout Session

G8

Policies and Economy

International Science, Policy, and Fisheries in the Central Arctic Ocean

H.P. Huntington[1*] and F. Ohnishi[2]

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[2] *Arctic Research Center, University of Hokkaido, Sapporo, Japan*

The five Arctic coastal states and five distant-water fishing jurisdictions are currently negotiating a fisheries agreement for the international waters of the central Arctic Ocean. Although no fishing has ever been done in these waters, an international agreement will prevent illegal, unregulated, and unreported (IUU) fishing and potential damage to the ecosystem. Reaching agreement requires aligning the objectives of the coastal and distant-water interests. An important step in this direction is developing an international scientific effort to study the central Arctic Ocean ecosystem to provide a basis for ecosystem-based fisheries management, if and when there are commercially viable fish stocks in these waters. The central Arctic Ocean is remote and, for most of the year, ice-covered, making research there expensive and technologically challenging. No nation is likely to bear all the costs necessary to study the region, and few nations have enough ice-capable research vessels to do so even if they wanted to. Therefore, international cooperation will be necessary to gather sufficient data to move beyond a precautionary approach of not fishing. All the parties in the negotiations have active Arctic Ocean research programs, including many international efforts. There is, however, no single organization or program that includes all the potential parties to the agreement or that has the responsibility to compile, analyze, and report fisheries-related data to the signatories. A transparent mechanism for data sharing, research coordination, and assessing the status of fish stocks and ecosystem health for the central Arctic Ocean will do a great deal to foster continued international cooperation in policy and fisheries management as well as science. This presentation will outline the principles upon which collaborative scientific work in the central Arctic Ocean should be based and how such an effort can build on international research efforts already underway.

Abstract submission for ISAR-5, Tokyo 2018, Japan

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Paper Title Arctic security: A cooperative move for building human secure transnational society

Key Words: Arctic, human security, climate change, environment

The Arctic – geographical space – located in the circumpolar north, administered by southern capitals of eight countries, perceive traditionally unique characteristics. The region is considered as the earth's final pristine environment. It has both distinct biodiversity represented by charismatic fauna and flora, and cultural diversity represented by diverse groups of indigenous peoples. Today, the region is being transformed rapidly, mainly due to the consequence of climate change. On one hand the implications being environmentally devastating, result in multi-dimensional threats to humans, animals and plants. On the other hand, the implications bring new economic opportunities as access to the region becomes easier with increasing ice-free sea routes, and increase in navigation, which eventually lead to intensify commercial activities including resource usage – Artic is known to be a resource rich region. This paradoxical development, some argue, would cause geopolitical tension putting the region at risk of military confrontation. Against this background, in this presentation, I look at Arctic security dynamics – whether the dynamics bring high politics in Arctic security framing. Given the renewed understanding of security developed throughout almost last two and half decades, I argue that Arctic does not foresee any military confrontation per se. Rather, various challenges facing the region give rise to human and societal concerns making it as a human security region. Actors both within and beyond the Arctic live with this reality, and as such, the region being highly institutionalized, high political debate co-exist with soft cooperation move for making the region a transnational human secure society.

G08-O03

Economic Development of the Arctic Regions of Russia: Analysis of Regional Budgets

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The purpose of the paper is to examine the financial sustainability of the Arctic regions of Russia, concentrating on the analysis of regional budgets (analysis of consolidated regional budget implementation data released by the Federal Treasury of Russia). Since the Russian Arctic areas are vast and significantly different from each other, we cannot generalize them and single out a typical Arctic region. Instead, in previous work, we have distinguished three types of region [1]. We follow this approach in this paper as well. I analyze seven regions of the Arctic Zone, i.e., Murmansk Oblast, Arkhangelsk Oblast, Nenets Autonomous Okrug (AO), Yamalo-Nenets AO, Krasnoyarsk Krai, Sakha Republic and Chukotka AO, excluding Komi and Karelia Republics, since only a few district of these two regions are included in the Russian definition of the Arctic Zone.

I pay special attention to tax and non-tax revenues, transfers from federal to regional budgets, balance of regional budgets and financing of budget deficits, taking into account different kinds of transfers from federal to regional budgets (dotation, subsidy, subvention etc.). According to Russia's budget and tax legislations, extraction taxes and export duties are two of the most important taxes on oil and gas, and these are exclusively revenues of the federal budget. The regional budget in oil and gas producing regions receives corporate and asset taxes from oil and gas companies (Figure 1).

Having analyzed these data, I will consider the contribution of the state to the development of the Arctic regions, especially the significance of the state program "Socio-economic development of the Russian Arctic zone until 2020," adopted by Government Resolution No. 366 dated April 21, 2014.

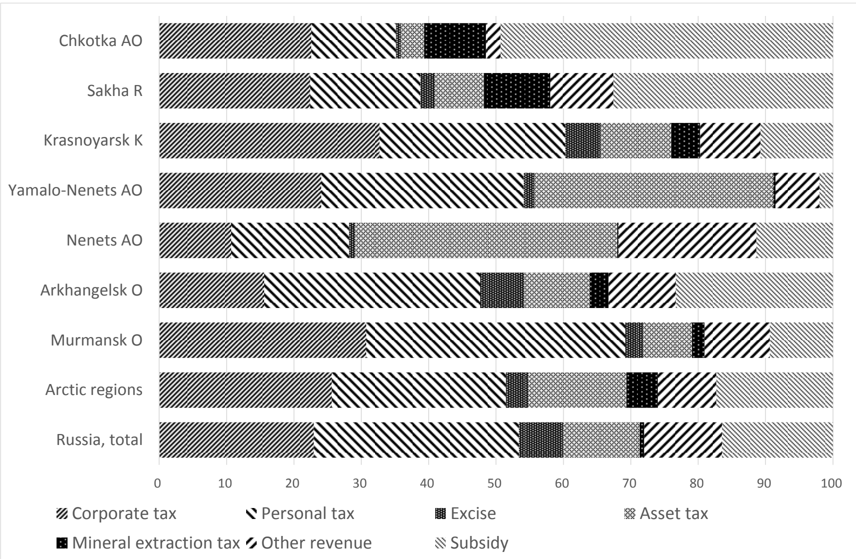

Figure 1. Structure of regional budget revenues in 2016, in percent

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G08-O04

Modeling the formation of income and resources of the local population of Sakha (Yakutia)

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Within the framework of the international scientific project COPERA, a group of researchers, including speakers, study the volume and structure of production and consumption of heat and energy in the Republic of Sakha (Yakutia). The object of research is also the consumer behavior of the population as a special factor of carbon emission in cold northern conditions. To this end, in 2017, a survey of local population "Comparative analysis of sources of income generation and the problem of poverty in traditional communities of the northern regions" was conducted on a wide range of issues: employment including trades&fisheries, social protection, life strategy for the coming years, usage of personal transport and modern means of communication, the problem of access to natural resources, etc. The poll was conducted in the northern Arctic settlement - Chokurdah and in the southern Arctic one - Ust-May. The results are compared and docked with official statistics. The results of the study are presented in the report. The system of subsidizing the consumption of thermal and electric energy was studied. It is proved that subsidizing does not stimulate the saving of resources.

G08-O05

Russian climate policy after the Paris Agreement: Perspectives of the North

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The report is within the RFBR project № 15-54-71003 (Belmont Forum) «C budget of ecosystems and cities and villages on permafrost in Eastern Russian Arctic – COPERA».

Negative climate changes counteraction is the first global project in the history of mankind, designed to ensure the sustainable development principles gradual implementation.

The meaning of the Paris Agreement from the standpoint of the involved parties obligations lies in the principle of the voluntary contribution of each participant to the global climate problem solution. The "indicative nationally defined deposits (NDC)" were announced by 156 countries on the conference` eve and altogether cover 95% of global emissions.

Russia as one of the largest countries in the world should form its response to the challenge of global warming. Paris agreement was signed by Russia on April 22, 2016, with 175 countries joining it. For its ratification in 2017 a Government Report with the assessment of macroeconomic consequences of agreement ratification is to be developed and be March 2020, that is just before the beginning of the agreement, the Action plan is to be developed.

Russia's obligations under the Paris Agreement are to achieve by 2030 year emissions volume in 70-75% to 1990 year level with the possibility of variation depending on various factors, such as the level of technological cooperation with developed countries, and in conditions of maximum consideration of carbon dioxide absorption (hereinafter — CO_2) by Russian forests ... It is important to note, that currently the volume of greenhouse gas emissions of the Russian economy is about 69% to the 1990 year level (mainly due to a fall in industrial production) — thus the goal determines Russia's possible increase the volume of emissions.

The national model of carbon regulation should be worked out by June, 2018, when the draft federal law "On the State Regulation of greenhouse gas emissions" is to be presented. So far, Russian legislation has no definition of greenhouse gases; they do not pose direct health threat and therefore do not belong to substances, emissions of which are the subject of Federal Law No 7-FZ "On Environmental Protection" regulation. The concept of system for monitoring, reporting and verifying the volume of greenhouse gas emissions in the Russian Federation was approved in 2015, but has not yet begun to work.

One of the principles of the Paris Agreement is the consideration of "various national circumstances", which brings to the fore the issue of an adequate assessment of the absorbing potential of Russian forests (in relation to CO_2). Russia's carbon balance plays an important role in the global carbon budget, thanks to the vast areas of forests. About 45-49% of the territory - forests, 25% - tundra and marshes, 16% - agricultural and meadow lands, 10% - water spaces. The total area of forests in Russia is 886,5 million hectares[1], of which 29% are boreal forests of Yakutia. The boreal forests form a kind of "green belt", covering the Northern Hemisphere a strip of different widths and passing through Russia, Alaska, Canada and Scandinavia, they protect humanity from environmental catastrophe by absorbing free carbon.

One of the urgent scientific tasks is the integration of climatic and socio-economic models, including spatial ones. Paper will discuss Russian policy perspectives.

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1 Square of forests and forestry resources [Electronic resource]. - Asses mode: http://forest-russia.narod.ru/.

G08-O06

Perspectives of Carbon Tax Implementation in Russia

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The report is within the RFBR project № 15-54-71003 (Belmont Forum) «C budget of ecosystems and cities and villages on permafrost in Eastern Russian Arctic – COPERA».

The carbon tax is seen as a prospective mechanism for the implementation of Russia's obligations arising in connection with the signing of the Paris Climate Agreement in April 2016. This tax is a part of the global "green finance" that is rapidly developing.

High energy intensity of the Russian economy due to the objective climatic and geographic features of the country as well as to the chronic technological backwardness will restrict national model of carbon regulation for several more decades. But Russia as one of the largest countries in the world should form its response to the challenge of global warming. New instruments of fiscal policy, including carbon tax can be effective if the tax system greening to be gradual and will not force sharp financial pressure on energy consumers.

A number of approaches within the Russian current taxation system can be realized: (1) Environmental payments, with Carbon Tax included in payments for negative environment impact the in terms of emissions into the air by stationary sources; (2) Carbon tax share in VAT paid by consumers of electricity and heat, oil products allocation; (3) Excise duty establishment of for motor gasoline, straight-run gasoline, diesel fuel, motor oils produced in the territory of the Russian Federation.

Russia's carbon balance plays an important role in the global carbon budget, thanks to the vast areas of forests. About 45-49% of the territory - forests, 25% - tundra and marshes, 16% - agricultural and meadow lands, 10% - water spaces. The total area of forests in Russia is 8,865 million square meters[1]. Ensuring sustainable development requires a balance of interests of the state, business and civil society. Introduction of a carbon tax can become a significant tax risk for the companies. One of the possible instruments for achieving this is the formation of the "corporate forests" or "ecosystems that are in the company's responsibility" within the framework of public-private partnership projects that, in addition to carrying out works to protect, reproduce the natural environment, could become the function of instrumental monitoring of emissions and removals CO_2.

Based on satellite imagery of Google Maps and Autodesk AutoCAD 2012 approximate calculation of annual carbon savings is made for diamond enterprise ALROSA, located in Mirninsky and Nyurbinsky districts of Yakutia in scenario of carbon tax and system of corporate forests implementation. The possible annual savings amount is up to 1,663 million US dollars at a carbon tax rate of 15 US dollars / tonnes CO_2 and 3.879 million US dollars at a rate of 35 US dollars / tonne of CO_2.

We come to the conclusion that private-public approach in forest management development will encourage enterprises to expand the radius of the zones, the larger the area of CO_2 absorbing the corporate natural environment, the greater the savings in payments for greenhouse gas emissions and positive effects the changing climate efforts.

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1 Square of forests and forestry resources [Electronic resource]. - Asses mode: http://forest-russia.narod.ru/.

January 17

Breakout Session

S15

Technology, Infrastructure and Human Space in the Past and Present of Northern Regions

The influence of Japanese technology on the Ainu

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The Ainu are native Japanese who lived on the island of Hokkaido. Hokkaido has a temperature climate, sits 41°-45° from the equator and endures heavy snow in winter. Until the latter half of the 19th Century, Hokkaido was a relatively unpopulated, wilderness terrain. The Ainu were a society that lived off hunting, fishing and trade. Their relations with mainland Japanese changed in the 15th Century, when the Japanese established a colony on the southwest side of Hokkaido. In this presentation, I would like to describe the influence Japanese technology had on Ainu society in the early modern era.

Trade with Japan had a great effect on the Ainu. The import of goods from Japan expressed a social status. The traded goods would be used as barter to pay in contract agreements and even as compensation for crimes. The increased wealth also brought increased inequality [1]. It could therefore be argued that the import from Japan stimulated a class society among the Ainu.

“Benzai-sen” were boats that transported goods all across Japan. These wooden boats had large cotton sails and could load about 150 tons of cargo [2]. They were essential for expanding Japan trade routes including those into Hokkaido.

Ainu boating technology was relatively primitive and amounted to little more than canoes. The smaller version was used for fishing and fit only two passengers. The bigger version could hold up to 30 tons of cargo and was intended for farther travel [3]. Either way, benzai-sen allowed for much larger trade and riches in resources.

Key to the advancement in shipping was the iron technology revolution. In the 16th and 17th centuries saw significant gains in iron technology in Japan, including tools designed for handling wood and farming. With regards to boating, the Japanese used this technology to produce large wooden boards[4]. They also were able to produce cotton in the 16th century. Thus, advances in iron technology were instrumental for the creation of bensai-sen..

It is well known that the iron revolution was essential for economic growth in Japan and had reverberating effects on the nation’s culture and society. As advances in trade indicate, there is evidence that the iron revolution had tremendous impact on the Ainu as well.

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S15-O02

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S15-O03

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S15-O04

Trying to understand the indirect impacts of Northern mine infrastructure: The Case of the Faro Mine

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Lakehead University, Canada

While increasing attention is paid to the social impacts of extractive resource activities in the Circumpolar North, less attention is paid to the infrastructure which is developed to enable these activities. While direct impacts of the construction phase of this infrastructure are often similar to the effects which concern northern communities, the indirect impacts, especially long-term, are less easily understood. Yet for some in the north, the long-term effects are those that are most important for the region. This paper will try and conceptualize the indirect impacts of extractive industry projects on northern communities using the Faro Mine which operated in the Yukon Canada from 1968 until the 1990s. It will examine the situation of new roads, hydro-electric facilities, and a new town.

S15-O05

High Tech for High North: Bringing remote northern communities closer to the rest of the world through information technology

A. Pestereva[1*]

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Reindeer and caribou have been very important for arctic livelihood for ages, however most of the world is reminded of reindeer only towards Christmas. Serious effects of climate change in the Arctic do not often concern population elsewhere in their everyday choices that may contribute to it. In Russia indigenous knowledge and land use practices have been traditionally shared within the communities, however this information is not always known or readily available for other actors, be that researchers, policy makers or business developers.

Two projects at UNI ARCTICenter help making remote northern communities closer to the rest of the world through educational outreach and knowledge sharing: iReindeer interactive educational module and indigenous knowledge community mapping portal.

iReindeer is a web quest gaming interface teaching K-12 students the basics of Arctic ecosystem functioning and reindeer/caribou migration using Taimyr Peninsula ecosystems and wild reindeer as an example. Open source mapping technologies enable creating the game set-up in a 3-D interactive environment using real world imagery and terrain data. In each level, based on real data (such as forage availability, climate, or predators), player interacts with a single aspect affecting the reindeer migration and learns about it along the way.

Indigenous knowledge community mapping portal represents a web GIS portal and accompanying technologies and methodologies enabling all interested participants themselves to collect, maintain and use spatial information regarding the traditional land use by indigenous communities of Russia.

Current information technology level, access and ubiquity make it possible to empower local indigenous communities to be in control of collection, sharing and utilizing their spatial knowledge, as well as engage broader population in learning about arctic ecosystems through an interesting interactive game with relatable character.

Session

Technology, Infrastructure and Human Space in the Past and Present of Northern Regions

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"Fashioning The New Arctic"

How long ago did a smartphone become an indispensable part of our life? Now, we got used to calling on Skype or WhatsApp and seeing our interlocutors... Ten years ago this was impossible. High-tech is everywhere in our lives. We can use a lot of new technologies in our research or our everyday life. But sometimes we forget that these technologies can be combined with other systems of knowledge and deployed to achieve societal goals, such as sustainable development. What do TESLA and reindeer herders may have in common? Are these two different worlds that going toward the common goal of sustainable future?

Forward-looking, innovative companies want to change our way of life by fostering sustainable technological and lifestyle options. Technology and automation instead of handmade crafts is changing today's production and business world, significantly affecting the relevant job market skills.

Indigenous people try to save our world in the different, but potentially complementary ways. Mutual learning and investment in joined efforts are likely to benefit of both. A whole generation of Arctic residents are growing up in the digital and connected world and now rely on technology for their daily activities. At the same time, Indigenous knowledge has been sustaining Indigenous communities for many centuries and still constitutes the fabric of Indigenous societies.

We did a marketing case study project which fulfill an unfilled market niche of Arctic, indigenous peoples by combining traditional and modern ways of dress into a new collection that represents the target market's traditional culture while being contemporary in style and therefore, accepted in urban societies. In addition, this project is designed to bring a source of economic development into rural regions of the Arctic by providing a sense of identity and improving the quality of life of urban communities. This project was launched by transformation of traditional beadwork and animal skin designs into computer aided design prints and patterns by a team of apparel design students enrolled in a fashion program in the United States. These print patterns were then printed as swatches and taken to Russia by the lead researcher to test market the designs within the indigenous Arctic population. Based on this research, a set of print patterns was chosen to move into the "Fashioning the New Arctic Collection" linked to the past by decorative patterns from traditional dress but restyled to appeal to a young urban consumer.

The launch collection of this empowerment brand has the potential to play a fundamental role in creating a new cultural identity for indigenous youth, and open the door to sustainable, economic development arising out of a traditional art form while remaining relevant to a growing urban demographic.

S15-O07

Innovative Arctic: Geography and Dynamics of Patented Innovation in Alaska

Andrey N Petrov and Salma Zbwewed,

ARCTICenter, University of Northern Iowa

In the last few years, Alaska's economy suffered as world oil prices plunged to very low levels and production declined. Modern economic development theories would suggest searching for alternative ways to manage northern regions. Investment in the knowledge-based economy seems to be one of the possible options. In Alaska, there have been very few studies of its knowledge economy. The key feature of a knowledge economy is a greater reliance on human capital than on natural resources, combined with efforts to integrate innovations in every stage of the production process. Patents are considered a good representation of innovative activity. We provide evidence drawn from patent data to document geography and dynamics in Alaska's knowledge production over thirty-five years (1976-2010). The results show that Alaska has considerable patent activity, especially in certain oil-sector-related industries, and strong clustering of innovation in major urban regions (Anchorage, Fairbanks, and Matanuska-Susitna boroughs). Alaska inventors, however, tend to be independent individuals ("lone eagles"), even though corporate innovation activity has been growing. In addition, small Alaska communities sometime demonstrate high levels of knowledge production in a few niche industries, articulating the importance of individual-driven and niche-based innovation in remote regions. Overall, between 1976 and 2010 Alaska's regional innovation system evolved from a small isolated system dominated by individual inventors focused on innovation in old, low-technology sectors to a relatively diversified (although still over-reliant on the oil sector) intra- and internationally connected system with a considerable presence of company-driven innovation, but with a strong position of individual inventors, including those from smaller communities.

S15-O08

GPS tracking of herds in the North: from methodological tool to object of study

Charlotte Marchina

"ASIES" Research Center, National Institute for Oriental Languages and Civilizations (INALCO), Université Sorbonne Paris-Cité, France

New technologies hold an increasing role in today's extensive herding techniques. Recently discovered algorithms will soon enable conceiving robots to replace sheepherder's dogs in Europe, and robot prototypes are being experimented with for driving cattle in Australia. In several Northern regions, technological developments mostly address the use of mobile phones and GPS. Sámi herders of Swedish Lapland have started to use GPS collars to follow their reindeer's movements from their smartphones [1]; and in the Inner Mongolia Autonomous Region, within the policy framework to implement an "ecological civilization", the Chinese government has encouraged herders to acquire GPS collars in order to settle them in modern villages [2]. Whether the initiative comes from the herders themselves or from the State, tracking the herds through GIS (Geographic Information Systems) creates new ways of being together for herders and animals.

In the frame of an interdisciplinary project combining social anthropology, geochemistry and archaeology, and which aims to study pastoral mobility in its evolution on a long-term scale [3], I started to use GPS collars to track herds in the Mongolian Altai, coupled with more classical anthropological fieldwork. Since June 2015, we are tracking the daily movements of a dozen of herd animals belonging to Kazakh nomadic herders. Not only these tools provide information that is impossible to access through classical surveying methods, such as occupied surfaces, distances travelled, travelling speed, and simultaneous movements of several individuals, but they also enable, for the first time, to observe inter-annual variations, directly linked to climatic transformations. My experience shows that herders themselves are very interested and sometimes even in demand of location-based data, which results from close collaboration with the scientist in the field, in the choice of the parameters of the device, and in the implementation process. Moreover, at a time when nomads of Inner and North Asia see their territories under dispute with multinational corporations coveting natural and fossil resources [3], it is even more evident that such devices and data could become of interest for herders.

The aim of this paper is thus to examine new technologies, mainly GPS collars used to track herds, not only as an object of study (that is, as used by the herders themselves), but also as a method (i.e. used by us as an investigation tool) and to propose a reflexive perspective on how these two approaches can mutually enlighten each other.

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January 18 2018

Keynote
Session presentation

Keynote speech 5

Coping with a warming winter climate in Arctic Russia: patterns of extreme weather affecting Nenets reindeer nomadism

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Sea ice loss is accelerating in the Barents and Kara Seas in the northwest region of Arctic Russia. Assessing potential drivers and linkages between sea ice retreat/thinning and maintenance of the region's ancient and unique social---ecological systems is a pressing task. Tundra nomadism remains a vitally important livelihood for indigenous Nenets and their large reindeer herds. Warming summer air temperatures in recent decades have been linked to more frequent and sustained summer high---pressure systems over West Siberia, but not to sea ice retreat. At the same time, autumn/winter rain---on---snow events across the region have become more frequent and intense. Here we review evidence for autumn atmospheric warming and precipitation increases over Arctic coastal lands in proximity to Barents and Kara sea ice loss. Two major rain---on---snow events during November 2006 and 2013 led to massive winter reindeer mortality episodes on Yamal Peninsula. Fieldwork with migratory Nenets herders has revealed that the ecological and socio---economic impacts from the catastrophic 2013 event will unfold for years to come. The suggested link between sea ice loss, more frequent and intense rain---on---snow events and high reindeer mortality has serious implications for the future of tundra Nenets nomadism. Nenets oral histories documented that smaller, more nimble privately owned herds fared better than larger collective herds. This strategy has already worked well for dealing with encroaching infrastructure. If Barents and Kara sea ice continues to decline, better forecasts of autumn ice retreat coupled with additional mobile slaughterhouses could help to buffer against reindeer starvation following future rain---on---snow events. Even a few days of early warning could make a critical difference. Realizing mutual coexistence of tundra nomadism within the Arctic's largest natural gas complex under a warming climate will require meaningful consultation, as well as ready access to – and careful interpretation of – real---time meteorological and sea ice data and modelling.

Community-led Monitoring and Ecological Restoration in the Arctic: History, Power and Resilience

Tero Mustonen

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The Arctic is in the middle of a monumental system shift [2] affecting the ecology, human societies and the position of the region in the global context. Monitoring of Arctic change is an increasingly interesting theme for the wider scientific community [2] as well as multinational corporations having vested interests in the Arctic resources and transport corridors and global assessments interpreting the speed, extent and quality of such change. Recent studies on effects of climate change [1] on biodiversity confirm the system shift to be on a planetary scale. Past monitoring efforts of the Arctic [2] have included the documented observations of the Indigenous and local-traditional peoples but these societies have not been seen as actors of change in themselves or an agency for independent adaptation [1]. This paper explores the top-down power histories of monitoring of the Arctic. It then provides alternate community-led examples of what has been called in scientific literature [3] "*dynamic governance and conservation*", responses and establishment of "safe havens" [1] for biodiversity and Indigenous peoples in the changing Arctic. Most specifically, the paper reviews the efforts under way in the Atlantic salmon catchment area of *Njâuddam* River in the Finnish-Norwegian sub-Arctic. The Skolt Sámi of the river system have successfully established community-based monitoring [4] detecting arrival of southern insect species and extreme weather events. This has led the Sámi to launch wide-scale Indigenous-led river ecosystem restoration, including renewed salmonid spawning areas and habitats, natural flows and a development of oral histories and cultural indicators of change that provides an independent monitoring feed alongside scientific studies of the catchment area.

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Evaluation of the Greenland Ice Sheet surface mass balance estimated by the NHM-SMAP regional climate model

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In the Greenland Ice Sheet (GrIS), the second largest terrestrial ice sheet, a significant loss of ice mass has been occurring since the early 1990s. Several recent studies revealed that a reduction in surface mass balance (SMB) plays more important role for the accelerated GrIS mass loss especially after 2009 rather than an increase in ice discharge. Although the GrIS SMB is often estimated by physically-based regional climate models (RCMs), uncertainties in the calculated SMBs are still large. To improve SMB estimates, we developed a 5 km resolution physically-based RCM combining the Japan Meteorological Agency Non-Hydrostatic atmospheric Model and the Snow Metamorphism and Albedo Process model (NHM-SMAP) with an output interval of 1 h, forced by the Japanese 55 year Reanalysis (JRA-55) (Niwano et al., 2017). Evaluation of NHM-SMAP applied in the GrIS was performed in terms of SMB during the 2011–2014 mass balance years. The ME (mean error), RMSE (root mean square error), and R^2 (coefficient of determination) values obtained during the study period were fairly good (0.75 m w.e., 1.07 m w.e., and 0.86, respectively) for a control simulation that calculates vertical water movement in snow and firn with the Richards equation. Because most RCMs calculate vertical water movement in snow and firn by a simple so-called bucket scheme, we performed additional numerical sensitivity tests to confirm the validity of the Richards equation scheme. According to results from the sensitivity tests that employed the bucket schemes with irreducible water contents of 2 % and 6 %, it was confirmed that the realistic Richards equation scheme contributed to the improvement in SMB estimates. Differences in the estimates of accumulated SMB for the entire GrIS were as great as 200 Gt year^{-1} between each simulation. This result highlights that the process chosen to simulate water percolation and retention in snow and firn thus plays an important role in estimating SMB for the present-day GrIS.

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Comprehensive Atmospheric Measurements at MOSAiC to Study Cloud-Atmosphere-Surface Interactions

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The central Arctic has undergone substantial change over the past couple decades, embodied by a vastly diminished sea-ice cover. As a result, the Arctic is opening to more human activities that require an improved ability to model the system on a range of temporal and spatial scales. Atmospheric processes pose some of the greatest challenges to modelling abilities in the central Arctic. These challenges are in part due to a dearth of detailed observations in this environment, but also due to the complexity of atmospheric processes and their interactions with the changing surface. Specific priority areas for central Arctic atmospheric research involve clouds, aerosols, precipitation processes, the boundary layers, and the roles that these play in the surface energy budget. The Multi-disciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC) will provide a unique opportunity to examine these Arctic processes and their contribution to the coupled Arctic system in great detail over a full annual cycle. A major contribution to this project will be made by the US Department of Energy's Atmospheric Radiation Measurement (ARM) Program with the deployment of the ARM Mobile Facility and Mobile Aerosol Observing System onboard the research vessel Polarstern. These facilities include a vast array of instruments to comprehensively measure the Arctic atmospheric system and address specific science themes including: (1) The surface energy budget of sea ice; (2) cloud and precipitation properties; (3) aerosol concentration and composition; and (4) the stable and unstable atmospheric boundary layer. Jointly these measurements, in coordination with others made during MOSAiC, will help to provide a process-level understanding of the Arctic system and specifically of how the atmosphere couples with other systems. They will also provide the basis for evaluating and improving process models and process representations in larger-scale models. This presentation will introduce the ARM measurement systems and outline the specific scientific research that will be enabled by these systems.

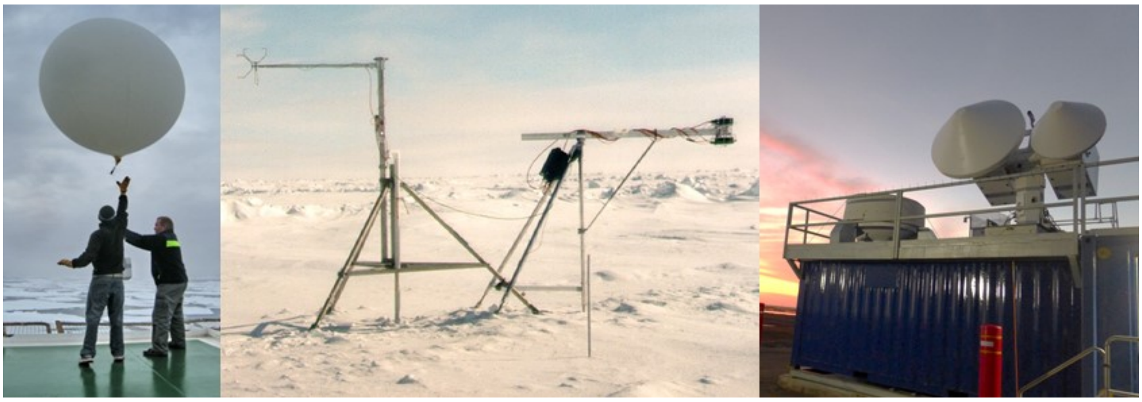

Figure 1. Example atmospheric measurements to be made at MOSAiC, including radiosondes, surface energy budget station, and scanning cloud-precipitation radars.

Heat transport from northern rivers to Canadian Arctic coast

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Northern rivers transport large amount of freshwater and thermal/geochemistry fluxes to the polar ocean system. Many recent studies document significant variations and changes in discharge, water temperature, and geochemistry characteristics in the large arctic watersheds. Based on recent data analysis and literature review, this presentation aims to synthesize our knowledge of northern river heat flux into the Canadian Arctic Ocean. It will describe the seasonal cycles of discharge, water temperature, and heat flux from the northern rivers and compare their main features across the pan-Arctic domain. It will also discuss basin specific results, such as statistical analyses and model simulations of historical changes and future projections of heat transport processes due to climate variation and human impact, particularly the effects of reservoir regulation. These results are critical for a better understanding of climatic and hydrologic linkages and variations over the northern regions. They are also important for regional hydrology and climate change investigations, such as basin-scale energy balance calculations, and land-ocean interactions, particularly large-scale ocean heat budget and model analyses across the arctic regions.

Early detection of changing pan-arctic wetland methane emission

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Pan-arctic wetlands is a large source of methane (CH_4) to the atmosphere, but its contribution to the observed global CH_4 anomalies and future climatic feedback remain poorly understood. Recent studies imply that the CH_4 emission from high-latitude is approximately stable, despite rapidly changing arctic environments. To resolve this discrepancy, we investigate the detectability of ongoing change in pan-arctic wetland CH_4 emission. Using results of multi-model simulation during 2000–2012 and multi-scenario projections with a process-based model (VISIT [1]) for the 21st century, we find that the small historical trends are attributable mainly to the insufficient analysis length, in addition to the 'hiatus' of climatic warming. Future projection analyses show that the CH_4 emission would increase by +22~46% by the 2030s and +61~94% by the 2060s, and be detectable in the near future, assuming continuous data accumulation. Aiming at optimizing future observational systems, we conducted observation-oriented analyses and specified responsive areas, focal period, and key emission pathways (e.g., ebullition at major circum-polar wetlands). These findings are noteworthy for climate management such as the Paris Agreement whether the given target is sufficient to prevent the arctic feedback.

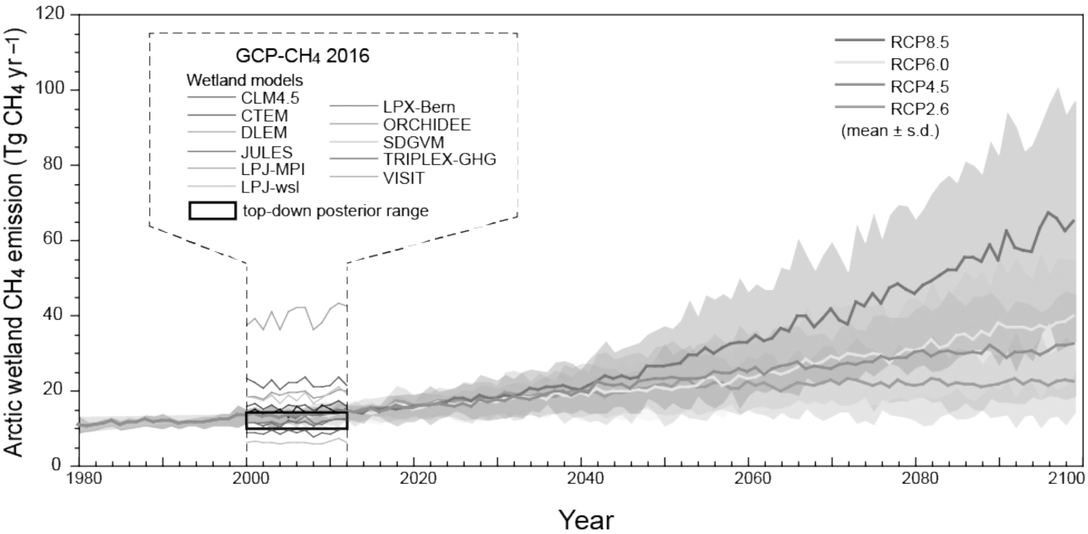

Figure 1. Simulated CH_4 emission from arctic wetlands in 1980–2099 and comparison with GCP-CH_4 models for the period 2000–2012.

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Assessing the Carbon Climate in the Upper Waters of a Changing Arctic Ocean

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The carbon system properties in upper waters of the deep central Arctic Ocean are largely determined by processes in the surrounding shelf seas. Substantial primary production occurs over the inflow shelves, the Barents, Bering and Chukchi seas, lowering the partial pressure of carbon dioxide (pCO_2). This is further amplified by cooling that increases the CO_2 solubility. Before the water equilibrates with the atmosphere it enters the ice covered central region, thus forming surface waters that are undersaturated by typically 50 to 100 µatm relative to the atmospheric pCO_2. In the upper halocline the conditions are the opposite, waters here are highly supersaturated with CO_2. This is the result of bacterial decay of organic matter occurring predominately at the sediment surface of the Chukchi and East Siberian seas. The decay products, CO_2 and nutrients, are added to a thin relatively high density bottom layer that is formed from brine draining out when sea ice is produced. This CO_2 rich, with pCO_2 levels of up to 1000 µatm, bottom water flow off the shelves and build up the upper halocline of large parts of the Canadian Basin. Climate change has an impact on the CO_2 conditions of both of the surface and halocline waters. Less sea ice in summer impacts the air-sea CO_2 flux and potentially also the brine formation in winter. Thawing of permafrost increases the transport of terrestrial organic matter to the shelf seas, which can result in higher pCO_2 in the upper halocline.

In this presentation historic seawater CO_2 chemistry data from the Arctic are compiled and presented to show the conditions as well as we know them. Unfortunately the temporal and spatial coverage is too limited to give a full view, stressing the need for a synoptic survey of the entire Arctic Ocean.

SP3-S11S13

The Global Arctic as a New Geopolitical Context – potential influences of Arctic actors beyond the (Arctic) region

Prof. Lassi Heininen[1]* and Prof. Matthias Finger, EPFL[2]

University of Lapland[1] and University of Akureyri[2]

To begin with, at the beginning of 21st century the Arctic as a geographical region is placed within the context of globalization and global geopolitics. Due to globalization what happens at the global level in terms of climate change, technology, industrial development, as well as social, cultural and political change, is not only affecting the Arctic; rather, it is transforming it. On the other hand, what takes place today in the Arctic, notably in terms of ice-melting, resource exploitation, transport, as well as knowledge-creation, stability-building, para- and science diplomacy affects the planet and accelerates the above global trends. At the same time, we have witnessed a sharp increase in the number of actors interested in the Arctic, and a great diversification has taken place in the background of actors involved. Thus, we have two interrelated systems and research foci, the Earth System and the 'globalized' Arctic. At the heart of our project lies a framework and a methodology for research about the globalized Arctic in the age of the Anthropocene: The *GlobalArctic* is interpreted here as a new geopolitical context, and used as a research method. This is the fresh point of view we will bring into the post-Cold War Arctic geopolitics with rather traditional debate between two narratives and perceptions: Whether the Arctic is a "zone of peace" based on the institutionalized cooperation, or, that there are disputes, growing tension and conflicts between states? In this presentation, not only the Arctic region is being transformed by global impacts, also the globalized Arctic and its actors have influences (in world politics and global economy) beyond the region. We will first, discuss the globalized Arctic as a new geopolitical context; second, examine and discuss roles of immaterial values - e.g., stability, shared knowledge, dialogue, interplay between science and politics - in international politics, as well as behind growing importance of the Arctic in international politics; and final, imagine how the global and stable Arctic could be interpreted as an asset to (re)shape international politics of turbulent times and world politics with 'uncommon instabilities'.

January 18

Breakout Session

G2

Ocean and Sea Ice

The Atlantic water inflow through the Fram Strait in a climate model

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The Fram Strait is the main pathway of the warm Atlantic Water toward the Arctic Ocean. Recent decline of sea ice extent is related to the warming of Atlantic water in the Arctic Ocean. Previous modeling study argued that the interannual variability of Atlantic water inflow and heat transport through the Fram Strait is caused by the variability of synoptic scale pattern of the wind around the Arctic Ocean (Kawasaki and Hasumi, 2016). Since they utilized an ice-ocean general circulation model, any interactions among atmosphere, sea-ice, and ocean have not been considered. On the other hand, the Fram Strait is the marginal ice zone, because the sea ice transported by the East Greenland Current from the Arctic Ocean reaches and melts due to oceanic heat of warm Atlantic water. Since the air-ice-sea interactions are large, the coupled system should be considered for examining the effect of wind stress on the heat transport through the Fram Strait. Thus, we investigate the interannual variability of heat transport and Atlantic water inflow by using a climate (air-sea coupled) model.

The ocean component of the climate model is horizontally high resolution (0.25 degree) model to simulate the Atlantic water inflow through the Fram Strait. The inflow and recirculation of the Atlantic Water in the Fram Strait is well reproduced in our model (Figure 1a, b). The warm Atlantic water reaches the Nansen Basin in our model. These results are not calculated in low-resolution ocean model in our previous study (Figure 1c). The wind stress and sea level pressure pattern inducing the interannual variability of Atlantic water inflow at the Fram Strait will be discussed in our presentation.

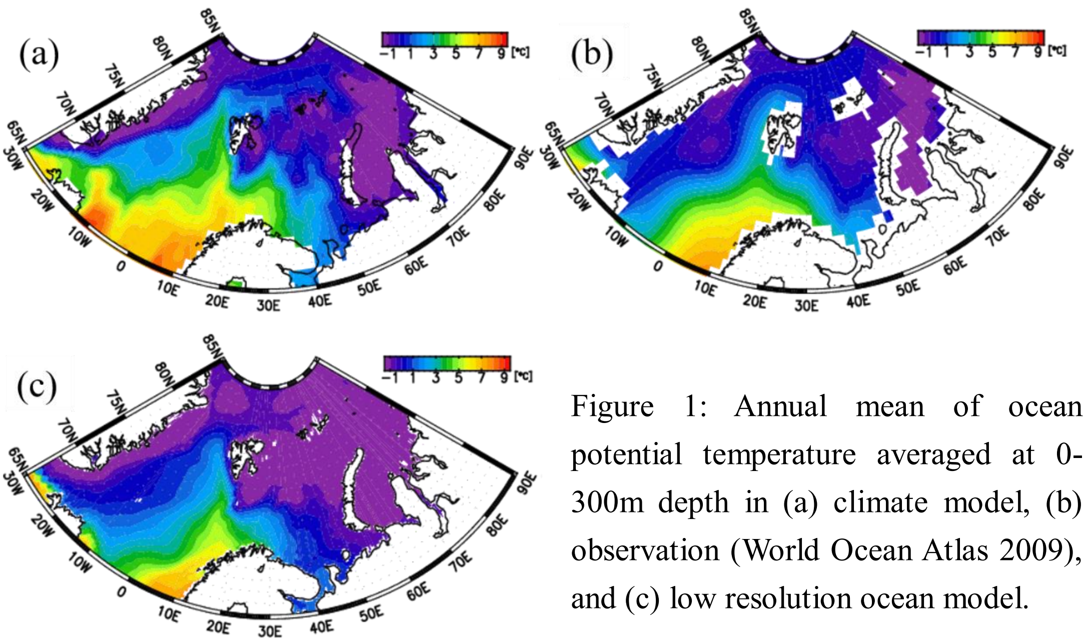

Figure 1: Annual mean of ocean potential temperature averaged at 0-300m depth in (a) climate model, (b) observation (World Ocean Atlas 2009), and (c) low resolution ocean model.

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G02-O13

Importance of Processes and Coupling for Arctic Sea Ice and Climate Modeling and Prediction

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The Regional Arctic System Model (RASM) has been developed to better understand the past and present operation of Arctic System at process scale and to predict its change at time scales from days to decades. It is a limited-area, fully coupled ice-ocean-atmosphere-land model that includes the Weather Research and Forecasting (WRF) model, the LANL Parallel Ocean Program (POP) and Community Ice Model (CICE) and the Variable Infiltration Capacity (VIC) land hydrology model, as well as a streamflow routing (RVIC) model to transport the freshwater flux from the land surface to the Arctic Ocean. All RASM components are coupled at high frequency (currently at 20-minute intervals) to allow realistic representation of inertial interactions among the model components. The model domain covers the entire Northern Hemisphere marine cryosphere, terrestrial drainage to the Arctic Ocean and its major inflow and outflow pathways, with optimal extension into the North Pacific / Atlantic to model the passage of cyclones into the Arctic. RASM baseline configuration consists of an eddy-permitting resolution of 1/12° (or ~9km) for the ice-ocean and 50 km for the atmosphere-land model components. In addition, we have developed, analyzed and will present results from a 1/48° (or ~2.4km) grid configuration for the ice-ocean model components.

Model results are presented from both fully coupled and a subset of RASM, where the atmospheric and land components are replaced with prescribed realistic atmospheric reanalysis data. Selected physical processes and resulting feedbacks of relevance to sea ice will be discussed to emphasize the need for high model resolution and fine-tuning of many present parameterizations of sub-grid physical processes when changing model spatial resolution. We also investigate sensitivity of simulated sea ice states to scale dependence of model parameters controlling ocean and sea ice dynamics, thermodynamics, and their coupling.

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A simultaneous optimization of Arctic sea ice model parameters by genetic algorithm

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Improvement and optimization of a numerical sea ice model are of great significance for understanding the sea ice physics and the Arctic climate system, and also a prerequisite for meaningful prediction. To improve sea ice properties simulated by a model, we develop a parameter optimization system for a coupled ocean-sea ice model. The system is based on a genetic algorithm. Since the sensitivities of dynamic and thermodynamic parameters of sea ice models are interrelated, the system is set up to optimize 15 model parameters simultaneously. We define a cost function which quantifies the model-observation misfits of three sea ice properties (ice concentration, ice drift and ice thickness) for the period 1990-2012 and optimize the model parameters so as to minimize the cost. We find that the system successfully reduces the cost for the three sea ice properties. On the other hand, we also find that different sets of parameters give similar costs close to the global minimum. A correlation analysis shows that the optimal parameters are interdependent and covariant. The result indicates that genetic algorithm can efficiently improve simulated sea ice properties, while additional observations of different sea ice properties are necessary to constrain the model parameters to unique values.

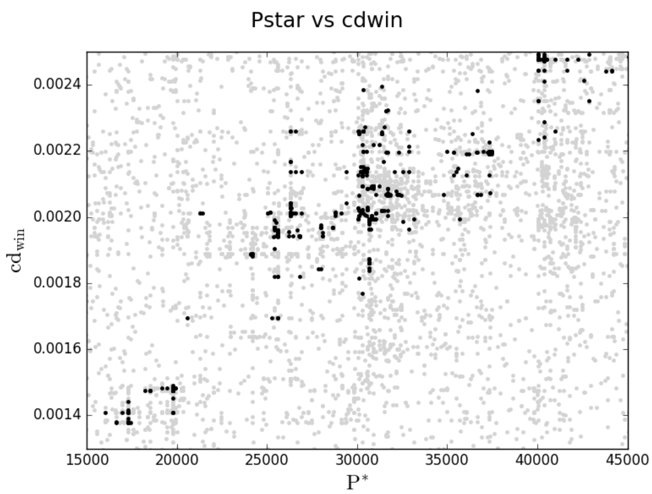

Figure 1. Combination of P* and cd_{win} tested by the genetic algorithm. black dots denote combinations which are near the minimum cost, while light-gray dots denote all combinations tested by the algorithm.

G02-O15

A model approach to carbon exchange in the air, sea, and ice of the marine Arctic

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Regional models that include seasonally ice-covered ocean typically treat ice cover as an inert barrier to the air-sea exchange of carbon. However, recent field research indicates that the chemical and biological processes in the sea ice contribute to the carbon transport between the ice and underlying water column. We have developed a coupled sea ice and pelagic ecosystem in a 1D model [1] that simulates carbon exchange in the seasonally ice-covered marine Arctic. Carbon sinks and sources due to pelagic and sympagic biological production, and sea-ice carbon fluxes due to ice growth and melt have been included, as well as ikaite precipitation (within the ice) and dissolution (in the water column). The model output is tuned to observations near Resolute Bay in the Canadian Arctic Archipelago. Sensitivity analyses focusing on the relative importance of the ice algal bloom, DIC-rich brine rejection during ice growth, and low-DIC meltwater release during ice melt, provide insight into the impacts of these processes on the air-sea exchange of carbon during the ice-free season. These carbon fluxes are presently being implemented in a 3D regional coupled ice-ocean biogeochemical model for the Arctic, and preliminary results from the 3D regional model will be presented as well.

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January 18

Breakout Session

S4

Biogeochemical Cycles and Biodiversity of Terrestrial Ecosystems under Arctic Warming

S04-O01

Study on stable isotopes of precipitation in Hokkaido, North Japan

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Spatial and temporal variations of the isotopic composition of precipitation were investigated to better understand their controlling factors. Precipitation was collected from six locations in Hokkaido, Japan, and event-based analyses were conducted for a period from March 2010 to February 2013. Compared to the three sites at Pacific Ocean side, relatively low δ values and a high d-excess for annual averages were observed at three sites located along the Japan Sea. Lower δ values in spring and fall and higher d-excess in winter were observed for the region along the Japan Sea.

In total, 264 precipitation events were identified. Precipitation originated predominantly from low-pressure system (LPS) events, which were classified as northwest (LPS-NW) and southeast (LPS-SE) events according to the routes of the low-pressure center, that passed northwest and southeast of Hokkaido, respectively. LPS-SE events showed relatively lower $\delta^{18}O$ than LPS-NW events, which is attributable to the lower $\delta^{18}O$ of water vapor resulting from heavy rainfalls in the upstream region of the LPS air mass trajectories over the Pacific Ocean. This phenomenon observed in Hokkaido can be found in other mid-latitude coastal regions and applied for hydrological, atmospheric and paleoclimate studies. A characteristic spatial pattern was found in LPS-NW events, in which lower $\delta^{18}O$ was observed on the Japan Sea side than on Pacific Ocean side in each season. This is likely due to the location of the sampling sites and their distance from the LPS: precipitation with lower $\delta^{18}O$ in the region along the Japan Sea occurs in a well-developed cloud system near the low-pressure center in cold and warm sectors of LPS, while precipitation with higher $\delta^{18}O$ on the Pacific side mainly occurs in a warm sector away from the low-pressure center. Air mass from the north does not always cause low δ in precipitation, and the precipitation process in the upstream region is another important factor controlling the isotopic composition of precipitation, other than the local temperature and precipitation amount.

S04-O02

Multi-year Effect of Wetting on CH_4 Flux at Taiga-Tundra Boundary in Northeastern Siberia Clarified by Stable Isotopes of CH_4

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Present affiliations: [†]Yangtze University, China, [‡]University of Alaska Fairbanks, USA

Under the amplified Arctic warming climatic response of CH_4 emission from northern wetlands needs to be understood because of its possible influence to the global climate. Extreme precipitation events might also happen and affect the CH_4 emission. Indigirka River Lowland in Northeastern Siberia has wetlands in a taiga-tundra boundary on permafrost, whose ecosystem is possibly sensitive to the climate change. Generally, higher water level leads to higher CH_4 efflux [1]. However, high water level can also coincide with low CH_4 flux [2] and flooding might affect CH_4 flux with a time lag [3]. To clarify causes for such relationships between wetting and CH_4 flux, it is necessary to assess the underlying processes, CH_4 production, oxidation and transport, which are reflected by isotopic compositions of CH_4. We observed interannual variations in chamber CH_4 flux and in concentration, $\delta^{13}C$ and δD of dissolved CH_4 near Chokurdakh (70.62°N, 147.90°E) over summers of 2009-2013. Especially, we focused on response of CH_4 flux to an unusual wetting which occurred in 2011.

Methane flux showed large interannual variation at wet areas of sphagnum mosses and sedges (36-1.4×10^2 mg CH_4 m^{-2} day^{-1}). Wet event with extreme precipitation occurred in 2011 and CH_4 flux increased at wet areas in this year. Although water level decreased from 2011 to 2013, CH_4 flux remained similarly large in 2012 and even increased in 2013. In addition, dissolved CH_4 concentration rose up by one order of magnitude from 2011 to 2012 (10 cm deep) and also increased from 2012 to 2013 (surface water, 20 cm deep). These increases of CH_4 flux and dissolved CH_4 concentration after the wetting might be explained by promoted CH_4 production and/or depressed CH_4 oxidation in 2012 and 2013 compared to 2011 due to soil reduction continued for multiple years after 2011. Less-scattered isotopic compositions of dissolved CH_4 gathering at high $\delta^{13}C$ and low δD in 2012 and 2013 than 2011 inferred both promotion of CH_4 production and depression of CH_4 oxidation. This multi-year effect of wetting on CH_4 flux and concentration, $\delta^{13}C$ and δD of dissolved CH_4 implicates not only instantaneous water level but also residence time of water might be important for predicting CH_4 emission following wet events.

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S04-O03

Perspectives of low-temperature microalgae biomass production in the Arctic

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The adaptation/acclimatization mechanisms of Arctic microalgae (including cyanobacteria and eukaryotic microalgae) evolved to withstand the harsh Arctic environment characterized by low temperature, freeze-thaw cycles, desiccation, salinity, and high and variable photosynthetically active and ultraviolet radiations. Hence, the Arctic microalgae developed ecological, physiological and molecular defensive and adaptive strategies, which include the synthesis of a tremendous diversity of compounds originating from different metabolic pathways which protect them against the above-mentioned stresses. Production of different biological compounds followed by various biotechnological applications, for instance, water treatment technology in low-temperature environments, and many others are the perspectives for human that widely explore and exploit rich Arctic resources. In proposed lecture, the non-marine environmental conditions in Arctic environments and microalgal adaptations will be introduced with respect to possible biotechnological applications. The presentation also provides a survey of the possible compounds to be exploited from Arctic microalgae. Possible constructions of photobioreactors for mass cultivation of microalgae are proposed for operations in the Arctic.

Methane flux measurements over a larch forest in eastern Siberia: emission or uptake?

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There are some studies measuring methane flux by a closed chamber method on the soil surfaces of boreal forests in eastern Siberia. However, the characteristics of methane flux over the forest ecosystem is still uncertain. The methane flux measurement by the eddy covariance method has thus been conducted over a larch forest in eastern Siberia during snow-free seasons since 2015. According to a previous study on the methane flux measurements using static chambers in this forest site, uptake of methane was observed on the forest floor, even at sites where the water table was situated a few centimeters below the soil surface [1]. Despite this, the fluxes measured by the eddy covariance method over the forest canopy in this study were highly variable, and the averaged fluxes was slightly positive. In addition, a clear diurnal variation in the methane flux was observed in June 2016, showing maximum methane emission in the daytime. Although the uncorrected flux showed a clear diurnal variation with negative value (uptake) in the daytime, it has changed to nearly zero flux (neutral) after WPL correction was applied. This value then became positive (emission) after spectroscopic (SS) correction was applied, which is necessary for the outputs obtained from LI-7700 open-path methane analyzer. This means these corrections could change the observed methane flux from uptake to emission, with its maximum equivalent to the emission from a meso-oligotrophic fen [1]. Further investigation is required to clarify the characteristics of methane flux in this forest.

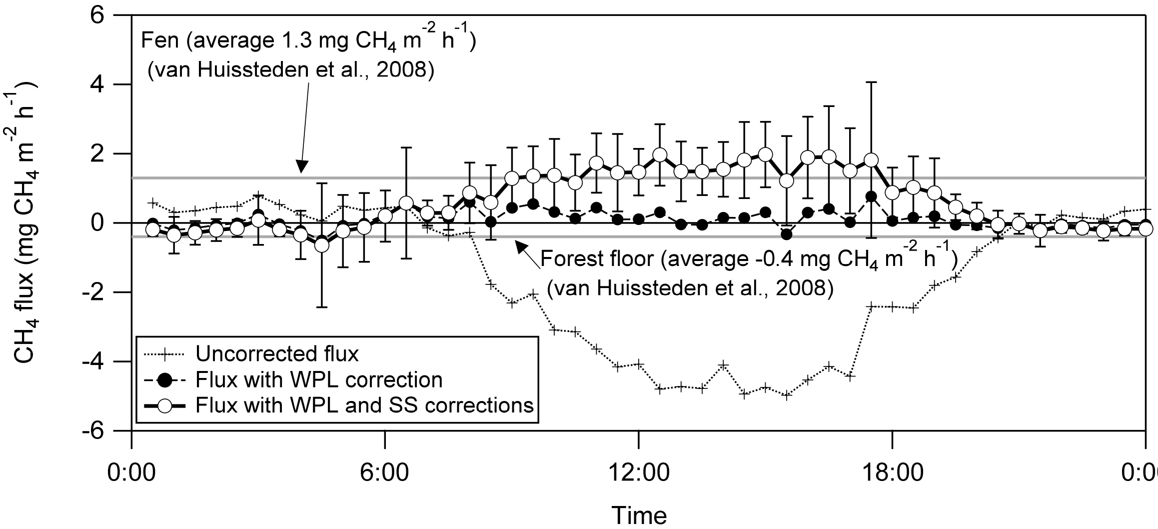

Figure 1. Diurnal variation in ensemble averaged half-hourly methane (CH_4) flux over a larch forest in Spasskaya Pad Research Station near Yakutsk, Russia (June 1–12, 2016)

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S04-O05

Accurate detection of spatio-temporal variability of plant phenology in boreal ecosystems by near-surface and satellite remote-sensing

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[7] *International Arctic Research Center, University of Alaska Fairbanks, USA*

Accurate detection of spatio-temporal variability of plant phenology such as the timing of leaf-flush, -coloring, and -fall is very important to evaluate ecosystem functions (e.g. photosynthetic capacity) and services (e.g. regulating services) in boreal ecosystems under rapid climate change. Towards this aim, near-surface and satellite remote-sensing are useful despite of uncertainties and insufficient ecological interpretation of data. Here, (1) we have captured daily phenology images by using time-lapse digital cameras in forest ecotone in Northern Siberia, deciduous coniferous forest in Eastern Siberia, and open-canopy evergreen coniferous forest in interior Alaska; (2) we detected the spatio-temporal variability of the timing of start (SGS) and end of growing season (EGS) by analyzing daily Terra and Aqua MODIS satellite-observed green-red vegetation index (GRVI); (3) we examined the relationship among daily phenology images, CO_2 flux-based daily net ecosystem exchange, and satellite-observed timing of SGS and EGS; and (4) we made phenology model for prediction of the timing of leaf-flush by examining the relationship between daily phenology images and daily mean air temperature. In this presentation, we show above-mentioned our last results and discuss our current understanding, issues, and future outlooks based on these results.

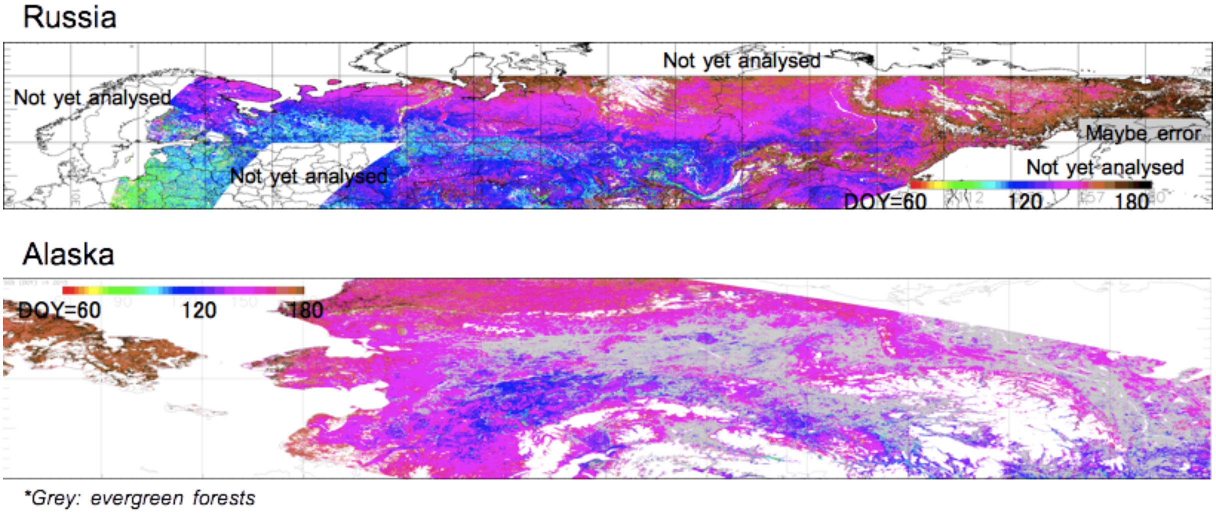

Figure 1. Spatial distribution of the timing of SGS in Russia (top) and Alaska (bottom) in 2015 by analyzing daily Terra and Aqua MODIS satellite-observed GRVI.

S04-O06

Seasonal changes in spectral reflectance in an open canopy black spruce forest in Interior Alaska

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In the Arctic and sub-Arctic regions, including Alaska, warming trends have been accelerating and the increased trend in surface temperature in the region over the past decade is twofold higher than that in the whole northern hemisphere. It is of particular importance whether the carbon uptake by terrestrial vegetation increases or decreases due to the change in phenology under climate change. In interior Alaska, black and white spruce are the dominant species. The spectral reflectance of these species with evergreen needles is relatively unchanged throughout the growing season, while it is likely that satellite phenology metrics should be greatly influenced by understory plant phenology. However, how the spectral signatures are influenced by the forest overstory status, understory plant phenology and other factors such as snow and observation conditions remains less investigated in Alaska. In this study, we investigated the overstory and understory seasonality in spectral reflectance observed in an open black spruce forest in Interior Alaska from 2015 to 2017 (Poker Flat Research Range, Alaska, USA) to understand how the seasonality in spectral reflectances are related with changes in the surface conditions such as snow melt, green-up and senescence of the understory vegetation. We also examined the relationship between seasonalities of overstory and understory and carbon and water fluxes measured by the eddy covariance method. This research was supported by JSPS Kakenhi (16H02948) and the JAMSTEC-IARC Collaboration Study (JICS).

January 18

Breakout Session

S5

Synoptic Arctic Survey – An Ocean Research Program for the Future

Arctic Ocean CO2 uptake: an improved multi-year estimate of the air–sea CO2 flux incorporating chlorophyll-a concentrations

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We estimated monthly air–sea CO_2 fluxes in the Arctic Ocean and its adjacent seas north of 60° N from 1997 to 2014, after mapping partial pressure of CO_2 in the surface water (pCO_{2w}) using a self-organizing map (SOM) technique incorporating chlorophyll-a concentration (Chl-a), sea surface temperature, sea surface salinity, sea ice concentration, atmospheric CO_2 mixing ratio, and geographical position. The overall relationship between pCO_{2w} and Chl-a is negative in most regions when Chl-a ≤ 1 mg m^{-3}, whereas there is no significant relationship when Chl-a > 1 mg m^{-3}. In the Kara Sea and the East Siberian Sea and the Bering Strait, however, the relationship is typically positive in summer. The addition of Chl-a as a parameter in the SOM process enabled us to improve the estimate of pCO_{2w} via better representation of its decline in spring, which resulted from biologically mediated pCO_{2w} reduction. Mainly as a result of the inclusion of Chl-a, the uncertainty in the CO_2 flux estimate was reduced, and a net annual Arctic Ocean CO_2 uptake of 180 ± 130 TgC y^{-1} was determined to be significant.

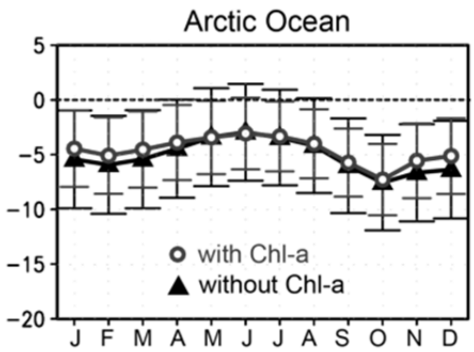

Figure 1. Eighteen-year monthly mean CO_2 flux [mmol m^{-2} day^{-1}] averaged over the Arctic Ocean. Black lines with triangles show estimates without Chl-a by Yasunaka et al. (2016); gray lines with open circles show estimates with Chl-a. Error bars show the uncertainty

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Responses of nutrient and phytoplankton distributions to gale-force winds in the western Arctic Ocean

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The Arctic sea ice has been melting dramatically in recent years, resulting in an enhancement of ocean circulation, accumulation of freshwater, strengthening of ocean stratification and deepening of nutricline in the Canada Basin, which may decrease biomass of large phytoplankton such as diatoms [1]. On the other hand, the sea ice loss is likely to increase eddy activities, and the eddies play important roles in lateral nutrient transports and thus an increase in phytoplankton biomass [2]. The sea ice loss also enhances wind-driven mixing of the ice-free ocean that may increase vertical nutrient fluxes and phytoplankton productivity. Indeed, gale-force winds (> 10 m/s) over the Chukchi Sea induced an increase in the vertical nutrient flux that doubled (tripled) the phytoplankton productivity (biomass) [3]. However, such changes in response to gale-forced winds are expected to be small in the Canada Basin, because the strengthening of ocean stratification and deepening of nutricline are progressing there. Here, we set up a fixed-point observation station in the Canada Basin (74.75°N, 162°W) during autumn 2014 and examined temporal changes of meteorological and hydrographic conditions with nutrient and phytoplankton distributions. The results suggest that gale-force winds did not induce increases in vertical nutrient fluxes and phytoplankton biomass because the nutricline (~60m) was deeper than the depth of wind-driven mixing (~20m). The phytoplankton distribution was more likely to be influenced by advection and eddies. In contrast to the Canada Basin, the nutricline in the Makarov Basin would be shoaling (~20m) with an inflow of nutrient-rich water from the East Siberian Sea [4]. Therefore, gale-force winds may impact the nutrient and phytoplankton distributions in the Makarov Basin. Further studies covering the multiple basins, such as the synoptic Arctic survey (SAS), are needed to compare the ocean and ecosystem responses to meteorological events between the basins.

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S5-O03

Variations in water mass distributions in western regions of the Pacific sector of the Arctic Ocean from 2011 to 2017

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Temporal and spatial variations of Pacific-origin waters majorly dominating upper layers of the Pacific sector of the Arctic Ocean are important for many processes, e.g., oceanic heat transfers, ice formations, and biochemical cycles. Although hydrographic data in western regions of this sector, such as the Chukchi Plateau, Chukchi Abyssal Plain, and East Siberian Sea, was relatively sparse until 2000s, summertime shipboard observations in these regions have been conducted by ice breaking R/V Araon since 2011. The observations have captured both Pacific summer and winter waters spreading westward in these regions, and their horizontal distributions and layer thickness have shown large inter-annual variations. In addition, properties of Pacific winter waters have been modified around shelf margins of the East Siberian Sea due to interactions with cold but relatively less saline shelf-origin waters. We will also show preliminary results obtained from the latest research cruise in the 2017 summer and discuss possible causes of the inter-annual variations of water mass distributions in these regions.

S5-O04

Influence of warm-core eddy on dissolved methane distribution in the southwestern Canada Basin during late summer/early fall 2015

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Recently the presence of eddies are commonly observed in subsurface water in the Arctic Ocean with high frequency about 125 eddies each year, including both warm-core eddy and cold-core eddy [1]. The presence of eddies is one of the possible mechanisms for transporting the shelf-water and nutrients from the continental shelf to the Beaufort Sea interior across the continental slope [2]. Methane (CH_4) is a potent greenhouse gas and plays major roles in both tropospheric and stratospheric chemistry [3]. A massive CH_4 emission from the seafloor into water column in the Arctic Ocean was examined but the vertical profile of CH_4 distribution is still scarce, so it is needed to be examined for comprehension of CH_4 dynamics in the water column. During leg 1 of a cruise MR15-03 by R/V *Mirai* in the Arctic Ocean from late August 2015 to beginning October 2015, seawater samples were collected from the surface to bottom to capture vertical CH_4 distribution in the Canada Basin. A cavity ring-down spectroscopy (CRDS) system coupled with a shower-head type equilibrator was also used to obtain quasi-continuous underway measurements of the mixing ratio of oceanic CH_4 in surface seawater, especially in transverse eddies zone. The results of the vertical profile of dissolved CH_4 concentration/saturation in the Canada Basin are observed as up to 35.8 nmol/kg and 942%, respectively. In this study, the existence of warm-core eddy implies that it would transport nutrients as well as CH_4 from the Chukchi Sea shelf-water to the Canada Basin. The eddy may plays a crucial role in controlling CH_4 distribution in the euphotic zone in our study area. We found a thicker spreading of sub-surface CH_4 peak in depth inside eddies zone has been compared to outside of eddies zone. In this presentation, we will show CH_4 distribution and its controlling factors by comparing inside/outside of eddies zones.

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S5-O05

Distributions of trace metals (Mn, Fe, Ni, Zn and Cd) in the western Arctic Ocean in late summer 2012

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Trace metals such as Fe, Mn, Ni, Zn and Cd are involved in numerous processes in the metabolisms of phytoplankton. Distributions of trace metals (Mn, Fe, Ni, Zn and Cd) in seawaters were investigated in the western Arctic (Chukchi Sea and Canada Basin) in 2012 September to elucidate the mechanism of the transport of these metals. From filtered (<0.22 μm) and unfiltered seawaters, dissolved and total dissolvable trace metal concentrations were determined, respectively. We found concentration maxima of all trace metals in the halocline and/or near bottom waters for both dissolved and total dissolvable fractions. Vertical profiles of all trace metals, except for Cd, also tended to show peaks near the surface water, suggesting that the inflow of low-salinity Pacific origin water from the Bering Strait, as well as local fresh water inputs such as river water and melting sea-ice, influenced trace metal distributions. The distribution patterns and concentration ranges were generally similar between dissolved and total dissolvable fractions for Ni, Zn and Cd. On the other hand, total dissolvable Fe and Mn concentrations were generally higher than dissolved fractions. Especially, high concentrations of total dissolvable Fe and Mn were found in the near bottom water in the Chukchi Sea shelf. From the sea-shelf, to the Canada Basin, dissolved Fe and Mn in the halocline waters tended to decrease with distance logarithmically. These results suggest that distributions of dissolved Fe and Mn were controlled mainly by input from shelf sediment and removal through scavenging processes. In contrast, the elevated Ni, Zn and Cd were transported further offshore from the Chukchi Sea shelf break to Canada Basin within the halocline layers. Our findings suggest the importance of the halocline water for the transport of Mn, Ni, Zn and Cd as well as Fe in the western Arctic during summer. The existence of source at the sea shelf and the transport process in the halocline water likely sustained the high concentrations and unique profiles of these trace metals in this region.

S5-O06

Radiocesium in the Arctic Ocean after Fukushima Dai-ichi nuclear power plant accident

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Radioactive cesium, ^{137}Cs is suitable for studies of water circulation in thermocline layer of the Arctic Ocean. Smith et al. (2011) [1] showed that radiocesium released to the North Atlantic Ocean from nuclear-fuel reprocessing plants in the United Kingdom and France mainly in the 1980s had been transported into the Arctic Ocean within decades along surface and subsurface northward currents. In case of Fukushima Dai-ichi nuclear power plant (FNPP1) accident in March 2011 ^{137}Cs and another radioactive isotope, ^{134}Cs were released into the North Pacific Ocean and spread eastward along surface currents [2]. Because ^{137}Cs derived from the reprocessing plants had been already spread into the Arctic Ocean by the FNPP1 accident, FNPP1-derived ^{137}Cs cannot be identified in the Arctic Ocean. On the other hand, ^{134}Cs could be a tracer for the FNPP1 accident because its background concentration in the Arctic Ocean was nearly zero before the accident due to its short half-life (about two years). In 2012 ^{134}Cs in surface water in the Arctic Ocean was below detection limit (about 0.1 Bq/m^3) [2,3], which implies that FNPP1-derived ^{134}Cs deposited from the atmosphere was negligible in the Arctic Ocean. At a station in the Canada Basin of the Arctic Ocean ^{134}Cs was also measured in subsurface layers to 800 m depth in September of 2012, 2013, 2014, and 2015. In 2012 and 2013 activity concentration of ^{134}Cs was below the detection limit from surface to 800 m depth. In September of 2014, about half and three years after the FNPP1 accident, a barely significant activity concentration (0.24 Bq/m^3) was observed only at 150 m depth [4]. Although temporal change in salinity was not clear, water temperature at the 150 m depth in 2014 was lower than those observed in 2012 and 2013. These data imply that seawater mass at 150 m depth in 2014 was originated from North Pacific water and less modified in polarward transportation through the Bering Sea, which resulted in transportation of FNPP1-derived ^{134}Cs from the North Pacific to Arctic Ocean. In September of 2015, however, the subsurface peak disappeared, suggesting the transportation of FNPP1-derived ^{134}Cs into the Arctic Ocean was restricted.

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S5-O07

Ensuring Comparability of Oceanic nutrient data in the Synoptic Arctic Survey

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There is a strong requirement for observation-based quantitative assessments of changes in ocean biogeochemistry, for instance to inform about the rate of ocean acidification, rate of de-oxygenation, or storage of anthropogenic carbon. None of these would have been possible without analytical techniques and procedures that follow-on from community agreed best practices, and by the use of certified reference materials (CRMs). Knowledge of changes in ocean productivity and remineralization processes is essential for the correct interpretation of observations of other global climate changes. However, up until recently inconsistency in nutrient measurements between different groups of analysts due to lack of CRMs has largely hampered quantitative assessments of changes in oceanic nutrient distributions on global scales [1]. To properly guarantee comparability of nutrient data from different laboratories, the precise mechanisms of a global consensus for reporting nutrient levels needs to be established. This will foster the comparability of nutrient data using globally accepted CRMs, followed by the recommendation of protocols (best practice guidelines) for their use throughout the world-wide marine chemistry community[2]. The Synoptic Arctic Survey, SAS, will be taking place within one season of one year (2020). In this SAS, the obtained dataset will be a unique baseline, which will allow future generations to track climate change and its impacts as they unfold in the Arctic Ocean over the coming years, decades and centuries. Therefore, for future generations it is now unacceptable to produce nutrient data sets without the consistency necessary to assess spatial and temporal trends and variability, potentially caused by human impacts, such as climate induced changes in ocean circulation and productivity/remineralization [2].To ensure comparability of nutrient data from future international collaborating projects such as SAS, it is critical to confirm comparability of nutrient data of SAS participating laboratories through participating in international inter-laboratory comparison exercise of nutrients CRMs that will be conducted in 2017/2018 by IOCCP-JAMSTEC, as part of the aims of the International SCOR working group #147, (COMPONUT)[3].

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S5-O08

Rapidly changing western Arctic Ocean sea-ice and ecosystem; Korean research efforts and plan

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Division of Polar Ocean Sciences
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The Arctic Ocean is experiencing profound changes under the present warming conditions and is predicted to be even more highly impacted in future global changes. The Korean Arctic Ocean Observing System (K-AOOS) Program using R/V Araon, funded by the Korean Ministry of Oceans and Fisheries, has been developed and undertaken by Korea Polar Research Institute (KOPRI) to detect the changes of the structure and processes in the water column and subsurface in the Arctic (Bering, Chukchi, East Siberian and Beaufort Seas) regions. The project will enable researchers to better understand and anticipate processes and changes resulting from rapidly declining sea-ice cover. KOPRI researchers, along with students and international collaborators, will study the oceanography and food web dynamics in the northern Bering Sea, southern Chukchi Sea, and in the East Siberian Sea. Fieldworks in summer between 2016 and 2020 will take place on board the Korean research icebreaker Araon. K-AOOS project is seeking to head to the ice-covered area in rapid transition that has been rarely visited and poorly studied. The researchers will observe physical, ecological, and biogeochemical parameters in rapid transition and how quickly environmental changes affect the ecosystem in the Arctic Ocean. This will be critical for the policy makers looking to preserve thriving Arctic ecosystems as sea ice concentrations continue to decline. The results will be integrated with regional impact studies to help develop effective adaptation strategies for the rapidly changing Arctic Ocean.

Figure 1. Sea ice work activities on the second sea ice camp using R/V Araon during the Korean arctic expedition in 2017

Korea Arctic Ocean Information System

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In recent years, polar research has been focused on climate change, natural resources and development of a new North Pole Route. Since 2010, the Korea Polar Research Institute (KOPRI) has been collecting various in-situ data from the Arctic and Antarctic oceans using ARAON, which is the first effort of Korea toward leading global polar research. As a part of these activities, KOPRI launches a project called "Korean Arctic Ocean Observing System (K-AOOS)", which focuses on rapid environmental changes in western Arctic ecosystems, and produces a huge amount of in-situ data. To properly share and visualize various ocean data acquired in the Arctic oceans, we develop a web-based GIS called "Korea Arctic Ocean Information System (KAOIS)". The system mainly consists of two parts: 1) providing a standard format for the Arctic ocean data, and 2) developing a visualization system using open-source GIS. Since KAOIS will be able to handle more than 30 types of ocean data such as physical, ecological and chemical data, and remote sensing data such as sea ice and ocean color to visualize with proper methods, we are expected to quantitatively and qualitatively accelerate efficiency of ocean data analysis via this system. Additionally, those who are interested in the Arctic oceans may be able to access all the data in KAOIS, and can visualize and share their own data with others.

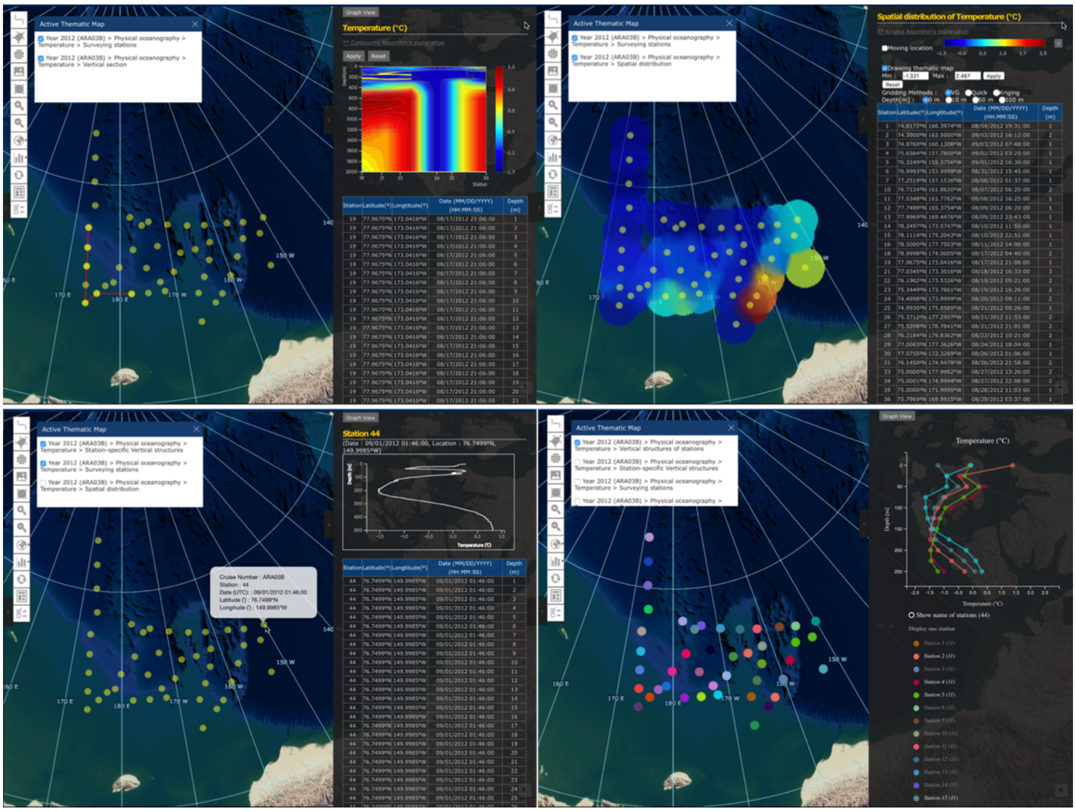

Figure 1. A prototype of Korea Arctic Ocean Information System

The Changing Arctic Transpolar System: A Multidisciplinary Russian-German Research Project

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Today the Siberian shelf seas, at the tail of the Transpolar Drift, are active locations for sea-ice formation and export as well as water-mass transformation. With the Transpolar Drift, sea ice drifts from these shelf seas across the Arctic Ocean, exiting into the North Atlantic off the east coast of Greenland. The effects of climate change are evident and recent studies in the Laptev Sea have shown that continued warming is putting the Siberian shelf seas at growing risk of abrupt and irreversible changes.

With the Russian-German research project „CATS – The Changing Arctic Transpolar System", a consortium of 10 research institutions and universities in Russia and Germany aims to assess how climate change will affect the highly sensitive Arctic environment and to what extent these changes may impact the climate in Europe. The main research region is the western Laptev Sea shelf and continental slope, Vilkitsky Strait and Cape Baranov (Severnaya Zemlya), located in the Russian EEZ. This topographically complex region features strong polynyas and sea-ice formation, and a variety of shelf processes that may impact the circulation and water masses of the Arctic Boundary Current near the beginning of the Transpolar Drift system. The Arctic Boundary Current transports a large amount of heat along the continental slope, which could potentially melt the entire Arctic sea-ice cover if released to the surface.

CATS will generate new sea-ice, ocean, and atmosphere datasets based on satellites, shipboard expeditions and autonomous sampling techniques, by use of, for instance, year-round multidisciplinary ocean observatories that will be operated in the central and northwestern Laptev Sea, or by Cape Baranov-based atmospheric boundary layer measurements. Ship-based oceanographic and biogeochemical surveys will be carried. The study will focus on relevant subjects as shelf processes and their impact on the Arctic Boundary Current, sea-ice retreat, changes of atmosphere/sea-ice/ocean interactions, bio-geochemical cycles, as well as on ecological consequences of climate change by use of field observations, multi-sensor satellite remote sensing, and coupled atmosphere/sea-ice/ocean models. Furthermore, the long-term variability of the Arctic transpolar system will be assessed using historical data for statistical models (1950s to present). Sediment cores from the western Laptev Sea and Vilkitsky Strait will be used to investigate the pre-industrial environment in a region that is critical for understanding the impact of global warming on the Arctic sea ice, ocean, and climate system.

Response of dimethyl sulfide production by phytoplankton to change in multiple environmental stressors in the western Arctic Ocean

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The Arctic Ocean environment is experiencing rapid climate changes such as warming, ocean acidification and sea ice reduction, influencing ecosystem dynamics including biogeochemical cycling. Dimethyl sulfide (DMS) and its major precursor dimethylsulfoniopropionate (DMSP) are produced through physiological function of phytoplankton in marine environment. It has been suggested that oceanic DMS emissions could play a dominant role in climate regulation on a regional basis especially in the polar region [1]. Unraveling the response of marine organisms against such environmental perturbations is important to better understand the present and future Arctic Ocean ecosystem and production of DMS and DMSP. We investigated the effects of temperature, CO_2 and salinity on plankton communities, DMS and DMSP in the Arctic Ocean using on-board manipulation experiment during R/V Mirai MR15-03 cruise. Temperature (2.2 or 7.2°C), CO_2 (300 or 600 μatm) and salinity (29.4 or 27.8) were manipulated using thermostat circulator, the addition of high CO_2 seawater, and pure water, respectively. The higher temperature enhanced the growth of phytoplankton community in terms of chlorophyll-*a*. Nano-sized (~2–10 μm) phytoplankton growth was increased due to the higher temperature but not CO_2 in the community. On the other hand, pico-sized (< 2 μm) phytoplankton growth was unchanged during the incubation. DMS and DMSP concentration were getting higher during the experiment for all batches. We will further discuss the relationships between production of DMS and DMSP and changes in the biological variables in this presentation.

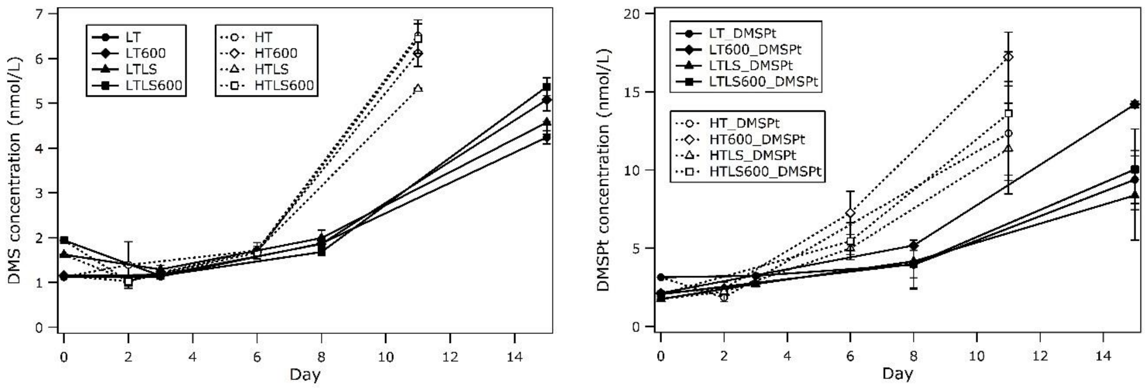

Figure 1. Time series of DMS and DMSPt concentrations during incubation experiments

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Absolute Salinity measurements in the Arctic Ocean

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In 2010, the International Thermodynamic Equation of Seawater 2010 (TEOS-10) was adopted as the replacement for the International Equation of State of Seawater 1980 (EOS-80). In TEOS-10, Absolute Salinity is introduced instead of using Practical Salinity. Density of seawater is defined as a function of Absolute Salinity rather than conductivity. To date, however, there is no sensor that can precisely measure Absolute Salinity in situ. Therefore, an algorithm to estimate Absolute Salinity from Practical Salinity measurement was provided along with TEOS-10. The algorithm exploits the correlation between the Absolute Salinity anomaly (difference between Absolute Salinity and Practical Salinity) and the silicate concentration, making use of the global atlas of silicate concentrations. In the surface layer of the Arctic Ocean, silicate concentration is small, so that Absolute Salinity anomaly estimated from TEOS-10 is also small. However, the direct density measurements in the Arctic Ocean showed that the Absolute Salinity anomalies were quite large in the area north of Point Barrow (Fig. 1). These anomalies might be caused by the effect of river water since total alkalinity is relatively large in the area. Similar Absolute Salinity anomalies which are not related silicate concentration were observed on the Extended Ellett line (cruise DY052 by RRS Discovery in 2016) in the North Atlantic between Scotland and Iceland. Absolute Salinity anomalies obtained in the Bering Sea and the Arctic Ocean in 2017 by R/V Mirai will also be examined to understand the spread of the Absolute Salinity anomalies which can't be estimated from the TEOS-10 algorithm to estimate Absolute Salinity anomaly.

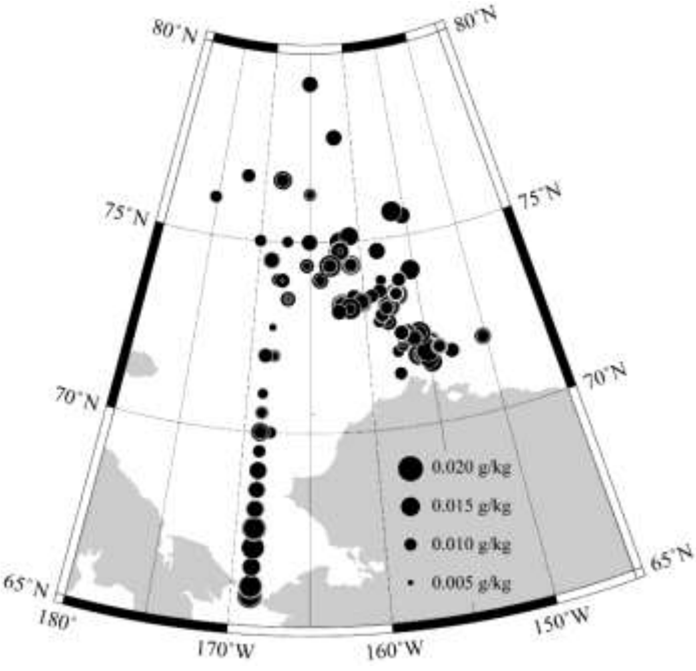

Figure 1. Absolute Salinity anomaly for depths shallower than 15 m. Data were obtained by the R/V Mirai cruises in 2010, 2014, 2015 and 2016.

January 18

Breakout Session

S2

Synergies for "New Arctic" Climate Prediction, Observation and Modeling

S02-O01

Seasonal progression of the deposition of black carbon by snowfall at Ny-Ålesund, Spitsbergen

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Deposition (wet and dry) of black carbon (BC) in the Arctic lowers snow albedo, thus possibly contributing to warming in the Arctic. However, key processes and the magnitude of the effect of the BC deposition on radiative forcing in the Arctic are poorly understood due to sparse BC samplings in snow with adequate spatiotemporal resolution and uncertainties in the measurements of BC in snow. We measured the size distribution of BC in snowpack and falling snow using a single particle soot photometer combined with a nebulizer. We sampled snowpack at two sites (11 m and 300 m above sea level) at Ny-Ålesund, Spitsbergen, in April 2013. The BC size distributions did not show significant variations with depth in the snowpack, suggesting stable size distributions in falling snow. The number and mass concentrations (C_{NBC} and C_{MBC}) at these sites agreed to within 19% and 10%, respectively, despite the sites' difference in snow water equivalence. This indicates the small influence of the amount of precipitation on these quantities. We also sampled falling snow near the surface using a windsock during the same snow accumulation period. Average C_{NBC} in snowpack and falling snow agreed to within 15%, after corrections for artifacts associated with the sampling of the falling snow. From the comparison of C_{NBC} and C_{MBC} in snowpack and falling snow, we estimated the relative contribution of dry deposition to total deposition to be about 22±6%. C_{NBC} and C_{MBC} in falling snow and BC concentrations in ambient air were highest in winter.

S02-O02

Seasonal differences in the characteristics of ice nucleating particles on Mt. Zeppelin in Ny-Ålesund, Svalbard: A case study in 2016/2017

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Mixed-phase clouds, composed of both ice crystals and supercooled water droplets, occur frequently in the Arctic lower troposphere throughout the year, especially over the Svalbard region [1]. It is well known that aerosol particles serving as ice nucleating particles (INPs) play an important role in forming ice in mixed-phase clouds. Although recent work discusses the possibility that sea spray aerosols emitted from sea surface microlayers may serve as efficient INPs in the Arctic atmosphere [2,3], little is known about the amounts and sources of INPs in the Svalbard region. In this presentation, we report on the results of the measurements of INPs at the Zeppelin Observatory (475 m AMSL) in Ny-Ålesund, Svalbard, during intensive field campaigns in July 2016 and March 2017. The number concentrations of INPs active under mixed-phase cloud conditions were measured using an established droplet-freezing technique [4]. The results show that INP number concentrations measured at the Zeppelin Observatory in July 2016 were about one order of magnitude higher than those in March 2017. Single particle analyses of ambient aerosol particles combined with backward trajectory analyses of air masses indicate that locally-emitted dust particles within the Svalbard region might be one of the significant aerosol sources in summertime. We further conducted freezing experiments with local dusts collected in Ny-Ålesund (i.e., glacial outwash sediments smaller than ~5 μm) and confirmed that the ice nucleating activity of the local dusts is much higer than that of desert dusts from low/mid-latitudes. We also found that the Ny-Ålesund dusts lose significantly their ice nucleating abilities after H_2O_2 treatment (i.e., after removal of organic matter), suggesting the presence of ice nucleation active organics in the dusts. Finally, we suggest that the observed INP populations at the Zeppelin Observatory in July 2016 might be well characterized by local dust emissions within the Svalbard region, as well as transport of aerosol particles from the surrounding oceans and/or continent, leading to enhanced INP number concentrations.

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S02-O03

Ship-based Observation and Regional Chemical Transport Model analysis for Atmospheric Black Carbon over the Arctic Ocean

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Black carbon (BC) is a major component of light-absorbing particulate matter in the atmosphere, causing positive radiative forcing. Also, BC deposition on the surface reduces the Earth's albedo and accelerates snow/ice melting by absorbing the sunlight. Therefore, the impact of BC on the Arctic climate needs to be assessed; however, observational information has been still insufficient. Over the Arctic Ocean, we have been conducting ship-based observations for BC using a single particle soot photometer (SP2) on R/V Mirai every year since 2014. To estimate the transport pathways of BC, we have also conducted model simulations during the period of cruise using a regional transport model (WRF-Chem 3.8.1).

Figure 1 shows temporal variations in the BC mass concentrations along the ship track during the arctic cruise in 2016. The variations in the observed concentrations, after eliminating data influenced by ship exhaust, were qualitatively well reproduced by the regional chemical transport model. Quantitatively, however, the model tended to overestimate the BC levels, suggesting the possibilities that the emission rates were overestimated and/or the removal rates were underestimated. The observed average mass concentration during 2016 was 0.8 ng/m3 in >70N, similar to the levels (~1.0ng/m^3) recorded during our previous observations in the Arctic during 2014 and 2015 [1]. We will present further analysis on the size distribution, coating, and possible sources. Also, we are going to report results of the arctic cruise in 2017.

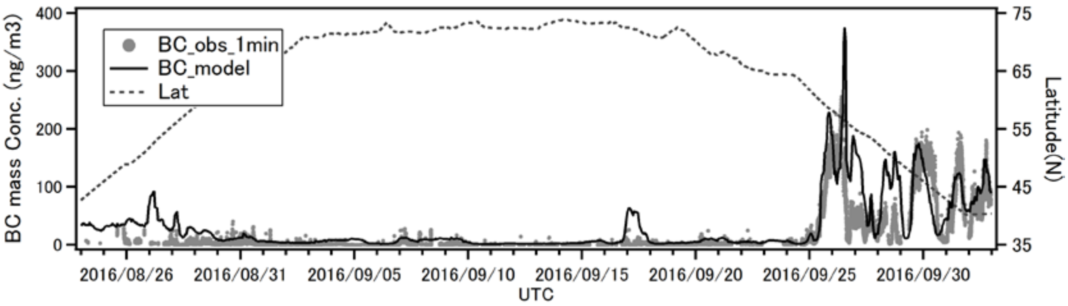

Figure 1.Temporal variation of BC mass concentrations along the cruise track. Gray dots and a solid line indicate the BC concentration levels observed and simulated by the WRF-Chem, respectively.

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S02-O04

Seasonal variability of near-inertial internal waves in the Northwind Abyssal Plain, Arctic Ocean

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According to long-standing researches in the Arctic Ocean, internal gravity wave activity and its contribution to local turbulent mixing have been considered to be quite low. In the modern era, the Arctic sea-ice extent has been dramatically diminishing, and therefore there is an increased chance of kinetic energy input from the air to the ocean. In this study, the seasonal change of near-inertial internal wave (NIW) kinetic energy is examined in comparison with local sea ice compactness and thickness. Here, the local sea-ice information was directly obtained by using an Ice Profiling Sonar that was mounted at top of a moored instrumentation in the Northwind Abyssal Plain. The year-round mooring was deployed by JAMSTEC in September 2013. The near-inertial bandpass filtered velocity was computed from horizontal velocity of an acoustic Doppler current profiler (ADCP) over the depths within upper 100 m. To ascertain energy source for the upper ocean, surface energy input and consequent inertial oscillation in mixed layer were predicted by using a mixed-layer slab model (Pollard & Millard, 1970). The ADCP velocity documented that NIW energy's variability was characterized by sea ice mobility, which is deeply associated with ice thickness. During the melt season, July to October, NIW activities achieved its maxima. In contrast, during the freezing period, ice shows the least mobility as well as greatest thickness, leading to the least energetic NIW activity.

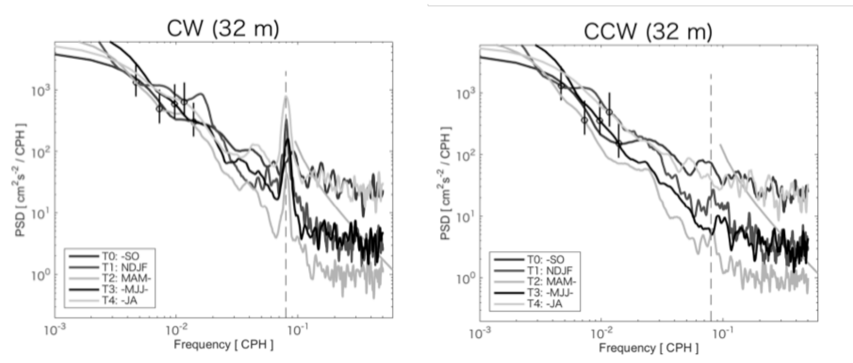

Figure 1. Moored rotary spectra of horizontal velocity: clockwise (left) and counterclockwise (right) rotation with time. The spectral curves were from horizontal velocity at depth of 32 m.

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S02-O05

Physical Oceanography activities during MOSAiC: a summary from the OCEAN team

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The poster will details the current, draft plan for physical observations in the ocean during MOSAiC. These are related to the science questions laid out in the MOSAiC Science and Implementation plans.

We will present the key variables that have been identified, the instrumentation for obtaining the measurements and a first look at a potential observation schedule.

This contribution is meant to initiate discussion and involve new MOSAiC partners.

Year-round surveys for air–sea ice gas flux in the Arctic Ocean

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Sea ice has rarely been considered in estimates of global biogeochemical cycles, especially gas exchanges, because of the assumption that, in ice-covered seas, sea-ice acts as a barrier for atmosphere–ocean exchange. However, recent work has shown that sea ice and its snow cover play an active role in the exchange of gases between the ocean and atmosphere. However, the lack of information for the winter-time and long term (e.g. year-round) sea ice biogeochemistry was pointed out, due to the difficulty to acquire data under harsh weather conditions and to keep the ice station for long time. During the MOSAiC campaign, we will examine the year-round air–sea ice CO_2 and CH_4 etc fluxes in the central Arctic Ocean. This survey will also include the collections for the samples on quantification on carbonate systems and biogeochemical properties in sea ice and under-ice water column.

S02-O07

Interaction between YOPP and MOSAiC from observations to modeling

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The Year of Polar Prediction (YOPP) has been in place since May 15, 2017. Several field campaigns have been conducted in the Arctic regions, which contributes to improving the skills of atmospheric, sea-ice, and oceanic forecasts on time scales ranging from hourly to seasonal. Three special observing periods (SOPs) in the Northern Hemisphere are scheduled during YOPP to obtain enhanced observation data mainly for forecasting purposes. One of the largest field campaigns as a part of SOPs is the Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC), which will start from mid-October 2019 by using *RV Polarstern* with the sea ice across the central Arctic during years 2019 to 2020. The feedback from scientific and operational efforts between YOPP and MOSAiC is essential to develop current numerical models and to understand unknown physical processes over the Arctic Ocean. Based on pilot studies for YOPP that have been conducted by collaborative international efforts, additional meteorological observations over the Arctic region were found to be very useful for predicting extreme weather events over the Arctic and beyond both in summer and winter [1-4]. During the YOPP and its consolidation phase, which covers the MOSAiC period, several data assimilation studies are scheduled using observed data. In this presentation, ongoing and planned research activities during YOPP and MOSAiC will be introduced, focusing on the Japanese activity as an example. With the aid of the Japanese Arctic flagship project, called the Arctic Challenge for Sustainability (ArCS) project, the Arctic research cruise using *RV Mirai* is scheduled to run from 2017 to 2019 every year. Thus, opportunities to collaborate with other institutions and international projects will be provided. In addition to this, during the early phase of MOSAiC (October 2019), when *RV Polarstern* starts year-round operation in the Siberian sector of the Arctic Ocean with drifting sea ice, *RV Mirai* will also travel to the ice-free Arctic Ocean to obtain the suite of comparable observation data in addition to *RV Polarstern*'s data. Both the data denial experiments and the verification of numerical models will be made for participation in an intercomparison model. Preparations for joining *RV Polarstern* cruise have also been initiated by communication with relevant people from domestic and MOSAiC coordination teams.

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S02-O08

Impact of extra Arctic radiosonde observations on 5-day weather forecasts over Alaska during August 2015

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This study has investigated the impact of extra radiosonde observations from the 2015 *Araon* summer Arctic cruise over the Chukchi and East Siberian seas on 5-day forecasts over Alaska. The radiosonde sounding data produced every 12 hour from 00UTC 04 AUG to 12UTC 18 AUG are additionally assimilated to the conventional ALERA2 reanalysis. With the two reanalysis data sets as the initial conditions, two sets of 10-day ensemble forecasts are produced and compared (CTL without *Araon* vs. OSE_A with *Araon*). To verify the forecast performance, we compare the Z500 fields between CTL and OSE_A. Two forecasts are not quite different for the earlier period of the analysis-forecast cycle (from 04 AUG to 08 AUG), but the accumulated impact on the error reduction of OSE_A is shown for the later period from 12 AUG to 18 AUG. More detailed analyses are made for the two selected forecasts begun at 00UTC 12 AUG and 00UTC 14 AUG (Figure 1), in which the OSE_A forecasts are improved significantly after 4-6 days and 3-5 days, respectively. The evolution of the forecast errors over Alaska are similar for the first few days of the forecasts, but the forecast errors are reduced while the positive signals of extra sounding observations reach the downstream Alaskan area after a couple of days. In these forecasts, the assimilation of extra Araon sounding data improved the geopotential height field by lowering abnormal high anomalies over Alaska.

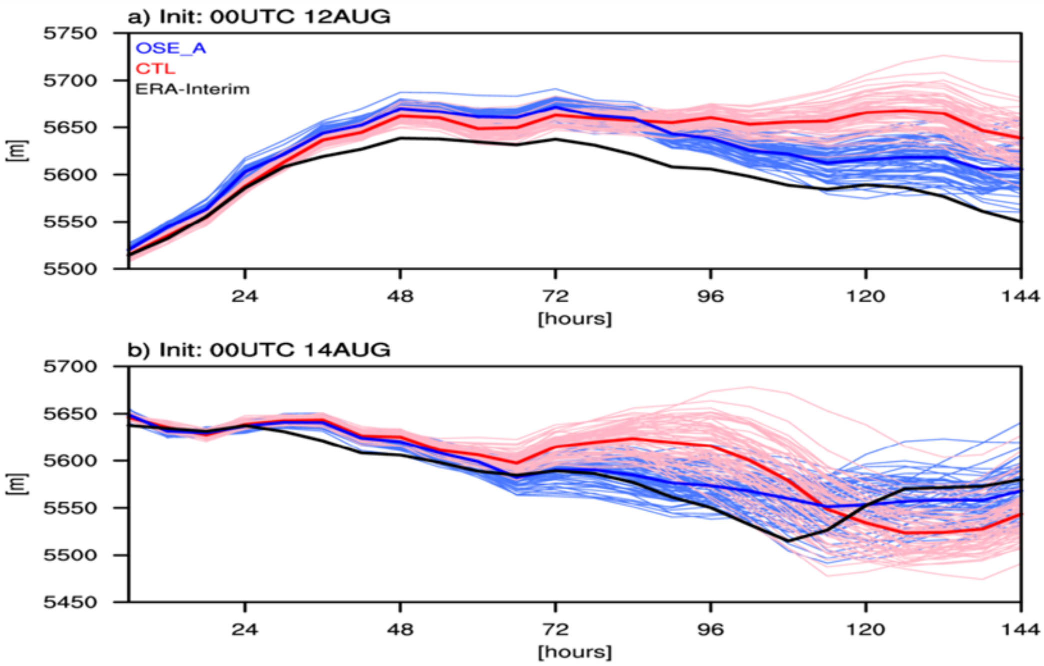

Figure 1. Time series of area-averaged 500-hPa geopotential height over Alaska from the ERA-Interim reanalysis (black) and the ensemble-mean of OSE_A (thick blue) and CTL (thick red) forecasts begun at (a) 00 UTC 12 AUG and (b) 00UTC 14 AUG. Light think blue and red lines indicate all ensemble members for OSE_A and CTL, respectively.

Effect of the Cycling WRF-3DVAR Data Assimilation of the Ship-borne Arctic Radiosonde Sounding on the Simulation of the Intense Arctic Cyclone in mid-August 2016

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The Arctic Ocean is more accessible to human activities as sea-ice declines. As a result, Arctic severe weather prediction is becoming practically more important. Previous studies have demonstrated that the cyclone activity tends to enhance seasonally during summer in the central Arctic Ocean and, during the last several decades, the entrance of extratropical cyclones has increased toward the Arctic [1-3]. One representative case was a violent, long-lived Arctic cyclone in early August of 2012, with record lifetime minimum central pressure of 966 hPa [4]. In mid-August 2016, another atypically intense Arctic cyclone was observed, which was comparable to the 2012 cyclone. Originating from Scandinavia, it explosively developed over the Eurasian sector of the central Arctic Ocean, reaching its lifetime minimum central pressure of 968 hPa on 16 August. Thereafter it was weakening for three days while moving eastward and finally dissipated by merging into another developing cyclone from Alaska.

In this study, we perform WRF forecasts of this 2016 cyclone's life cycle with the initial (00Z 10 August) and boundary conditions from the NCEP GFS forecast fields. In addition, extra Arctic radiosonde sounding data over the Chukchi and East Siberian seas are available, since we produced on the icebreaker Araon. For an experimental purpose, we test the assimilation impact of those extra sounding data using the WRF-3DVAR. Three model experiments have been set up: 1) a control run without extra data assimilation (DA_NO), 2) an experiment with one-time assimilation on 00Z 10 August (DA_10), and 3) an experiment with 24-hr cycling assimilation from 00Z 10 through 00Z 13 August. Comparing the central pressure evolution among the three experiments, DA_NO and DA_10 simulated the cyclone's life cycle in a very similar way, whereas DA_13 shows a notable discrepancy on the simulation of the weakening phase from 16 August. In DA_13, the weakening rate is even more rapid, compared with the reanalysis data: the central pressure increased to the weakest peak of 979 hPa within 36-hr (c.f., from 968 hPa to 984 hPa within 48-hr in the reanalysis data). The reason of this difference is that an anticylonic increment generated by the cycling sounding data assimilation grows and spreads to the central Arctic Ocean and excessively affects the cyclone weakening while it passes around the International Dateline, located at the closest distance from the Araon. Therefore, the extra Araon Arctic sounding data could affect the cyclone's central pressure forecast around the time of its lifetime peak period.

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Medium-range forecast skill for Arctic Cyclones

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Arctic cyclones (ACs) have environmental and social impacts on the Arctic [1-2]. In this study, we assessed the forecast performance of medium-range ensemble forecasts provided by The Interactive Grand Global Ensemble (TIGGE), regarding the central pressure and position of ACs for the summer (June – August) of 2008 – 2016. Forecast data from five leading numerical weather prediction (NWP) centers were used: the Canadian Meteorological Center (CMC), the European Centre for Medium-range Weather Forecasts (ECMWF), the Japan Meteorological Agency (JMA), the US National Centers for Environmental Prediction (NCEP), and the UK Meteorological Office (UKMO). Ten dominant AC evensts were detected based on the following criteria: the central pressure of < 980 hPa, the central position of > 70°N, and the areal-mean temperature anomaly at 250 hPa of > 5 K.

In predicting the central pressure of the ACs, the ECMWF has the highest skill in the 0.5- to 3.5-day forecasts, followed by CMC (Fig. 1a). In the 4.5- to 5.5-day forecasts, CMC shows a similar skill to ECMWF, and its 6.5-day forecast shows the highest skill in all the centers. The 2.5-day ECMWF forecast is as accurate as the 1.5-day CMC, JMA and UKMO forecasts. In the 0.5-day forecasts, all the NWP centers except for NCEP have the mean pressure errors of < 3 hPa. The NCEP forecast in the range from 0.5 to 3.5 days ahead shows the lowest skill in predicting the central pressure. Regarding the central position of the ACs (Fig. 1b), ECMWF has the highest skill for the 1.5- to 5.5-day forecasts. These ECMWF forecasts show the 1-day advantage in predicting the central position of the ACs, as well as the central pressure, compared with the other centers. In the 0.5-day forecasts, the mean position error is below 100 km for all the centers and JMA shows the lowest mean error of 25 km. In general, ECMWF has the highest performance in predicting ACs at medium-range timescale.

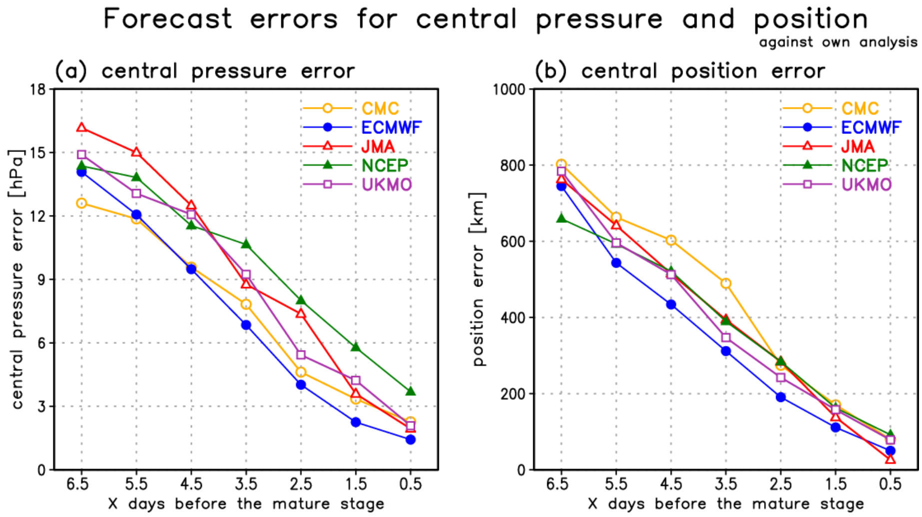

Figure 1. Mean forecast errors in the central (a) pressure and (b) position of ACs in the summer of 2008 – 2016 for CMC, ECMWF, JMA, NCEP, and UKMO ensemble forecasts. The forecasts were verified against their own analysis.

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S02-O11

Analysis of arctic cyclone of August 2012 using non-hydrostatic global atmosphere and ocean coupled model

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In recent years, sea ice in the Arctic region in summer has decreased (e.g., *Comiso et al*., 2008). In August 2012, decrease of sea ice is prominent, and influence of a strong low pressure in Arctic region (Arctic Cyclone; hereafter we call this as AC) is considered as one of the factor. This AC was much developed (about 966 hPa) and lasted for more than 10 days (*Simmons and Rudeva*, 2012). During this period, a strong wind was observed in Arctic region, and sea ice was transported, and ocean was disturbed. As a result, large decrease of sea ice was happened. In this study, we simulated this AC using a new atmospheric ocean coupled model "NICOCO" developed by combining global non - hydrostatic atmospheric model NICAM and global ocean model COCO. A purpose of this study is to understand the atmosphere, ocean, and ice interactions.

Figure 1 show the track and time variation of central sea level pressure (SLP) of AC. Here, the integration for NICOCO was performed for 7 days starting from 3 August 2012, at 0000 UTC. We set the horizontal grid spacing of about 50 km, and performed three experiments. (1: called as Exp1) use the cumulus parameterization (CHIKIRA scheme). (2: Exp2) does not use the cumulus parameterization. (3: Exp3) same as Exp1, but for the fix ocean component (ice component does not fix). All experiments can simulate the track of AC which heading to the North Pole. However, compared to observation, it slightly shifted westward. As for the development of the central SLP, although there is a difference depending on whether cumulus parameterization is used or not, reproducibility is successfully simulated.

We try to further improve the reproducibility of AC (e.g., track) and investigate the factors determining the track. In the presentation, we will also discuss about decrease of sea ice.

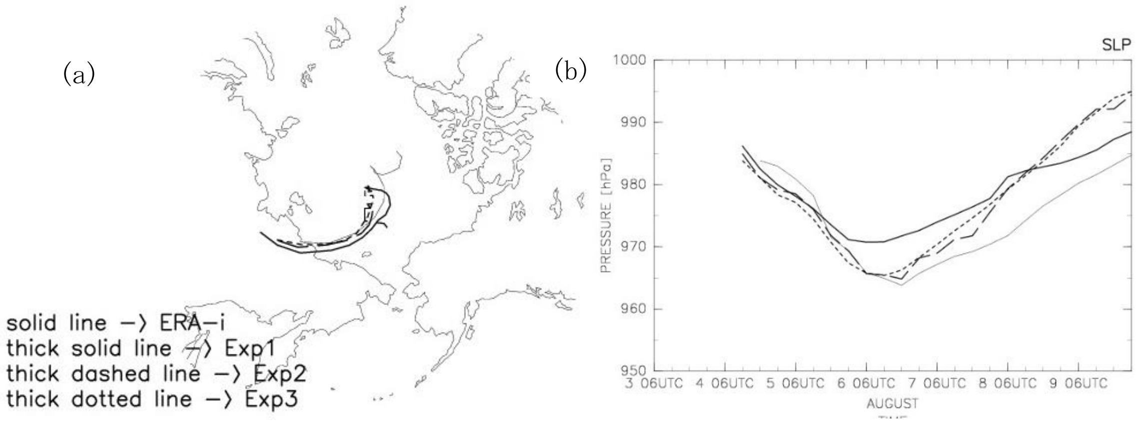

Figure 1. Solid, thick solid, thick dashed, and thick dotted line in figures indicate the (a) track and (b) central sea level pressure of AC in ERA-Interim data, Exp1, Exp2, and Exp3, respectively.

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Medium-range forecast skill of summertime sea ice conditions over the East Siberian Sea: Importance of synoptic-scale atmospheric fluctuations

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[4] Arctic Research Center, Hokkaido University, Japan

Accelerated retreat of Arctic Ocean summertime sea ice has focused attention on the potential use of the Northern Sea Route (NSR), for which sea ice thickness (SIT) information is crucial for safe maritime navigation. This study evaluated the medium-range forecast skill of summertime SIT, with special emphasis on the East Siberian Sea (ESS), based on the Towards an Operational Prediction system for the North Atlantic European coastal Zones ver. 4 (TOPAZ4) data assimilation system (Sakov et al. 2012). Intercomparison between all available observed (in situ and satellite) and operational model SIT data showed that TOPAZ4 reanalysis data reproduces the observed seasonal cycle (maximum in May and minimum in October) for the entire Arctic Ocean, with an average negative bias of ~30 cm.

Examination of vessel-tracking data and TOPAZ4 reanalysis data suggests the significant delay in vessel speed that occurred in July 2014 during passage of the ESS was caused by northwestward sea ice drift (~20 cm s^{-1}) as well as significant SIT (~150 cm). To explore the mechanism controlling the summertime (July) sea ice motions, we examined the speed and direction based on free-drift theory. The estimated values of the wind factor and the deviation angle are approximately within the range of typical surface wind parameters of 2 % for the wind factor and 30° for the deviation angle in the Arctic Ocean (Thorndike and Colony, 1982).

Forecast data of TOPAZ4 indicates northward sea ice drift occured in July 8, 2014 can be predicted skillfully with a lead-time of 5 days. The ECMWF medium-range forecast data show that the forecasts of the ensemble members spread after July 8 and the ensemble mean values are notably different from the analysis values. These results demonstrate the skill in the prediction of sea ice motion is attributable to that of the atmospheric wind condition. Therefore, TOPAZ4 data assimilation system could provide useful medium-range sea ice forecasts for summertime maritime navigation of the NSR. Since it was reported that additional radiosonde observations over the Arctic Ocean have had considerable impact on the prediction skill in synoptic-scale fluctuations (e.g., Inoue et al., 2015), it is expected that radiosonde observations in the Arctic Ocean could lead to further extension of the lead-time for predictions of summertime sea ice.

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January 18

Breakout Session

S3

A complex Adapting Arctic Ecohydrology in the Context of Changing Climate

S03-O01

Cancelled

S03-O02

Spatial variability of streamflow in continuous permafrost environment in Central Yakutia, Russia

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Runoff generation in permafrost environments are controlled by time-variable frozen aquiclude, limited connectivity between surface and ground water, long snow season and period of river ice cover. Although influence of ground thawing/freezing and surface conditions on streamflow generation is not fully understood, both rain and snow are usually assumed to be the main driver of any hydrological events.

The study aims at investigation of runoff formation and identification of key hydrological processes at set of close-by watersheds in Central Yakutia, Eastern Siberia, Russia. Nineteen river basins with areas from 40 to 65000 km^2, practically all active gauges up to the moment, were chosen for streamflow analysis. Precipitation and air temperature data from 22 meteorological stations were employed for the study. The river basins are characterized by relatively flat topography, dry and cold climate. Mean annual precipitation varies from 240 to 390 mm/year. Mean annual air temperature changes from -7.7 to -11.9°C. Altitude ranges from 60 to 1000 m a.s.l. Permafrost thickness is 200-500 m. Dominant landscape is coniferous taiga.

Mean annual flow depth of the studied rivers varies in more than two orders of magnitude from 0.61 to 80 mm/year (Figure 1). High spatial variability of streamflow that far exceeds variability of precipitation suggests that surface conditions could play more important role in runoff generation than rain and snow input. Variation coefficient (Cv) characterizes year-to-year dynamics of streamflow. Cv of rivers with lower flow depth is much higher than "high flow" rivers. Role of different control factors such as geology, permafrost distribution, lakes, contributing areas and others will be discussed. Careful investigation of runoff generation processes is needed for successful modelling strategies and future projections.

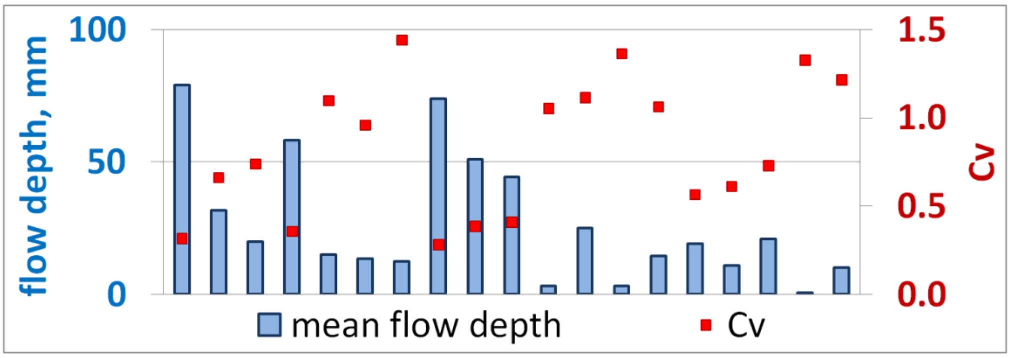

Figure 1. Mean annual flow depth and its variation coefficient for 19 studied basins

S03-O003

Hydrological changes in the Arctic circumpolar tundra and pan-Arctic large river basins from 2002 to 2016

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The summer air temperature has been increasing across the Arctic circumpolar tundra in the upper section of the Lena River Basin since 2002 [1]. Therefore, it is evident that Arctic hydrological change is affected by the warming summer air temperature. In this study, we analyzed the interannual variation of terrestrial water storage (TWS) in the Arctic circumpolar region using monthly Gravity Recovery and Climate Experiment (GRACE) data from 2002 to 2016, and clarified the causes of the variation using global land reanalysis, river runoff, and inundation area data. In addition, the TWS from Global Land Data Assimilation (GLDAS1 and GLDAS2) datasets was used to analyze the variation in the amount of TWS estimated using GRACE data. Four different products are available from the land surface models (LSMs) in GLDAS1, while GLDAS2 has only one product. We also analyzed the variations in surface inundation extent areas (IEA) simultaneously using global inundation area data provided by Global Inundation Extent from Multi-Satellites (GIEMS) [2]. In order to analyze the variation in the basin's TWS, the observed flow rate data in the vicinity of the estuary of the three major pan-Arctic rivers (the Lena, Mackenzie, and Yukon) were used. For the Lena River in the Eurasian continent, we used R-ArcticNet (developed and maintained the University of New Hampshire), while the Canadian hydrometric database (HYDAT) and the USGS website were referred to for the Mackenzie and Yukon Rivers, respectively.

TWS, annual evapotranspiration, and the summer air temperature data, excluding IEA, show statistically significant linear trends ($p<0.05$) from 2002 to 2016. The TWS data obtained from GRACE and GLDAS1 or GLDAS2 show a consistent seasonal and interannual variability (R^2: 0.80). Therefore, the fluctuation in TWS with GRACE data can be assessed by reanalyzing certain factors in the GLDAS data. The summer air temperature has shown an increase of 0.13° C year^{-1}. On the other hand, TWS showed a decreasing trend of -1.2 mm year^{-1}, and the rate of decrease was close to the increasing evapotranspiration trend. Although the results were not statistically significant, the IEA showed a slightly decreasing trend. In addition, we characterized the cause of variations in TWS in large pan-Arctic river basins with respect to various forcing variables such as precipitation and evaporation.

Acknowledgemets

This work was partly carried out by the Joint Research Program of the Institute for Space-Earth Environmental Research (ISEE), Nagoya University.

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S03-O04

Permafrost groundwater age of spring discharges around Khangai Mountains in central Mongolia

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Better understanding of groundwater dynamics in permafrost zones is a critical issue in permafrost hydrology. Assessing permafrost vulnerability in conjunction with changing climate is important for local peoples, and thus detecting permafrost thaw is needed in this research discipline. In order to detect permafrost thawing (ground ice melting) in the isolated permafrost zone of Mongolia, groundwater age was determined around the Khangai Mountains by the use of transient tracers of tritium (^{3}H) and chlorofluorocarbons (CFCs). Spring water samples were collected at several discharge sites including two thermokarst landscapes, the Chuluut (N 48°05.142′, E 100°20.745′) and the Galuut (N 46°33.441′, E 99°59.378′), from August 2015 to May 2017. Tritium and CFCs concentrations of the spring water discharges at the two thermokarst landscapes were very low (especially at the Galuut site). An atmospheric water budget analysis indicated that net precipitation (i.e. net recharge to the groundwater) was almost zero at the southern part of the Khangai Mountains including Galuut site. Thus, it was implied that the spring water of the Galuut thermokarst site contained large amount of ground ice-melt water. Additionally, because the CFCs concentrations at the Galuut site have been decreasing gradually, the permafrost thawing is now progressive in this site. Therefore, large vulnerability in the permafrost thaw was detected in conjunction with current climate change in the region. Compared with the results obtained by a previous research [1], which estimated permafrost groundwater age in eastern Siberia, the estimated groundwater age in the Khangai Mountains has large variability.

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S03-O05

Perennial Snowfields in the Central Brooks Range, Alaska: A Landsat Based Time Series of Extent Changes in Gates of the Arctic National Park and Preserve

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Pronounced warming of the Arctic is driving significant physical and ecological changes, including losses in extent of perennial snowfields in Gates of the Arctic National Park and Preserve in the central Brooks Range mountains of Northern Alaska. These snowfields are sensitive indicators of climate change and an important eco-hydrological resource. Like glaciers, they form through accumulation and compaction of seasonal layers of snow, however, in contrast to glaciers; these features never grow thick enough to flow under the influence of gravity. Perennial snowfields can alter hydrology, geology, permafrost distribution, and are important ecosystems for an array of wildlife, including caribou, which flock to snowfields for insect avoidance and to thermoregulate. Caribou are critical to the traditional subsistence lifestyle for Native Alaskan people in the Arctic.

This research quantifies how perennial snowfields are changing and addresses impacts to caribou and subsistence. Quantifying historic snowfield extents is done through remote sensing techniques by creating a time series of changes from Landsat satellite images. The project also entails use of Digital Elevation Models (DEMs), in-situ field collected data, and local Native Alaskan indigenous knowledge, to support the Landsat based model. Intial results indicate notable losses in perennial snowfield extents over the study area. The goal of this interdisciplinary project is to help subsistence users, hydrologists, ecologists, and other scientists and stake holders understand snowfield changes and implications for caribou.

S03-O06

Active-layer thickness at permafrost larch forests in eastern Siberia

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This study investigated spatial variability of active-layer thickness (ALT) at larch-dominated forests in the middle part of the Lena basin, eastern Siberia. Forest ecosystem in this region is characterized by low precipitation, a short growing season, and extensive permafrost. Seasonal thawing permafrost supplies soil water, which is prevented to infiltrating by an impermeable frozen layer, and supports forest development.

We compared temporal and spatial variability of ALT at two larch-dominated forests mixed with birch and willow, in the southern and middle parts of the Lena basin. One is the Spasskaya Pad station (SP) on alluvial terrace near Yakutsk (62° 15´N, 129° 14´E). The other is Elgeeii (EG) station (60° 0´N, 133° 49´E) located at erosional plain, 300 km southeast of Yakutsk. Reflecting different geographical location, these two sites have contrastive soil characteristics; sandy-loam soils at SP has less water retention compared to clay-loam soils at EG. Based on continuous measurement of soil temperature and water, soil water in the active layer was more and its seasonal variation was more stable at EG compared to SP and seasonal thawing speed is larger at SP [1]. Field measurements of ALT using handheld dynamic cone penetrometer [2] were repeated in each site in June–July (first half of summer) and September (before soil freezing). Although averages of ALT observed in the same season was not differ in two sites, their spatial variability showed contrast in two sites and season (Figure 1.). Vertical profile of penetration resistance indicates that active layer in EG was relatively uniformly soft while that in SP was harder and had vertical structure at some points. Considering also accompanied observation of surrounding forest, factors of variability of ALT are discussed.

This work was carried out by JSPS KAKENHI (26242026, 26252021), ArCS (Arctic Challenge for Sustainability) project and joint research program for Space-Earth Environmental Research, Nagoya University.

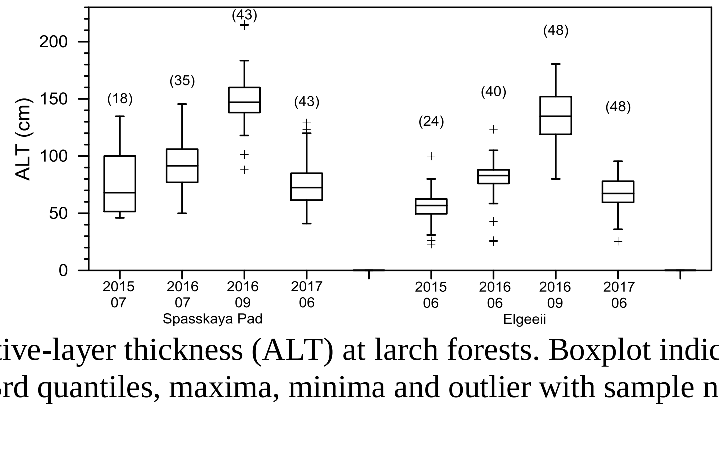

Figure 1. Active-layer thickness (ALT) at larch forests. Boxplot indicates median, 1st and 3rd quantiles, maxima, minima and outlier with sample number.

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S03-O07

The amplified Arctic terrestrial ecohydrological processes under the climate change

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The Arctic has experienced a set of various changes due to warming climate. The significant changes include increased vegetation biomass, permafrost degradation, increased river discharge, and decreasing sea ice. The declining sea ice has associated with the deepening of snow cover on the terrestrial surface, sequentially affecting permafrost and ecohydrological cycle along the seasonal processes. A land surface model CHANGE examined the warming climate induced changes in the Arctic eco-hydrologic system. In addition to enhanced snow insulation, the Arctic warming triggered deeper active layer thickness, which positively correlated to evapotranspiration and net primary productivity. Deeper snow and the early melt resulted in earlier and larger discharge peak in spring. Temperature warming derived later fall freezeup and earlier spring breakup. As a result, longer ice-free period contributed to warming river water, consequently increasing warmer freshwater to Arctic Ocean. These results increase our understanding on the warming climate derived changes in the Arctic ecohydrological system and on potential changes under the future climate.

January 18

Breakout Session

G7

Geospace

G07-O11

Energetic electron precipitations associated with chorus waves; Initial observations from Arase and ground-based observations

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The pulsating aurora is caused by intermittent precipitations of a few – 10s keV electrons, and it is expected that the pitch angle scattering by chorus waves at the magnetosphere is a primary process to cause the pulsating aurora. In March and April, 2017, a series of the campaign observation focused on the chorus-wave particle interactions from conjugate observations from Arase and ground-based observations, and the pulsating aurora as a manifest of chorus-wave particle interactions was the important observation subject. During the campaign observations, good conjugate observations were realized between Arase and ground-based observations in Scandinavia. Associated with the pulsating aurora, the EISCAT radar at Tromso, Norway observed strong ionization in the low altitude. During the period, the Arase satellite observed intense chorus waves near the magnetic equator for a few hours, suggesting that strong pitch angle scattering took place. From the conjugate observations from Arase and ground-based observations, we discuss how chorus waves cause strong precipitation of electrons from plasma sheet and radiation belts.

Ground-based optical observations of pulsating aurora in coordination with ARASE/ERG satellite

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Pulsating aurora (PsA) is one of the major types of aurora often seen in the lower latitude part of the auroral region in the morning side. The period of the main optical pulsation ranges from a few to a few tens of seconds, and PsA is almost always observed during the recovery phase of substorm. Recent coordinated satellite-ground observations of PsA indicated that the temporal variation of the main optical pulsation is closely associated with the intensity modulation of whistler mode chorus waves in the morning side magnetosphere because the intensities of the chorus waves and optical pulsation show similar temporal variation. However, it is still under debate what process causes the precipitation of PsA electrons and what factor controls the period of optical pulsation.

To further associate the chorus intensity variation in the magnetosphere and optical pulsation in the ionosphere, we need to conduct simultaneous ground/satellite observations of PsA. For this purpose, we have installed 3 identical all-sky cameras (ASI) in the northern Scandinavia to observe PsA in a wide area. The cameras were installed into Tromsø in Norway, Sodankylä and Kevo in Finland. By employing highly-sensitive EMCCD cameras (Hamamatsu C9100-23B), we succeeded in capturing PsA with a temporal resolution of 100 Hz. The temporal resolution of the camera is sufficient for resolving the temporal variation of both the main pulsation (a few to a few tens of second) and internal modulation (~3 Hz).

During the first coordinated campaign observations of PsA with the ARASE/ERG satellite in March 2017, we obtained several case examples of simultaneous observations of PsA and chorus by the ASIs and ARASE. In the presentation, we focus on some of the events obtained during the campaign and introduce on-going analysis on the fine-scale correlation between the main modulation of PsA and chorus bursts.

Acknowledgement: The operation of the EMCCD camera at Sodankyla has been supported by Sodankyla Geophysical Observatory (SGO).

G07-O13

Role of Space-based and Ground-based Infrastructure in Studies of the Atmospheric Forcing by High-Energy Particle Precipitation and the New Research Opportunity by the EISCAT_3D Incoherent Scatter Facility.

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Particle precipitation as source of atmospheric variability challenges us to implement better and continuously monitoring observational infrastructure at high latitudes. An example research target is the effect of high-energy electron precipitation during pulsating aurora on mesospheric ozone, the concentration of which may be reduced by several tens of percent, similarily as during some solar proton events, which are known to occur more rarely than pulsating aurora. So far the Assessment Reports by the Intergovernmental Panel on Climate Change did not include explicitely the particle forcing of middle and upper atmosphere in their climate model scenarios. This will appear for the first time in the upcoming climate simulations.

After reviewing the recent results related to atmospheric forcing by particle precipitation via effects on chemical composition, we show the research potential of new ground-based radio measurement techniques, such as spectral riometry and incoherent scatter by new phased-array radars, such as EISCAT_3D, which will be a volumetric, 3- dimensionally imaging radar, distributed in Norway, Sweden, and Finland. It is expected to be operational from 2021 onwards, surpassing all the current IS radars of the world in technology. It will be able to produce continuous information of ionospheric plasma parameters in a volume, including 3D-vector plasma velocities. For the first time we will be able to map the 3D electric currents in ionosphere, as well as we will have continuous vector wind measurements in mesosphere.

The geographical area covered by the EISCAT_3D measurements can be expanded by suitably selected other continuous observations, such as optical and satellite tomography networks. A new 100 Hz all-sky camera network was recently installed in Northern Scandinavia in order to support the Japanese Arase satellite mission. In near future the ground-based measurement network will also include new mesospheric ozone observations and a north-south chain of spectral riometers in Finland. New space missions will gain from this emerging enhancement of ground-based observations. Possibly essential new data could be provided by polar orbiting cubesats for which scientific level instrumentation is currently being developed.

G07-O14

EISCAT radar measurements of energetic particle precipitation during ARASE satellite conjunctions

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The ARASE satellite mission aims to study the acceleration and loss mechanisms of relativistic electrons during geospace storms by observing both "the cause", i.e., magnetospheric waves responsible for the acceleration/loss, and "the effect", i.e., the corresponding energetic electron flux populations seen by the particle detectors onboard. Ground-based verification of the precipitating electron fluxes serves as a crucial complement for this approach.

European Incoherent Scatter (EISCAT) radars measure the height-dependent density of free electrons, and its time-dependent response to variable ionising radiation from space, yielding information on both the ionisation source processes (solar electro-magnetic radiation, energetic particle precipitation, cosmic rays) and their consequences on the atmosphere (changes in chemistry, energetics and dynamics).

To determine the precipitation characteristics in the ARASE & EISCAT conjunctions, a novel inversion technique based on a detailed ion chemistry model (SIC) and the MCMC inversion is introduced. In addition, potential chemical consequences of the energetic particle precipitation are assessed.

G07-O15

Energetic electron precipitation and auroral morphology at the substorm recovery phase

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It is well known that auroral patterns at the substorm recovery phase are characterized by diffuse or patch structures with intensity pulsation. According to satellite measurements and simulation studies, the precipitating electrons associated with these aurorae can reach or exceed energies of a few hundred keV through resonant wave-particle interactions in the magnetosphere. However, because of difficulty of simultaneous measurements, the dependency of energetic electron precipitation (EEP) on auroral morphological changes in the mesoscale has not been investigated to date. In order to study this dependency, we have analyzed data from the European Incoherent Scatter (EISCAT) radar, the Kilpisjärvi Atmospheric Imaging Receiver Array (KAIRA) riometer, collocated cameras, ground-based magnetometers, the Van Allen Probe satellites, Polar Operational Environmental Satellites (POES), and the Antarctic-Arctic Radiation-belt (Dynamic) Deposition-VLF Atmospheric Research Konsortium (AARDDVARK). Here we undertake a detailed examination of two case studies. The selected two events suggest that the highest energy of EEP on those days occurred with auroral patch formation from post-midnight to dawn, coinciding with the substorm onset at local midnight. Measurements of the EISCAT radar showed ionization as low as 65 km altitude, corresponding to EEP with energies of about 500 keV.

Enhancements of the deep ionospheric ionization induced by the EEP modify the chemical-reaction balance involving atmospheric minor species such as NOx and HOx. These species may cause reduction in the ozone density at the ionization altitude or the lower region where these species are transported by the vertical convection in the dynamics. Since the EEP is a typical phenomenon at the substorm recovery phase, the ozone density depletion may be a frequent signature although our understanding has not yet reached the maturity of the mechanism behind these evidences. This presentation will discuss the processes related to the EEP and its effects on the atmosphere through changes in the minor components.

January 18

Breakout Session

G4

Ice Sheets, Glaciers and Ice Cores

G04-O01

The role of the North Atlantic Oscillation (NAO) on recent Greenland surface mass loss and mass partitioning

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Despite recent changes in Greenland surface mass losses and atmospheric circulation over the Arctic, little attention has been given to the potential role of large-scale atmospheric processes on the spatial and temporal variability of mass loss and partitioning of the GrIS mass loss. Using a combination of satellite gravimetry measurements, outputs of the MAR regional climate model and reanalysis data, we show that changes in atmospheric patterns since 2013 over the North Atlantic region of the Arctic (NAA) modulate total mass loss trends over Greenland together with the spatial and temporal distribution of mass loss partitioning. For example, during the 2002 – 2012 period, melting persistently increased, especially along the west coast, as a consequence of increased insulation and negative NAO conditions characterizing that period. Starting in 2013, runoff along the west coast decreased while snowfall increased substantially, when NAO turned to a more neutral/positive state. Modeled surface mass balance terms since 1950 indicate that part of the GRACE-period, specifically the period between 2002 and 2012, was exceptional in terms of snowfall over the east and northeast regions. During that period snowfall trend decreased to almost 0 Gt/yr from a long-term increasing trend, which presumed again in 2013. To identify the potential impact of atmospheric patterns on mass balance and its partitioning, we studied the spatial and temporal correlations between NAO and snowfall/runoff. Our results indicate that the correlation between summer snowfall and NAO is not stable during the 1950 – 2015 period. We further looked at changes in patterns of circulation using self organizing maps (SOMs) to identify the atmospheric patterns characterizing snowfall during different periods. We discuss potential implications for past changes and future GCM and RCM simulations.

G04-O02

Positive feedback effect of NIR albedo reduction on surface melting observed at SIGMA-A on Greenland ice sheet

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Drastic surface melting of Greenland ice sheet (GrIS) is occurring after the middle of 1990s. Surface albedo is one the most important parameter for heat budget of ice sheet surface. In accumulation area of GrIS the surface albedo is controlled by change of snow grain size because a contribution of light absorbing snow impurity such as black carbon to albedo reduction is low (Aoki et al., 2014). In particular, the near-infrared (NIR) albedo is an important indicator for the change of snow surface condition, as NIR albedo strongly depends on snow grain size. To investigate the surface melting we have observed the meteorological parameters with an automatic weather station (AWS) at SIGMA-A site (78°N, 67°W, 1,490 m a.s.l.) since June 2012. Figure 1 shows the annual variations of air temperature and near-infrared albedo measured at SIGMA-A. During this period a remarkable surface melting was occurred in summer seasons of 2012 and 2015. In those summer seasons the air temperature increased up to 4-6°C and significant NIR albedo reduction was observed. Examining a relationship between air temperature and NIR albedo, NIR albedo correlates strongly with air temperature at around 0°C and substantially−decreases at a higher temperature than -2°C. The possible mechanism is that an increase of temperature accelerates snow metamorphism, by which snow grain growth occurs and thus NIR-albedo decreases. Remarkable surface melting by temperature increase would be accelerated by a positive feedback effect through the NIR-albedo reduction in 2012 and 2015.

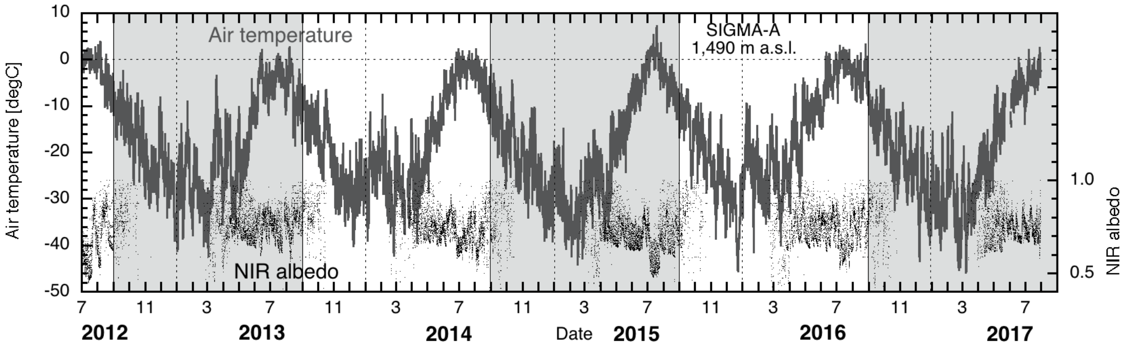

Figure 1. Annual variations of air temperature and near-infrared albedo measured at SIGMA-A

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Simulations of the evolution of the Greenland ice sheet under Paris Agreement warming scenarios

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At the 2015 United Nations Climate Change Conference (COP21), it was negotiated to limit global warming to well below 2.0°C and, if possible, to 1.5°C above pre-industrial levels (“Paris Agreement”). The Intergovernmental Panel on Climate Change (IPCC) will provide a special report on the impacts of a 1.5°C warming (“SR1.5”). A major consequence of global warming is sea level rise, for which increased mass loss of the Greenland and Antarctic ice sheets is a significant contribution. Here, we focus on the Greenland ice sheet, and use two different ice sheet models, namely SICOPOLIS and ISSM, to simulate the response of the ice sheet to several future climate scenarios. In order to do so, an initial condition for the present-day ice sheet is required, which will be produced as the result of a paleoclimatic spin-up as described by Goelzer et al. [1]. The five future climate scenarios to be considered are a constant-climate control run, 1.5°C warming with or without interim overshooting, and 2°C warming with or without interim overshooting. These scenarios were produced by several general circulation models (GCMs) within the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP2b, [2]) and, together with a post-processing by the Surface Energy and Mass balance model of Intermediate Complexity (SEMIC, [3]), will be defined as space- and time-dependent anomalies of the surface temperature and surface mass balance over the Greenland ice sheet. Using these anomalies as forcings, we will investigate the change of ice thickness, extent, discharge and mass balance of the ice sheet with SICOPOLIS and ISSM for all scenarios until the year 2300. In addition to the results themselves, using the two models allows assessing uncertainties that arise from different model physics and numerical techniques.

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Tracking Crevasse Extent over the Greenland Ice Sheet using ICESat-1

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ICESat-1 was the first public laser altimeter satellite and provided detailed measurements of arctic ice elevation—and ice elevation change—during it's 7-year mission. However, ICESat-1 acquired more than just point estimates of elevation; it acquired full time-spectrum waveform data for each of it's footprints. Recent advances in computational hardware and machine learning algorithms has made it possible to retrieve far more information from the archival data, including probabilistic estimates of surface type, morphology, and roughness of individual laser footprints. More specifically, these probabilistic estimates have allowed us to model and simulate the distribution of crevasses throughout the Greenland ice sheet for a portion of the ICESat-1 mission. Crevasses play a significant role in melt water evacuation, serving to both instantiate moulins [1], and drain melt water to the bed in proportion to their areal coverage [2]. While crevasses on the Greenland ice sheet are hugely important for understanding feedbacks to the ice sheet hydrological system, distributing and communicating data that is fundamentally probabilistic raises it's own set of challenges. We have opted to distribute our data product in multiple forms, including point data corresponding to original laser shot measurements, and gridded products of surface probability.

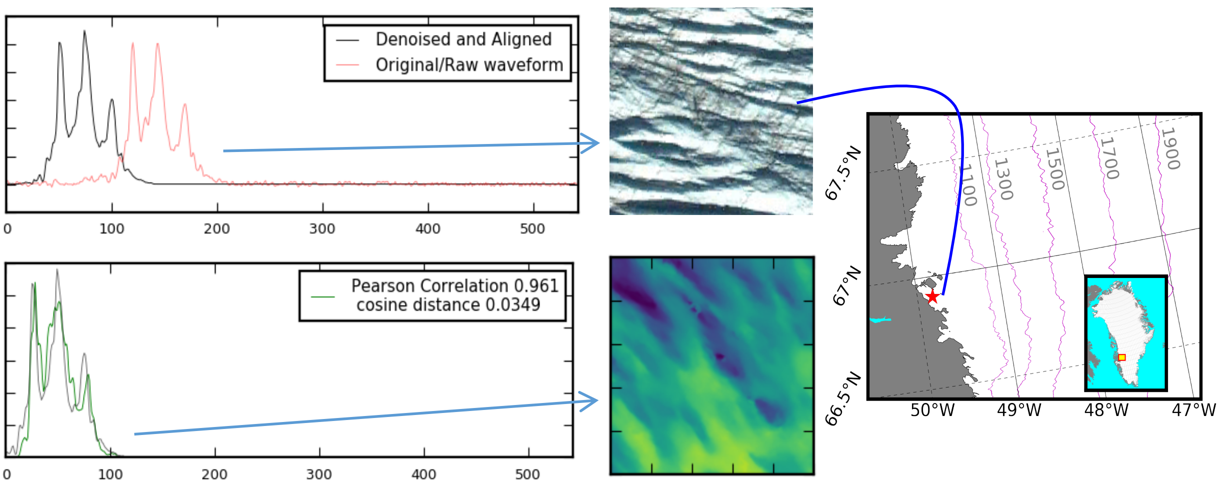

Figure 1. Original and filtered waveform from ICESat-1 over crevasse field (*top*); matched signal and estimated surface from reference library (*bottom*); location of crevasse field (*right*)

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G04-O05

Seismic noise as a proxy for glacier dynamics

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Historically, seismic noise has been an obstacle for detection seismology, because weak or distant events could be missed due to a reduction of a Signal-to-Noise ratio. Recently, however, noise analysis (mainly seismic tomography) has been recognised as a powerful tool for evaluating spatial and temporal variation of subsurface structure and, for instance, fluid-related processes [1].

Here, we analyse the intensity of seismic noise at a fast-flowing Bowdoin Glacier in northwest Greenland. A series of comprehensive seismic experiments was conducted at this calving tidewater glacier between July 2015 and July 2017, and included an array of borehole seismometers drilled directly into ice near the calving front and left for a full year [2, 3].

To quantify temporal variation of the noise strength, we deconvolve seismic traces from an instrument response and evaluate Power Spectral Density partitioned by different frequency bands. We find that the amplitude of noise is correlated with a surprisingly vast range of local processes. The latter include: first and foremost, glacier ice-speed variation; second, tide-modulated strain of glacier terminus; third, major hydraulic events like Glacier Lake Outburst Floods leading to a growth of sediment plumes; and finally, forth, a well-known effect of ocean waves generating microseisms.

The physical mechanisms driving some of these relationships have to be established. Yet, we recognise that the presented approach can be a powerful tool for high-frequency continuous monitoring of glacial processes, and, therefore, should be further explored.

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G04-O06

Seasonal/long-term changes in Rayleigh-wave phase velocity at the bottom of Greenland ice sheet

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The Greenland ice sheet (GrIS) is a huge storehouse of water on Earth, and has a potential to raise global sea level by ~7 m when completely melted. It is widely reported that the recent climate change has been causing a serious changes in the ice sheet status. The Greenland Ice Sheet Monitoring Network (GLISN), an international project with 11 countries initiated in 2009, now provides a broadband, continuous and realtime seismic data from 33 stations in and around Greenland. Seismic observation, therefore, is now drawing a wide attention as a direct method to monitor the ice sheet status in realtime. Mordret et al. (2016) applied the seismic interferometry to ambient seismic noise data for two years (2012-2013) from seven GLISN stations at southwest Greenland and revealed clear decrease of crustal seismic velocity in summer. However, they suggested difficulty of detecting secular variability in seismic velocity since they consider that the ambient noise has less sensitivity to the long-term changes.

In this study, we apply the seismic interferometry to the data from stations distributed all over Greenland and for longer observation period to show the possibility to detect secular changes in crustal seismic velocity. Seismic interferometry is a method taking a cross-correlation between noise data from two stations to detect Green's function of seismic waves as if one station was a source and another was a receiver. We used vertical component of seismic waveforms for 4.5 years (Sep. 1, 2011 – Feb. 29, 2015) from 16 GLISN stations, which provide clear surface wave pulses for 68 station pairs. For each pair, we defined the 4.5-year averaged CCF as a reference waveform, and detected slight phase shifts of three-month averaged CCFs from the reference to obtain relative temporal changes in crustal velocity below the two stations. We carefully selected the results with respect to computation error and the data quality, and obtained the final results for 36 station pairs.

The significant findings of this study are as follows. Firstly, clear seasonal and long-term changes in Rayleigh-wave phase velocity were found beneath a number of GLISN station pairs. Unlike the case of southwestern Greenland (Mordret et al., 2016), the velocity changes show a strong regionality that is more remarkable at inland areas. Secondly, a plausible mechanism causing the velocity changes was proposed, which consistently explains most of the observed characteristics, taking into account the air and ice mass loading/unloading, depth sensitivity of Rayleigh waves, and heterogeneities of the GrIS basal conditions. We found that, even at adjacent station pairs in the inland GrIS, the difference in the GrIS basal conditions could possibly cause completely opposite patterns of velocity changes as a response to air and snow pressure. The results demonstrate that changes in Rayleigh-wave phase velocity might be a useful tool in determining the GrIS basal conditions.

Japanese activities under EGRIP (East Greenland Ice Core Project)

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The Greenland Ice Sheet has recently been experiencing drastic changes, such as extended summer melting and increasing mass losses. There is an urgent need to understand the mechanisms of such changes because they are directly linked to global sea level rise. Greenland ice cores have so far provided valuable information on melt events and changes in the surface mass balance in the past. The previous ice cores, however, were drilled at sites with minimal horizontal ice flow, which have given us only limited information on ice flow dynamics. Understanding the mechanisms of ice deformation and basal sliding is a prerequisite for better projections of the future changes of the Greenland Ice Sheet and sea level rise. To understand the Greenland Ice Sheet dynamics, the East Greenland Ice Core Project (EGRIP), an international project led by the University of Copenhagen, was launched in 2015. Under EGRIP, a deep ice core to the bed will be drilled at the onset of the North-East Greenland Ice Stream (NEGIS), where horizontal flow velocity is expected to be several tens of meters per year. As NEGIS is the largest ice stream in Greenland, the EGRIP ice core and bore-hole measurements will certainly advance our knowledge on the dynamics and past changes of the Greenland Ice Sheet. The EGRIP core will also give us an ideal opportunity to reconstruct the climate and environment changes during the early Holocene, which was considered to be warmer than today and should be an excellent analogue to the future Greenland affected by global warming.

Japan participates in the EGRIP under the ArCS (Arctic Challenge for Sustainability) project. Japan takes part in ice-core drilling and processing, as well as analyses of physical properties, chemistry and gases. In 2015 and 2016, Japan carried out snow-pit studies and aerosol sampling at the EGRIP site. In addition to the ice core analyses and field activities, Japan studies mechanical properties of artificial ice to derive a new flow law of ice. Japan also carries out studies on ice sheet modeling including GIA (Glacial Isostatic Adjustment) modeling, and paleo-climate modeling. Some of the results obtained from pit-studies and mechanical tests of artificial ice will be presented at ISAR-5.

G04-O08

Reconstruction of nitrogen isotopic composition of nitrate preserved in high-accumulation dome at South East Greenland

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Nitrate is one of the major anions found in snow. Nitrate (NO_3^-) deposition results from reactions between nitrogen oxides (NO_x = NO + NO_2) and atmospheric oxidants. Global main sources of NO_x are fossil fuel, biomass burning, biogenic soil emissions, and lightning. A recent increase in NO_3^- in ice cores has been associated with increasing anthropogenic emissions of NO_x. Based on the changes in NO_3^- concentration, however, it is not easy to identify specific sources of NO_x which takes into account for the changes in NO_3^- concentrations, hindering the development of mitigation policy of anthropogenic pollution and its effect on the environment. Nitrogen and oxygen isotopic compositions of NO_3^- provide information on changes in the nitrogen source and its formation pathways, but ice core records for NO_3^- concentrations and its isotopic compositions are problematic because of post depositional loss of NO_3^- via photolysis [e,g, 1]. In this study, we analyzed isotopic compositions of NO_3^- preserved in the high-accumulation dome ice core, South East Greenland, which has a dome with high accumulation rate (about 1 m yr^{-1}) in water equivalent [2]. In this study, $\delta^{15}N$, $\delta^{18}O$, and $\Delta^{17}O$ values of NO_3^- were measured by the bacterial method coupled with N_2O decomposition via microwave-induced plasma (MIP) [3].

The nitrogen isotopic compositions for NO_3^- were generally lower than those reported in Summit, Greenland [4, 5], suggesting that some extent of NO_3^- deposited in Summit is removed via photolysis. Based on the trend of reconstructed $\delta^{15}N$ values and NO_x emission inventory, switches from coal to oil combustion mainly in North America was likely a factor changing the nitrogen cycle in the Arctic environments.

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Composition of salt inclusions in the southeastern Greenland (SE-Dome) ice core analyzed by micro-Raman spectroscopy

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Emission regulation of anthropogenic NO_X and SO_X since late 90's rather caused excess atmospheric ammonium (NH_3) in North Hemisphere agricultural regions [1]. The Arctic is one of the most sensitive areas for future warming. Aerosols in the Arctic are transported from the Northern Hemisphere and mostly experience wet deposition [2]. Ice cores preserve past water-soluble aerosols. From these viewpoints, ice cores from the Arctic are suitable to evaluate recent variations in aerosol composition due to human activity in the Northern Hemisphere and aerosol transportation. Cloud nuclei formation, which is an important factor of radiative forcing, depends on chemical form of aerosols. Thus, differences in chemical forms of these aerosols in ice core samples are important to evaluate the past radiative-forcing change. In this study, we identified the chemical form of aerosols (water-soluble inclusions) by using micro-Raman spectroscopy and especially focused on ammonium salts in the ice core samples from southeastern dome in Greenland (SE-Dome). This research was funded by MEXT (Japanese Ministry of Education, Culture, Sports, Science and Technology) through Arctic Challenge for Sustainability (ArCS) the Arctic region research project.

SE-Dome ice core samples were collected in 2015 and enabled us to reconstruct seasonal variations owing to extremely high accumulation rate (~1m/yr.). The ice samples were sublimated on Ni sheets in a clean booth under −22 degrees Celsius, and residual inclusions were analyzed. We analyzed 100 particles from spring and summer samples. Sampling interval is every eight years and that of samples deposited in 90's is every two years. We identified $CaSO_4$, Na_2SO_4, $(NH_4)_2SO_4$, $NaNO_3$, NH_4NO_3, $Na_2SO_4 \cdot NaNO_3$ (double salt) and $CaCO_3$ by Raman spectra. This is the first report to identify ammonium salts ($(NH_4)_2SO_4$ and NH_4NO_3) from an ice core sample. $(NH_4)_2SO_4$ are not detected from the spring samples deposited on and after 1994 while NH_4NO_3 are observed from all samples. The concentrations increased for NH_4^+ and NO_3^- and decreased for SO_4^{2-} after late 90's. The observed NH_4^+ increasing trend is probably due to excess NH_3 emission in North America mentioned above. We infer that reduction of SO_X emission since late 90's presumably reduced $(NH_4)_2SO_4$ formation in the Northern Hemisphere agricultural regions and its transportation to the Arctic such as Greenland. In contrast, $(NH_4)_2SO_4$ are main components in the summer samples. NH_4NO_3 is unstable and discharged NH_4^+ rapidly react with SO_4^{2-} under higher temperature [3]. Thus, these alteration processes from NH_4NO_3 to $(NH_4)_2SO_4$ were possibly enhanced in summer. There is no decreasing trend after late 90's in the summer samples. We suggested that $CaSO_4$ and Na_2SO_4 were formed hardly due to low concentration of Na^+ and Ca^{2+} in the summer after late 90's.

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Speciation of calcium in particles trapped in Greenlandic ice core

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Mineral dusts which is one of important components in aerosols react with gaseous or solutes in droplets in the atmosphere to form secondary species. For example, calcite ($CaCO_3$) contained in mineral dusts is a major mineral at the earth's surface and reactive with acid in the atmosphere because of their high alkaline property [1]. $CaCO_3$ reacts with sulfuric acid (H_2SO_4) and forms gypsum ($CaSO_4 \cdot 2H_2O$) during long-range transportation [2]. After 1970s, global emission of sulfuric dioxide (SO_2: precursor of H_2SO_4) decreases [3]. Thus, it is possible that $CaSO_4 \cdot 2H_2O$ fraction to total calcium in mineral dust, which reflects degree of reaction of $CaCO_3$ with H_2SO_4, also decreases depending the emission of SO_2. In this study, calcium species was investigated for the particles trapped in ice core drilled in Greenland, in which atmospheric particles and gases are transported from continents in Northern hemisphere [4].

Ice core sample was drilled at the southeast Greenland (SE Dome: 67.2°N, 36.4°W). Ice layers dated at 1971, 1978, 1987, 1995, and 2004 in the core sample were sublimated in low-temperature room (−17 ˚C) based on [5]. Calcium-bearing particles in the trapped particles were identified and their species were determined by micro X-ray fluorescence mapping and micro X-ray absorption fine structure spectroscopy, respectively.

$CaSO_4 \cdot 2H_2O$ fractions to total calcium in 1971, 1978, and 1987 were lower than those of $CaCO_3$. In contrast, the fraction of the two species showed opposite trends in 1995 and 2004. The results suggested that reaction of $CaCO_3$ with H_2SO_4 was more active in recent years. In China, amount of emission of SO_2 has increased after 1970s, whereas those in North America and Europe have decreased [3]. In addition, China is one of the major sources of mineral aerosol transported to Greenland [6]. It is suggested that mineral particles transported to Greenland reacted with H_2SO_4 mainly emitted in China.

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G04-O11

Effect of solid particles on polycrystalline ice and its relations with rapid deformation of ice-age ice

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Variations of Greenland and Antarctic ice-sheet play a fundamental role in climate change. Although ice-sheet behaviors have large spatial and temporal scales, the importance of microstructures of ice-sheet ice has been suggested from detailed analysis of ice cores [1]. The cloudy band, which locates in the ice cores and holds highly-concentrated impurities, corresponds to the ice-age ice. Ice core analysis revealed that the deformation of ice-age ice (glacial periods ice) is faster than that of interglacial periods ice [2]. However, it's not known exactly why. Especially, the effect of solid particles on the polycrystalline deformation, ice-sheet dynamics and evolution is not clarified.

We performed uniaxial deformation experiments and microstructure observations using artificial polycrystalline ice with and without dispersed silica particles to investigate the effect of solid particles on the polycrystalline deformation. Deformation experiments were conducted with temperature of -20C^{o} and load stress of 0.5, 1, and 2MPa. Our experiments revealed different trends for softening-hardening effect of polycrystalline-ice deformation due to silica-dispersion. Silica-dispersed ice becomes softer than pure-water ice when the initial grain size is very small (<100μm). On the other hand, silica-dispersed ice becomes harder than pure-water ice when the initial grain size is large (>100μm). Microstructural observations of deformed ice samples suggest different deformation mechanism for different initial grain sizes. Grain boundaries for large-grained ice show irregular (curved and bulging) shapes, while those for small-grained ice shows straight shapes. Irregular boundary is a typical feature when ice deforms by dislocation creep [3]. On the other hand, straight boundary is a feature for grain boundary sliding and diffusion [4]. It is considered that a difference of softening-hardening effect of polycrystalline-ice deformation due to silica-dispersion is caused by different deformation mechanism.

In this presentation, we discuss the role of solid particles on polycrystalline-ice deformation from mechanical experiments and microstructure observations, and the cause of rapid deformation of ice-age ice.

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January 18

Breakout Session

S11S13

Environmental, Economic, Societal and Geopolitical Dynamics in the Arctic, their Global Drivers and Implications

S11S13-O01

European cooperation: Poland a strategic link to ensure Artic governance

La coopération européenne : La Pologne un maillon stratégique pour garantir une gouvernance de l'Arctique

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1. ABSTRACT

Although the Artic remains one of the most regulated sea in the world the Baltic, Artic's governance faces today its greatest challenges: "European cooperation", which requires not only the agreement of the member states, but also a good lobby for the influence of the world powers. First of all, an agreement between the member states of the European Union raises the identity of each member state and its own visions of governance in order to arrive at this new stage of integral collective governance. Secondly, the influence of third states, such as the United States, Russia and China in its global geopolitical relations with each of the member states of the European Union, poses a threat to full collective governance.

That is why this article analyzes the importance of international geopolitical relations aiming at full cooperation in the European Union, which will enable collective governance of the Artic. In this regard, the analysis goes on to take the example of Poland and its articulating role for European cooperation in the prevention and precaution of conflicts with other states and thus work together towards Artic governance.

Would the Polish initiative for the Three Seas, the Artic, the Adriatic Sea and the Black Sea, respond to the requirements of European defense mandates and collective governance? Or rather the search for certain Baltic countries to build a strategic place in the European co-operation whose maritime domain?

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S11S13-O02

The Role of Non-Arctic States in Regime Building for the Central Arctic Ocean Fisheries Management

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Climate change has brought about fish dynamics at the Arctic Ocean. So far there has been no exact prediction for fish distribution at the Arctic Ocean and no immediate positive expectation for fishery at the Central Arctic Ocean (CAO), but the multi-lateral negotiations on the regime building for CAO fisheries management are ongoing in light of the precautionary approach. The five Arctic Ocean coastal states (A5) have taken up either implicit or explicit stewardship in initiating and coordinating the negotiation process for regime building; however, the prolonged process for the multi-lateral negotiations attended by A5 and 5 invited entities (China, EU, Iceland, Japan, Korea) starting from the late 2015 implies some divergence among, most probably, Arctic States and Non-Arctic States. The paper seeks to explore the legal framework and general principles which should guide the outcome of regime building for CAO fisheries management, and then, based on this, the paper will elaborate on the role of Arctic States (here referred to as A5) and non-Arctic States in regime building. Generally speaking, the law of the sea and other important fisheries regulations like Fish Stock Agreement will provide the guideline for CAO fisheries management regime building, while more tailored schemes are needed to attend to the uniqueness of the CAO. A5's stewardship mainly facilitated by its geo-advantages is recognized primarily by their good intention for international cooperation. Non-Arctic States' involvement in CAO fisheries management starts from their participation in regime building, and will be further enhanced by their scientific capability. With ice melting at the Arctic Ocean, the Arctic opens a new era during which Arctic and non-Arctic States strive for a sustainable Arctic with joint efforts. The study into the role of non-Arctic States in regime building for CAO fisheries management is of practical significance in that it will have implications for the role of non-Arctic States in a more general domain for Arctic governance.

The Role of non-Arctic Regions in the Globalized Arctic

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Recent years have witnessed a great diversification of actors interested and involved in the Arctic. While the new role of the state-level actors has been easy to notify, for example, through their official status as observers in the Arctic Council, the entry of various regions on the stage has lacked similar kind of official recognition. The circumpolar cooperation involving regions both from Arctic and non-Arctic states has, in fact, witnessed some setbacks during the past years, for example, through the shrinking membership of the Northern Forum. Nevertheless, this trend may be changing as Lapland and Alaska, for example, have reactivated in the Northern Forum. At the same time, regions far away from the shores of the Arctic Ocean have become more involved in processes concerning the Arctic. When analyzing the role of non-Arctic regions in the globalized Arctic, this paper concentrates on, but does not limit itself, to the case of Hokkaido. During the last decades of the 20th century, Hokkaido showed a great dedication toward the cooperation between northern regions and demands for renewed efforts have been made at the time when Arctic threats and possibilities have attracted a new kind of attention. While anchoring itself in the concept of paradiplomacy, i.e. international activities of subnational and non-state actors, this study pays attention to the venues and ways of bilateral and multilateral cooperation between Arctic and non-Arctic regions. In other words, the objective of this research is to understand how the institutional setting for cooperation has changed and how the logic, aims and drivers of cooperation between regions have evolved.

S11S13-O04

Security as a Key Prerequisite for Stability and Sustainable Environment in the Arctic

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Following the end of the Cold War, the international security has begun to take on a more regionalized character. The regional security in the Arctic is built around interdependence mainly on political, military, economic and environmental issues. There are several theoretical approaches which enable to study regional security. One of them is the securitization theory, which was developed predominantly for the national/regional level analysis. Since its introduction in 1998 by Copenhagen professors, the securitization has become a significant and widely used approach to security. The securitization theory provides interesting lens through which the emergence of security issues can be analyzed. It aims to reveal thresholds beyond which the securitization process begins. The theory examines how a specific issue becomes securitized, while being removed from the political process to the security agenda.

Political leaders are using the word "security" as a declaration of emergency reserving the right to use all available means to prevent an undesired threat. By doing so, the governments have often direct or indirect influence on the society/community. Although, different communities may respond to the same security circumstances in different ways, the distinction between an articulated threat and a real security threat is fundamental for the community. While numerous issues in the Arctic are challenging, they do not necessarily have to be described in terms of security. Better understanding of the mechanisms behind the securitization process makes the society/community able to evaluate whether the measures proposed by the political leaders are fully justified. By evaluation of real/artificial threats, and identification of the securitizing actors and their motivations, the community directly contributes to stability and sustainability in the region.

Society and communities in the Arctic need theoretically, conceptually and methodologically rigorous knowledge about politics to understand the changes or needed audience approval of exceptional steps/adopted policies/measures by the government. Better understanding of the complexity of risks and threats related to securitization in the Arctic, contributes to the secure and sustainable environment. The aim of the paper is to analyze securitization in the Arctic by unveiling dynamics of securitization across sectors and actors on national level (with focus on the United States) and internationally. The paper provides explanation of the mechanisms behind the securitization process, which enables society/community to evaluate the measures proposed by the political leaders. This is particularly relevant for the policy- and decision-makers, experts, environmentalists and activists groups, journalists, representatives of business, indigenous peoples, civil society and local communities.

S11S13-O05

The Arctic and the International Discourse on Climate Change: Which Implications for Arctic Indigenous Peoples.

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When it comes to political decisions taken outside the Arctic that have great impact on its natural and human environment, the building of a climate change regime certainly comes as a relevant example. The role and place of the Arctic region within international climate negotiations and policy has been extensively assessed in previous research [1]. The latter has underlined how "the canary into the coalmine" narrative, the one portraying the North as an early indicator of the impacts of climate change worldwide, has been prominent in scientific assessment and public discourse, although just partially effective in terms of national, regional and international commitments [2]. Thereby, while no specific reference is made to the particular circumstances of the region in any of the three legal instruments regulating global warming internationally [3], this narrative has had an impact in many other ways. With regard to Arctic Indigenous Peoples (IPs), for instance, Shadian (2017) argues that the shift in focus from sustainable development to climate change, has influenced the consideration of Arctic IPs. First regarded as legitimate steward of their ancestral territories, thus entitled to land rights and regional development, they are now depicted as victims of global warming [4]. Against this background, this article examines how the Arctic region has been conceptualized in relation to climate change (e.g. from an ice melting symbol, to the last frontier for the exploitation of resources and the "global Arctic") and the implications that an international discourse on climate change may have for Arctic IPs. In light of the recently adopted Paris Agreement [5], potential pathways for improving IPs' capacity are considered, also reconnecting with the role that non-Arctic actors can play in engaging in Arctic politics regarding climate change.

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January 18

Breakout Session

G3

Rivers, Lakes, Permafrost and Snow Cover

Changes of streamflow and heat flow in the largest Russian Arctic Rivers

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Long-term phases of changes in naturalized streamflow and heat flow of the largest Russian Arctic Rivers (Ob', Yenisei, Lena) during the period of observation (from 1930-1940 till 2000s) were revealed on the basis of normalized cumulative deviations curves. Their characteristics and the effects of impact of anthropogenic factors are evaluated.

Since 1930-1940s till the beginning of the 21st century, the naturalized annual and seasonal river runoff in the largest river basins was characterized by two main long-term phases of its changes. The phase of decreased runoff (since the 1930-1940s) was replaced in the 1970-1980s by a long-term phase of increased streamflow. The duration of phases was several decades and are characterized by significant runoff differences.

In the long-term variations of the heat flow of the Ob, Yenisei, Lena also were found two major long-term phases. The phase of the decreased heat flow, which began in 1930-1940-ies and lasted for 35-55 years, was replaced in 1970-1980 by 20-year phase of its increase (except the Yenisei, where this phase began in the late 1990s.) and has continued until now. Similar long-term phases are observed for river water temperature of considered rivers. Differences in heat flow reaches 20% during the phase of its increased and decreased values for the Yenisei Rivers, but for other rivers they are not higher than 10%.

The long-term phases of decreased and increased streamflow and heat flow of Arctic Rivers of Russia are closely associated with the indices of zonal atmospheric air transport intensity.

G03-O02

Features and extent of the degradation of ice-wedges in Central Yakutia under the influence of modern climate warming

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The modern climate warming has increased the development of cryogenic processes in Yakutia in the last two or three decades, which negatively affecting on landscapes. One of the most dangerous processes is thermokarst, caused by the degradation of ice wedges in edoma landscapes. In the taiga zone of Central Yakutia, degradation is primarily affected by anthropogenic and disturbed landscapes devoid of forest cover.

The change in the mean annual air temperature by 2-3 °C from the 1960s - 1970s caused an increase in the mean annual ground temperature 0.5 °C and a significant increase in the depth of seasonal thawing in forestless areas of edoma, with the destruction of the shielding layer which caused mass degradation of the ice wedges.

The mean rate of degradation of edoma with ice wedges on Yukechi monitoring site flat areas is up to 1 cm, in thermokarst depressions is from 10-15 cm to 25 cm per year. The formation of thermokarst lake depends on the size of the catchment and the ice content of the ground.

Almost all forestless areas of edoma have initial thermokarst damage - small holes in the underground cavities formed when the upper head of ice wedge melts and the polygonal micro relief. The thermokarst stages were studied by A.I. Efimov and N.A. Grave [1] and subsequently P.A. Soloviev [2], and they were completely used Yakut names - rudimentary byllar, byllar, ieye, dyuede, tyympy and alas. All these stages have their own landscape-hydrological and geocryological definition. The report presents data on the morphological structure of each stage of thermokarst.

Young thermokarst lakes on the edoma is rapidly growing with expanding of lake area. From 1980 to 2016, the area of young thermokarst lakes increased by 3-4 times. This has a negative impact not only on the surrounding forest landscapes, but also on communications, roads, buildings and pipelines.

Permafrost landscapes with high content of underground ice, which occupy about 25% of the territory of Yakutia, are in critical condition under the influence of modern climate warming. Results of field research show that any anthropogenic impact can lead to degradation of permafrost and socio-economic value of landscapes. Alases, genetically related to edoma, are the most populated areas in Yakutia. Therefore, understanding the trends in the dynamics of permafrost and landscapes is not only ecological, but also has socio-economic, cultural and historical significance.

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G03-O03

Engineering-Geocryological Mapping of the Republic of Sakha (Yakutia)

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The map of engineering-geocryological zoning of the Republic of Sakha (Yakutia) compiled in ArcGIS 10 is intended to provide information for the comprehensive evaluation of land-use and the planning of civil engineering works, including preliminary selection of transportation and communication routes, as well as for the assessment of geological hazards for mitigation and prevention. Engineering-geocryological zoning of Yakutia is particularly important and necessary in view of accelerated development of northern areas, including the Arctic. Compilation was based on the analysis and generalization of the main factors controlling geocryological conditions relevant for civil engineering practice. Engineering-geocryological conditions were studied to a depth of 10-20 m within which permafrost can influence or be influenced by the existing or new engineering work. This depth coincides with the zone of annual temperature variation in permafrost. The following hierarchy of mapping taxons was used: Regions, Areas, and Districts. The mixed classification principle was selected, when each classification parameter was assigned with a different classification taxon. Regions, the highest taxons, were assigned to the largest land elements which determine the closely related *exogeneous (and permafrost) processes*. The second, lower taxonomic level – the Area – was used to depict the *soil and rock units*. The District taxon was used to show the geocryological characteristics of soils and rocks, viz. *temperature and ice content*, within the upper 10-20 m of the ground. Hydrogeological conditions and seismicity were depicted on complementary maps. On the morphostructure scale, four regions are recognized within Yakutia. ***I. The Coastal Lowlands and Shallow Seashelf Region*** is the lowest-lying morphological feature (a negative morphostructure) distinctive in the present-day topography [1, p. 12-18]. The most hazardous processes in this region include thermokarst and wave erosion of the coasts composed predominantly of loess-like silts with peat interlayers. These materials are often more than 30-40 m in thickness. On the coasts, permafrost temperatures at the zero annual amplitude depth are often below -10°C. Thin discontinuous permafrost is likely in the shallow shelves. ***II. Central Siberian Plains and Plateaus*** **–** This region is characterized by a wide variety and medium intensity (Rank 2-3) of exogeneous (permafrost) processes. Karst is common in carbonate rocks. Surficial materials are also variable, with solid rocks in the plateaus and soils and soft rocks in the plains. In much of the region, permafrost temperatures at the depth of zero annual amplitude vary from -7° to -12°C. ***III. The Baikal-Stanovoy Region*** is characterized by high topography and recent tectonic activity responsible for widespread rock failures, including those induced by seismic activity, rock falls, slides and streams (Rank 4-5). Bedrock occurs at the surface in most of the region and consist of Archaean and Proterozoic crystalline rocks and subordinate Riphean and Paleozoic carbonate rocks. Intermontane depressions contain soft rocks of Mesozoic age. The region lies within the zone of discontinuous permafrost. ***IV. Verkhoyansk-Chukotka Region*** is dominated by mountains and thus rock falling and sliding are common processes here (Rank 4-5). Soft rocks are widespread with temperatures of -5°C or lower.

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G03-O04

Probabilistic modelling of methane emissions from Arctic shelf during Holocene

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East Siberian Arctic Shelf has an area of over 2 million square kilometres. It is covered by shallow seas no deeper than 80 metres, and is estimated to contain up to 1000 gigaton of methane locked in the form of hydrates [1], which are located in a thick layer of permafrost of up to 1000 meters deep [2]. The sub-sea permafrost has been degrading throughout the duration of the current interglacial, Holocene, driven by the formation of thaw lakes and by the subsequent inundation of the shelf [2]. This provides pathways for the methane from decaying hydrates to escape into the atmosphere. Using probabilistic modelling of the main location-specific parameters that affect the stability of hydrates and permeability of the permafrost, we identify hotspots for methane emissions and estimate methane fluxes from the entire shelf throughout Holocene. We also establish pre-conditions for possible increase in the emissions due to anthropogenic warming.

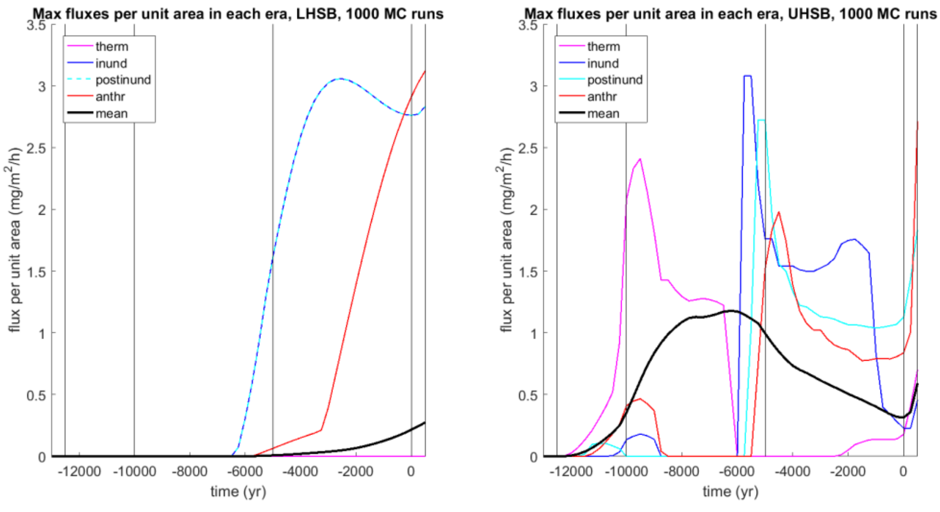

Figure 1. Methane fluxes from lower (left) and upper (right) hydrates stability boundaries. Coloured lines correspond to hotspots during a number of distinct eras defined by thermokarst lakes, inundation and anthropogenic warming. Thick black line denotes the mean flux for the entire shelf.

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G03-O05

Assessment of seasonal snow cover mass in NH and the Arctic during satellite-era (1980-present)

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[3]*Ouranos, Canada*

Reliable information on snow cover across the Northern Hemisphere and Arctic and sub-Arctic regions is needed for climate monitoring, for understanding the Arctic climate system, and for the evaluation of the role of snow cover and its feedback in climate models. In addition to being of significant interest for climatological investigations, reliable information on snow cover is of high value for the purpose of hydrological forecasting and numerical weather prediction. Terrestrial snow covers up to 50 million km² of the Northern Hemisphere in winter and is characterized by high spatial and temporal variability making satellite observations the only means for providing timely and complete observations of the global snow cover. The purpose of the ESA funded SnowPEx project has been to obtain a quantitative understanding of the uncertainty in existing Snow Extent (SE) and Snow Water Equivalent (SWE) products through an internationally coordinated and consistent evaluation exercise.

Based on the investigations in the ESA SnowPEx project, the GlobSnow SWE product [1] (which has shown good retrieval accuracy and consistency) was assessed and augmented with the JAXA JXAM5 daily SE product [2] (which shows a consistently accurate, daily time-series, starting from 1980). A cumulative SE mask was generated from the JXAM5 data by combining the available (cloud free) information from each observed day and filling the gaps (in observed daily product) from the previous day (gap filled) snow status – resulting in a cumulative binary snow mask (spanning from 1980 to present day). The outcome (daily gap filled snow mask) has the most recent observation recorded for each pixel. This cumulative snow mask was applied to correct the retrieved SWE products, which were assessed in regard to the amount of snow (SWE) during the winter season and the long term trends in Hemispheric SWE (i.e. total integrated snow mass).

The assessment shows that the total amount of snow decreases when the SWE product is constrained using SE data, especially during the melt season. The difference in the constrained and the original hemispheric SWE are varying from year to year. The daily SE-constrained SWE products were used to calculate the daily and monthly SWE masses and trends for years 1980 to 2016. The linear trends in the constrained SWE products are compared with the trends observed for the nominal GlobSnow SWE product. The assessments were carried out for the whole Northern Hemisphere, and for Eurasia, North America and the Arctic separately.

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January 16

Poster session

G1
Atmosphere

G2
Ocean and Sea Ice

G5
Terrestrial Ecosystems

G6S6
Changes in Sea Ice, Oceans and Ecosystems in the Arctic Ocean

G9
Social and Cultural Dimensions

S1
Arctic Warming by Natural Variability and/or Human Impact

S7S8
Arctic Challenge for Ice Observation and Ice Navigation

S9
Understanding the Changing Arctic through Data: Stewardship, Publication, and Science

G01-P01

How well do medium-range ensemble forecasts simulate atmospheric blocking events?

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Department of Physics, University of Oxford, UK

This study assesses the performance of seven operational medium-range ensemble forecasts of atmospheric blocking events in winter and summer of 2007–2015 over the Northern and Southern Hemispheres (NH and SH).

Generally, state-of-the-art numerical weather prediction models simulate the frequency of blocking events well, even at a lead time of 15 days, except for some extreme events. Verification based on Brier Skill Scores for probabilistic blocking forecasts shows that forecasts over the NH tend to be better than those over the SH. In both hemispheres, probabilistic skills are higher in winter than in summer. In both seasons over the NH, models show higher skill for Euro-Atlantic and Pacific blocking than Ural blocking. In the SH, the highest (lowest) skills are for probabilistic forecasts of Andes (Australia-New Zealand) blocking in winter (summer). ECMWF (European Centre for Medium-Range Weather Forecasts) shows much higher skill than the other centres in all cases.

G01-P02

Remote tropical influence on a regional Arctic warming over the Barents Sea since the late 1990s

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In the Arctic, a region over the Barents Sea exhibits the strongest warming in the wintertime surface air temperature in association with a rapid sea-ice reduction since the late 1990s (Fig 1a). We explore a possible tropical influence on this regional expression of the Arctic warming. A series of ensemble A/CGCM experiments are performed for the period 1982-2013: (1) AGCM forced with global, time-varying observed sea ice concentration (SIC) and SST (GOGA) (2) AGCM forced with time-varying SST only in tropics and daily climatological mean SST and SIC elsewhere (TOGA) and (3) CGCM experiment with tropical SST nudged towards the observed (C-TOGA). The radiative forcing is fixed to values for present-day climate. A/CGCM experiments consist of 10 and 5 members, respectively. The Arctic warming is measured by a linear trend in the ensemble and winter-time mean 2-m temperature during the period 1997/98 through 2012/13. GOGA displays an Arctic warming particularly strong over the Barents Sea presumably due to a thermodynamic effect of the reduced SIC prescribed to AGCM (Fig. 1b). More surprisingly, C-TOGA shows the regional Arctic warming that is even stronger than GOGA (Fig. 1c). The warming is associated with the coherent sea-ice decline among 5 ensemble members despite that the sea-ice in the Barents Sea freely evolves and the only external forcing is the tropical SST in the CGCM experiment. Interestingly, there is also a slight warming in the Arctic eastern hemisphere in TOGA with no interannualy-varying SIC and SST prescribed in high-latitudes, suggesting a remote tropical effect on the Arctic warming via atmospheric teleconnection. We will discuss how the triggering of the Arctic warming from tropics seen in TOGA is further enhanced in C-TOGA via the atmosphere-ocean-sea ice interaction over the high-latitude Atlantic and Arctic oceans.

Acknowledgements: This work is supported by the Arctic Challenge for Sustainability (ArCS) project and by the Japan Science and Technology through Belmont Forum CRA “InterDec”. The Earth Simulator is used for simulations in support of JAMSTEC.

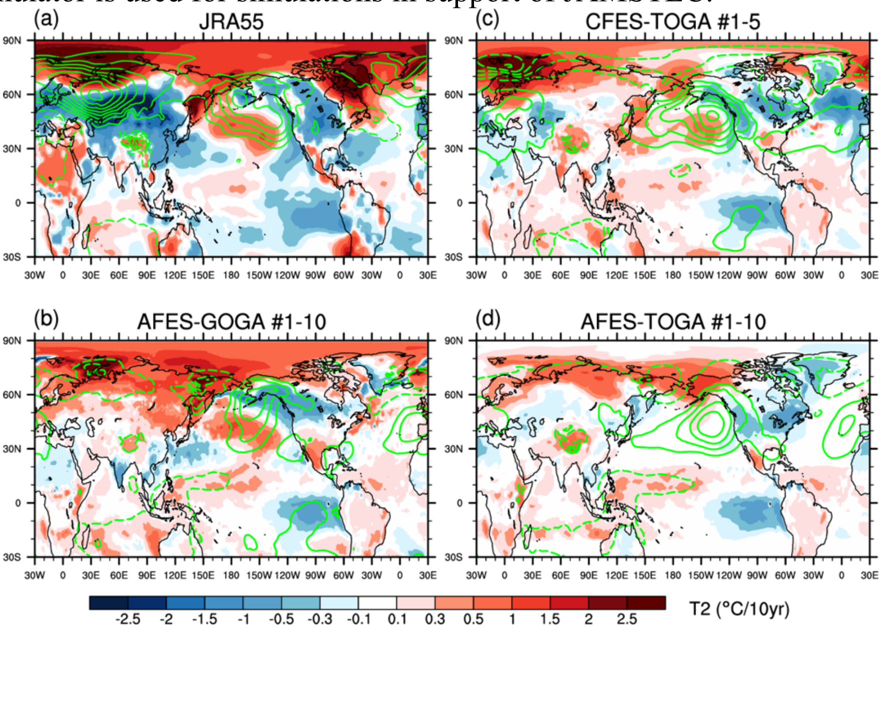

Figure 1. Linear trend in the ensemble and winter-time (Dec-Feb) mean 2-m temperature (shade) and SLP (contour) during the period 1997/98 through 2012/13 in (a) JRA55, (b) GOGA, (c) C-TOGA and (d) TOGA. C.I. is 1 and 0.5 hPa in (a) and (b-d), respectively.

G01-P03

A lag-relationship between the Arctic Oscillation in winter and the summer climate in the Northern Hemisphere

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The Arctic Oscillation (AO) is a dominant statistical mode, which is characterized by a seesaw pattern of atmospheric circulation between the middle and high latitudes in the Northern Hemisphere. Ogi et al. (2004) showed a lag-relationship between the wintertime AO and summertime climate in the middle- and high latitudes in the Northern Hemisphere for the period of the second half of 20th century. However, a climate regime shift, including the dramatic changes of AO in winter, occurred in the last 1980s. In addition, sea ice in the Arctic Ocean has gradually decreased in the recent two decades. The lag-relationship between the wintertime AO and the summertime climate might change in the recent two decades. Thus, this study examined the long-term changes of the lag-relationship between the wintertime and the succeeding summertime climate, focusing with the climate regime shift of the last 1980s.

We calculated lag-correlation coefficients between the monthly averaged zonal mean 500-hPa geopotential height and the AO index in winter. As a result, the lag-relationship between the wintertime AO condition and the succeeding summer climate has greatly changed before and after the climate regime shift (Fig.1). Before the climate regime shift, a meridional seesaw pattern in the succeeding summer appeared again, which was similar to that in winter. The seesaw patterns both in winter and summer corresponded to Ogi et al. (2004). This may suggest the wintertime AO is linked to the atmospheric circulations in the succeeding summer. However, after the climate regime shift, the seesaw pattern did not appear again in summer.

To understand the processes of the long-term changes, we focused on the long-term changes, in sea ice extent and SST. A lag-relationship among the wintertime AO, sea ice extent and SST in the succeeding summer changed before and after the climate regime shift. In addition, a remarkable change was observed particularly in the Barents Sea. Before the climate regime shift, lag-relationship between the winter AO and the succeeding summer sea ice (SST) in the Barents Sea was negative (positive). Whereas after the climate regime shift, the lag-relationship was nearly opposite. These results may be one of the factors for the long-term changes of the lag-relationship between the winter AO and the summer atmospheric anomalies.

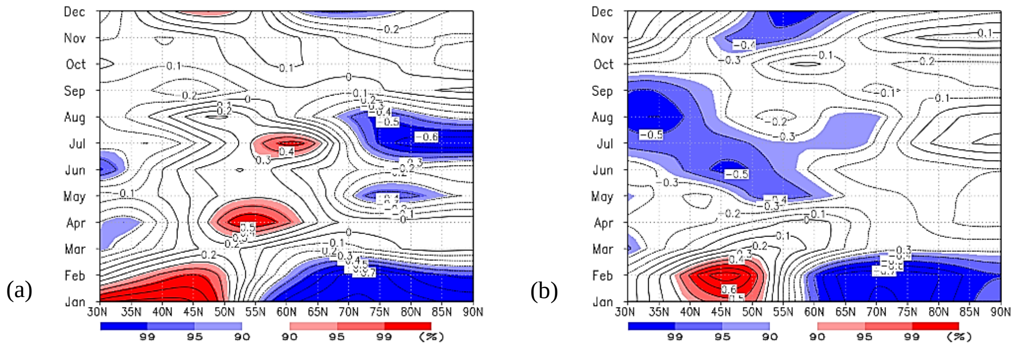

Figure 1. Lag-correlation coefficients between the winter SV NAM index (Jan-Feb) and the monthly averaged zonal mean 500-hPa geopotential height. Shading indicates the statistical confidence levels (90, 95, 99%).
(a) before the climate regime shift (from 1958 to 1985) and (b) after the climate regime shift (from 1991 to 2015).

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G01-P04

Synoptic-scale Fire Weather Conditions in Southern Sakha - Relationship with Warm Air Mass

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We examined synoptic-scale fire weather conditions for the boreal forests in the Southern Sakha during very active fire periods. Active fire periods were identified using the NASA MODIS hotspot data from 2002 to 2016. Synoptic-scale fire weather conditions were examined using NOAA weather data (mean height and temperature). Analysis results based on synoptic-scale weather and temperature patterns (warm air mass distribution) show that there is a relatively strong correlation with very active (concurrent and wide spread) fires in southern Sakha. In addition, similar and common weather patterns at the upper air level (500hPa) during seven active fire periods are found. A series of weather phenomena until the occurrence of a large fire are as follows. First stage: Low-pressure system is formed in the western part of Siberia. Second stage: The meandering of the westerly wind increases, a low-pressure trough from the north moves to south, and a high-pressure ridge forms toward the north. Third stage: A cutoff low is formed and moves toward south. Fourth stage: The ridge moves to the north side of the cutoff low, and a blocking high is formed. Fifth stage: The blocking high or the ridge approaches or covers southern Sakha. At this stage, the largest fire in each fire period occurs under relatively high air temperature and wind speed. Weather and temperature patterns at the lower air level (925hPa) clearly show existence of large massive of warm air mass (mainly cTe: Continental Temperate) and development of low-pressure system near southern Sakha. Additional conditions to fourth and fifth stage: If the Bering Sea low and a low-pressure trough exist in the east of Sakha, the eastward movement of blocking high is hindered or the high-pressure system stagnates, and fires could continue.

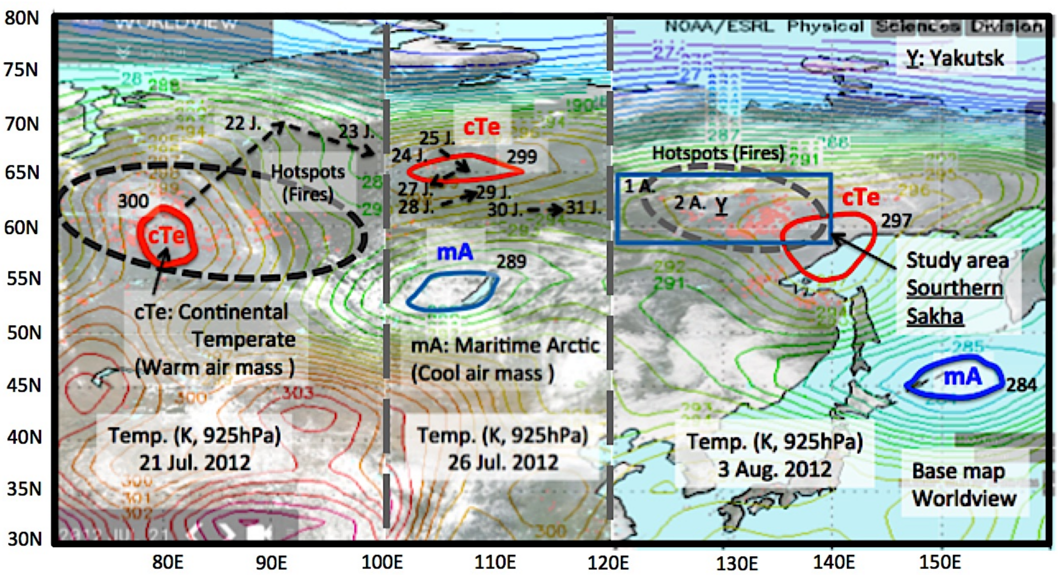

Figure 1. Movement of warm air mass and hotspots (fires)

G01-P05

Seasonal feedback analysis on polar amplification in warm climate induced by orbit/CO2 and impact of wetland

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Past proxy records indicate the mid-Holocene (6ka) and the last interglacial (127ka) are warmer than the present-day due to the different orbital parameters of the Earth (Otto-Bliesner et al. 2013). In both periods, high latitude warming is much larger than that of global average, a.k.a. polar amplification, which is also seen in CO2-induced climate warming projection (Laine et al. 2016). O'ishi and Abe-Ouchi (2011) used a vegetation coupled GCM and quantified the contribution of vegetation feedback to warming in 6ka. In the present study, we applied a feedback analysis method proposed by Lu and Cai (2009) on 6ka, 127ka and doubled CO2 by vegetation-coupled GCM experiments similar to O'ishi and Abe-Ouchi (2011) to reveal more detailed feedback mechanisms with and without vegetation feedback.

We also introduced a simple wetland scheme (Nitta et al. 2015) into a land surface scheme of a GCM and will evaluate the effect of wetland upon polar amplification and feedback mechanisms by the method of Lu and Cai (2009).

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G01-P06

Temporal variations of the mole fraction, carbon and hydrogen isotope ratios of atmospheric methane in the Hudson Bay Lowlands, Canada

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We have conducted simultaneous measurements of the mole fraction, carbon and hydrogen isotope ratios ($\delta^{13}C$ and δD) of atmospheric methane (CH_4) at Churchill (58°44'N, 93°50'W) in the northern part of the Hudson Bay Lowlands (HBL), Canada since 2007. Compared with the measurements at an Arctic baseline monitoring station, Ny-Ålesund, Svalbard (78°55'N, 11°56'E), the CH_4 mole fraction is generally higher and $\delta^{13}C$ and δD are lower at Churchill, carrying the signature of to regional biogenic CH_4 emissions. Clear seasonal cycles of the CH_4 mole fraction, $\delta^{13}C$ and δD are observable at Churchill, and their seasonal phases in summer are earlier by about one month than those at Ny-Ålesund. Using one-box model analysis, the phase difference is ascribed to the different seasonal influence of CH_4 emissions from boreal wetlands at the two sites. Short-term CH_4 variations are also observed at Churchill throughout the year. By analyzing the observed isotopic signatures of atmospheric CH_4, it is confirmed that the short-term CH_4 variations are mainly produced by biogenic CH_4 released from the HBL wetlands in summer, and by fossil fuel CH_4 transported through high Arctic regions in winter. Forward simulations of an atmospheric chemistry-transport model, with wetland CH_4 fluxes prescribed by a process-based model, show unrealistically high CH_4 mole fractions for Churchill in summer, suggesting that the CH_4 emissions assigned to the HBL wetlands are overestimated. Our best estimate of the HBL CH_4 emissions is 2.6 ± 0.3 $TgCH_4$ yr^{-1} as an average of 2007-2013, which agrees well with recent estimation by inverse modeling studies.

G01-P07

Observations of atmospheric black carbon at Poker Flat Research Range, Alaska, since April 2016

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Black carbon (BC) particles are formed by incomplete combustion of fossil fuels, biofuels and forest fires, and act as an important climate forcer – by absorbing sunlight in the atmosphere and snow/ice. High concentrations of BC also negatively affect human health. Observation of BC mass concentration at Poker Flat Research Range (PFRR; 65.12N, 147.43W; 491 m asl) was started on 28 April 2016 to estimate the impact of Alaska local emissions and long-range transport from mid-latitude to pan-Arctic region on the Arctic environment.

BC mass concentration was measured by continuous soot-monitoring system (BCM3130 or COSMOS) with filter-based technique. The effect of Alaskan fire emissions was analyzed by using the Alaska fire information (AICC, ArcIMS) and 10-day backward trajectories every 1 hour from PFRR using HYSPLIT with GDAS1 meteorological field.

Figure 1 shows monthly BC mass concentrations from May 2016 to May 2017. Analysis of backward trajectories and AICC data showed that one of the main sources of BC from May to September 2016 was Alaskan forest fires. The pathways of backward trajectories passed over Alaskan forest fire region on 93 days out of 149 days from May to September 2016. Daily BC mass concentrations and its standard deviation were 0.029±0.081 μg/m³ for the days affected by forest fires, and 0.020±0.019 μg/m³ for other days, respectively.

The effect of long-range transport from the East Asia was also analyzed using trajectories, and it was found that Chinese airmass was transported to PFRR on 14 days in February 2017, 1 day in July 2016 and 3 days in June 2016.

In future, we plan to start observations of BC in Yakutsk (Russia) and continue observation at PFRR to obtain more data for detailed analysis of sources and long-range transport of BC to the Arctic region.

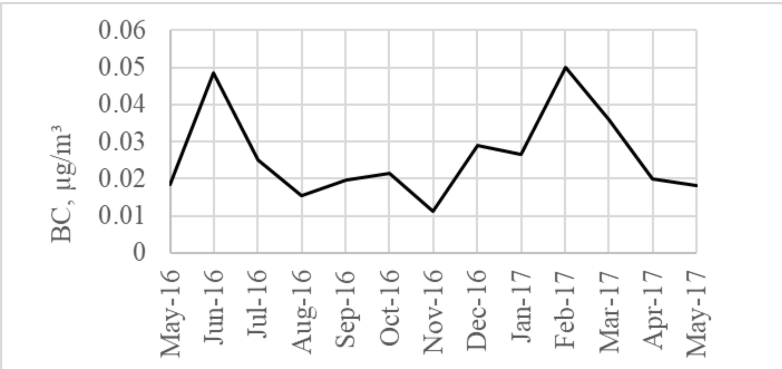

Figure 1. Monthly averages of BC mass concentrations at PFRR.

G01-P08

The water-soluble species in airborne particles at NEEM

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In the northern hemisphere, especially Greenland, it is considered that ocean and stratosphere are major sources of halogen species. However, there is little data about halogen species contained in airborne particles and snow in Greenland. In this research, trace inorganic species (Br, Cl, F, I) in airborne particles and snow at NEEM, Greenland were analyzed.

The airborne particle samples and snow samples were collected at clean snow area at NEEM, Greenland (77°45'N, 51°06'W, 2500 m). Air sampling was performed from June, 2012 to August, 2012. The samples were collected by low volume air sampler in every day. Surface snow samples were also collected.

The quantitative analyses of water-soluble species were performed using an ion chromatograph mass spectrometer (IC-MS). The IC-MS system consists of a single quadrupole type mass spectrometer connected to an ion chromatograph. IonPac AS11-HC was used as the separation column of the ion chromatograph. 14 anion species including halogen species (Br^-, BrO_3^-, CH_3COO^-, $CH_3SO_3^-$, Cl^-, $C_2O_4^{2-}$, F^-, $HCOO^-$, I^-, IO_3^-, NO_2^-, NO_3^-, PO_4^{3-}, SO_4^{2-}) were analyzed.

Average concentration of Br^- in the atmosphere was 0.4 ug m^{-3}. The maximum concentration of Br^- was ca. 2 ug m^{-3}. The concentration of BrO_3^- was below detecton limit. Average concentration of I^- was 0.07 ug m^{-3}. The maximum concentration of I^- was 0.3 ug m^{-3}. Average concentration of IO_3^- was 0.1 ug m^{-3}. The maximum concentration of IO_3^- was 0.6 ug m^{-3}. Further results and discussion about the behavior and origin of halogen species in airborne particles and snow will be presented.

Clouds with low lidar returns and high cloud radar echoes

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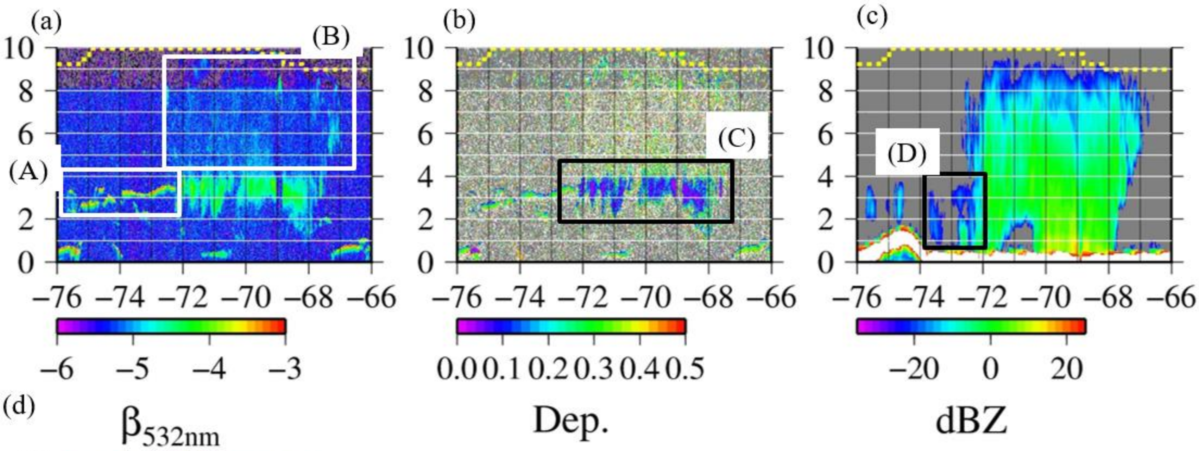
Cloud radiative interaction in the polar regions is not well known because of high occurrence frequency of mixed-phase clouds. Lidar is usually used to measure aerosol and cloud particles because lidar is more sensitive for smaller particles than radar. We report at least 5 % of clouds in the high latitudes have weak lidar returns while they have significant cloud radar echoes. The lidar data (B) in Figure 1a is one of such examples. Figure 1 shows the data of the space-borne lidar CALIOP, the cloud radar CloudSat, and the imager MODIS. All of them were measured simultaneously. The signals with low lidar returns and significant radar echoes denote their particle size and particle number concentration are large and sparse (hereafter we call it LSC).

The figure shows LSC (B) located above pristine ice crystals (C) while no signals was detected above supercooled water (A). It may suggest large and falling particles of LSC change supercooled droplets into ice crystals through the seeder-feeder effect. LSC itself would be negligible for the radiation budget because it is not visible. LSC, however, would be important for the radiation budget. We will show the global distribution of LSC.



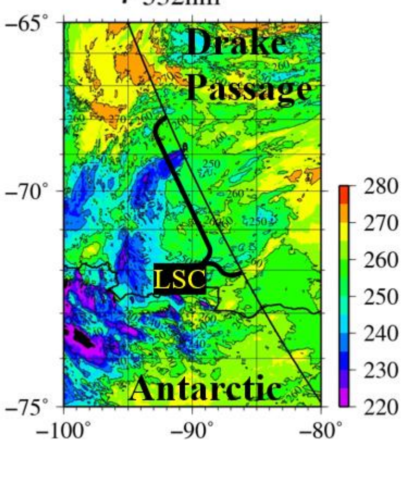


Figure 1. (a)-(c) The latitude-height sections of CALIOP and CloudSat data, and (d) latitude-longitude section of the IR imager MODIS. The data were observed above the Antarctic ocean, the Drake Passage, around 21:10 UTC on January 8, 2007. (a) attenuated lidar backscattering coefficient, (b) lidar depolarization ratio, and (c) radar reflectivity factor. Yellow dashed curves in (a)-(c) denote a tropopause height. The black curve in (d) is the orbit of the sensors. The lidar and radar data suggest the signals in the figure are (A) supercooled water, (B) LSC, (C) pristine ice crystals, (D) mixed-phase clouds, respectively.

G01-P10

Seasonal variation of lower stratospheric aerosols observed by lidar above Svalbard, Norway

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The polar stratosphere is considered to be a sink area of Brewer-Dobson circulation, where temporal and spatial distribution of aerosol will be complicated and effected by horizontal transportation from lower latitude and stratosphere-troposphere exchange processes. We installed a compact Mie lidar at Ny-Aalesund (79N, 12E), Norway in March, 2014 and perform continuous observation of tropospheric and stratospheric aerosols for about three years.

The 532nm integrated backscattering coefficient of stratospheric background aerosol (in the height range of tropopause to 25km) in 2015-2016 was low vales of 0.7-4.0×10^{-7}sr, which suggests that stratospheric aerosol amount level was close to the background level during volcanically quiescent periods. The time variation of IBC (including PSC active period) in the height range of tropopause - 20km showed the increments in winter. The IBC at the height range of 20 - 25km showed the increment in summer and winter.

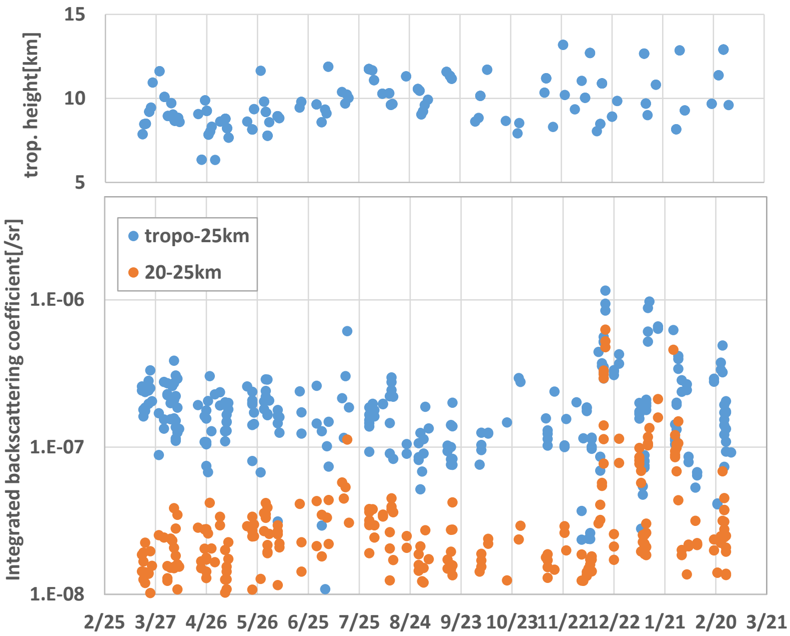

Figure 1 Time variations of tropopause height (upper) and 532nm integrated backscattering coefficient of stratospheric aerosol (lower).

Seasonal characteristics of trace gas transport in the Arctic upper troposphere/lower stratosphere

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Thermal and dynamical structures of atmosphere over the polar region have significant seasonal variation in association with that in solar heating, meridional gradient of temperature, and synoptic/planetary-scale wave activities over mid-latitude. To capture characteristics of trace gas distribution in the Arctic upper troposphere/lower stratosphere (UT/LS) combined with meteorological elements, this study focuses on seasonal variation in trace gas mixing ratio and air-mass transport mapped on the cross-section of equivalent latitude and potential temperature, which are estimated from aircraft measurement and trajectory analysis, respectively. Air samplings have been conducted once a month with Japan Airlines flight between France/Russia and Japan at spatial intervals of 10˚ or 15˚ in longitude along individual flight track at around 11 km over Siberia by the Comprehensive Observation Network for TRace gases by AIrLiner (CONTRAIL) project. Mixing ratios of tropospheric trace gases such as CH_4, N_2O, and CO obtained by the project from April 2012 to December 2016 are used in this study. Kinematic backward trajectories are initialized at each air sampling point, then calculated for a maximum of 30 days with European Centre For Medium-Range Weather Forecasts (ECMWF) ERA-Interim data as meteorological input. Based on the mixing ratios of totally 659 air samples and the trajectory calculations, characteristics of trace gas distribution and air-mass transport are extracted by the seasons. The seasonal characteristics in the Arctic UT/LS indicated from this study are as follows:

- Winter
  Air-masses which have less tropospheric trace gases are transported downward associated with diabatic cooling in the stratosphere, especially, higher region than 360 K.
- Spring
  Transport pathway changes to isentropically, and two-way meridional transport is active at around 7 PVU potential vorticity level where trace gas gradient becomes large.
- Summer
  Isentropical transport is dominant, in addition, some air-masses convectively lifted up to ~340 K with tropospheric trace gases.
- Autumn
  Transport of tropospheric trace gases into the Arctic lowermost stratosphere is maximized in association with monsoon activities which supply tropospheric air-mass to the subtropical UT/LS.

Mapping the spatial-temporal Changes of sea Ice in the Bohai Sea using Landsat Archive

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The occurrence of sea ice disasters poses great threat to oil and gas exploration and other maritime activities in the Bohai Sea. Sea ice concentration and coverage are crucial parameters in investigating sea ice disasters [1]. Landsat images are freely available every 16 days for more than thirty years [2]. These data were used to map the spatial-temporal changes of sea ice in the Bohai sea. Both surface reflectance and brightness temperature product were investigated for sea ice area mapping in this study [3]. Based on our analysis result, the integration of surface reflectance and brightness temperature can greatly improve sea ice classification. Thus, the proposed method was applied to all available Landsat imagery to map the historic sea ice coverage in the Bohai Sea region. Our time series of sea ice area were quantitatively compared and validated by sea ice coverage records from several other sources. Results showed that the integration of surface reflectance and brightness temperature was effective for sea ice mapping. Nevertheless, no data was available for several years because only years with cloud-free Landsat data can be mapped. Future research will consider the fusion of Landsat with other data sources such as passive microwave data.

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An improved method for Antarctic Sea Ice Concentration Estimation from Passive Microwave Data

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Sea ice concentration (SIC) is an important indicator of polar sea ice change and global climate change [1], [2]. In general, SIC is estimated utilizing passive microwave data, which are effective due to the daily revisit, the relatively low sensitivity to atmospheric water content and clouds, and the large contrast in emissivity between open water and sea ice. To improve the accuracy of the traditional NASA Team (NT) sea ice concentration (SIC) algorithm, a new SIC estimation method is proposed by combining the NT algorithm and a numerical optimization technique with the Special Sensor Microwave/Imager (SSM/I) data and the Advanced Microwave Scanning Radiometer for EOS (AMSR-E) data respectively.

The NT algorithm was based on the proposed SIC estimation equation. According to this equation, the observed brightness temperature (T_B) in each channel of passive microwave data could be expressed as the combination of the three dominant ocean surface cover types. In a real situation, certain factors which may result in noise (n) which should be taken into consideration. For example, the sensor resolution may lead to discrepancies in T_B between the images and the corresponding tie points, and attenuation associated with surface radiation transfer can lead to T_B changes. Then the least squares method (FCLS) was used to further optimize the estimation results from the improved equation.

Validation was performed using a comparison between the results from the SSM/I-based SICs (the proposed method, the NT algorithm, and the bootstrap algorithm) and in situ data, the AMSR-E-based SICs (the proposed method, the NT2 algorithm, and the ASI algorithm) and in situ data. The quantitative results from SSM/I show that the proposed method generates a more accurate SIC with smaller bias (0.2) and RMSE (9.7) than the other two algorithms. According to the former research, the accuracies of SIC can be influenced by the seasonal (winter and summer) change due to the variations in the sea ice surface. Therefore, the accuracies of the SIC in both summer and winter were generated, respectively. The results indicate that the proposed method consistently presents better accuracies (with bias 2.0 in summer and 2.0 in winter, RMSE 13.3 in summer and 7.3 in winter) than the other methods. The accuracies of all the methods in summer are clearly lower than those in winter, among which the accuracy of the bootstrap-based SIC is the lowest. This is due to the fact that the ice consolidation in winter results in the values of the tie points and brightness temperature being stable. In contrast, this consolidation is easily destroyed by surface melt in summer. The accuracies of the improved FCLS, NT2 and ASI using AMSR-E indicates that the performance of the proposed method is found to be better than that of the NT2 algorithm and ASI algorithm in quantitative comparisons. This research demonstrates the benefit of incorporating numerical optimization into SIC estimation.

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G02-P03

Ice-ocean albedo feedback in the Arctic Ocean shifting to a seasonal sea ice zone

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Sea ice in the Arctic Ocean is a sensitive component of the global climate. Satellite observations reveal the drastic reduction of summer sea ice extent and thus the reduction of a thick multiyear sea ice cover [1]. Associated with such change, "ice-ocean albedo feedback" has received increasing attention as a major factor in sea ice retreat of the Arctic Ocean. This feedback is owing to a gap of surface albedos between "black" open water and "white" sea ice: once sea ice concentration decreases at the beginning of the melt season, heat input into the upper ocean through the increased open water fraction is enhanced, leading to a further decrease in ice concentration through sea ice melt. However, quantitative understanding of heat and sea ice budget in the ice-covered area of Arctic Ocean is still insufficient. Here we have calculated heat budget and sea-ice budget over the Pacific Arctic Ocean using sea ice parameters (e.g., concentration, drift velocity, and mean thickness) derived from satellite observations for 36 years from 1979 to 2014. Results show that the amount of heat input through the open water fraction in the ice-covered area quantitatively corresponds well with the volume of sea ice melt during the melt season (Figure 1). Also, we have found that the ice melt volume significantly correlates with the ice divergence in the earliest stage of melt season (mid-May to early-June), particularly after 2000s. This indicates the enhancement of sea ice melt through the ice-ocean albedo feedback, and it is confirmed by a simplified ice-ocean coupled model. A comparison between sea ice conditions before and after 2000 suggests that a doubled ice divergence in the early melt season associated with the reduction of multiyear ice can explain about 70 % of increased sea ice melt through the ice-ocean albedo feedback [2].

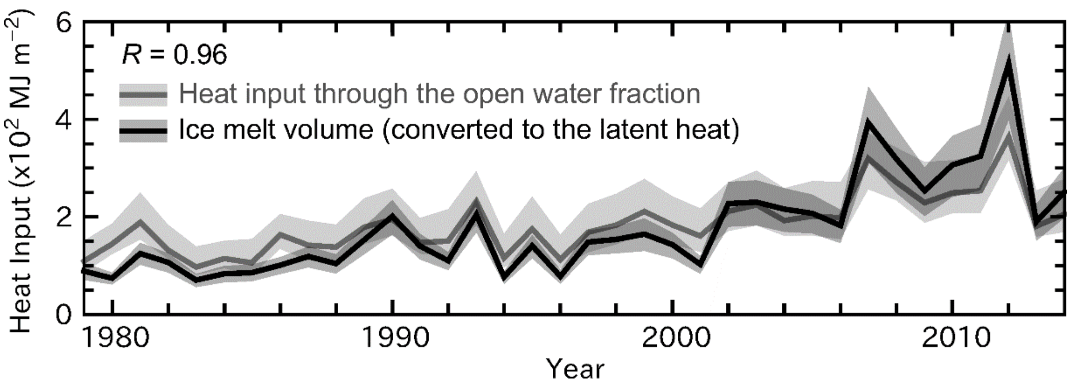

Figure 1. Interannual variations of total heat input into the upper ocean through the open water fraction (gray line) and the sea ice melt volume (black line) over the ice-covered area.

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[2] H. Kashiwase, K.I. Ohshima, S. Nihashi, H. Eicken, Evidence for ice-ocean albedo feedback in the Arctic Ocean shifting to a seasonal ice zone, *Scientific Reports* **7** (2017)

Spectral albedo of sea ice at Qaanaaq fjord in northwest Greenland

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Spectral albedos of sea ice with snow cover and sea ice without snow cover where snow was artificially removed around measurement point, were measured at Qaanaaq fjord in northwest Greenland in June 2017 (Fig. 1). Thickness of the sea ice was approximately 1.3 m with 5 cm of snow over the sea ice. Upper part of the sea ice contained a granular ice (surface ~ 9 cm) and a columnar ice (~ 20 cm) including a large amount of air bubble. Snow over the sea ice consisted of two layers of granular and wet granular snow. The albedo measurements were made using a portable grating spectrometer, FieldSpec 3, covering the wavelength from 350 nm to 2500 nm (PANalytical). The spectral albedos of the sea ice with snow cover were approximately 0.75 – 0.8 in the ultraviolet and visible wavelengths and decreased with some specific peaks along the near-infrared wavelength (Fig. 2). The spectrum shape was similar to the snow one, implying that the multiple scattering by snow over the sea ice is dominant in all spectrum. When removing the snow over the sea ice (Fig. 1), the spectral albedos considerably decreased in all spectrum, although we could not completely remove the snow around the measurement point such as a semi-infinite plane parallel sea ice surface. Spectral albedos were approximately 0.35 – 0.55 in the ultraviolet and visible wavelengths, 0.05 – 0.25 in the near-infrared wavelength and almost constant of approximately 0.05 in the shortwave near-infrared wavelength. At ultraviolet and visible wavelengths, the albedos were dominated by the multiple scattering by the air bubble within the sea ice because a light absorption by ice is so week in these wavelengths; in near-infrared regions the albedos were reflected by the Fresnel reflection in the sea ice surface. Since light absorption by ice in these regions is relatively strong comparing to the visible region, the light could not be penetrated deeply within the sea ice, resulting that surface reflection would be dominant in these regions.

Fig.1 Photograph of spectral albedo measurement.

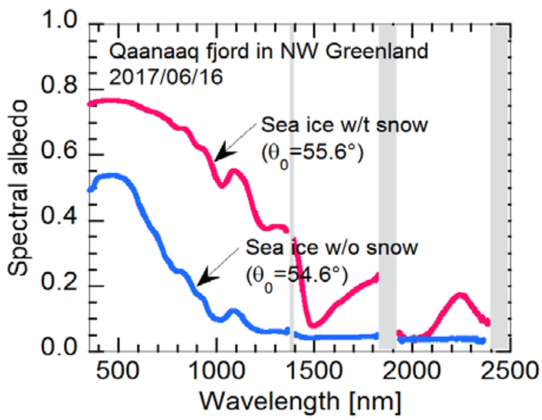

Fig.2 Spectral albedo of sea ice with or without snow cover. θ_0 is solar zenith angle.

G02-P05

Under-ice turbulent microstructure and upper ocean vertical fluxes in the Makarov and Eurasian Basins, Arctic Ocean, in 2015

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The Arctic Ocean is generally assumed to be fairly quiescent when compared to many other oceans. The sea-ice cover, a strong halocline and a shallow, cold mixed-layer prevent much of the ocean to be affected by atmospheric conditions and properties of the ocean mixed-layer. In turn, the mixed-layer and the sea-ice is largely isolated from the warm layer of Atlantic origin below by the lower halocline. Yet, the content of heat, freshwater and biologically important nutrients differs strongly between these different layers. Hence, it is crucial to be able to estimate vertical fluxes of salt, heat and nutrients to understand variability in the upper Arctic Ocean and the sea-ice, including the ecosystem. Yet, it is difficult to obtain direct flux measurements, and estimates are sparse. We present sets of under-ice turbulent microstructure profiles in the Eurasian and Makarov Basin of the Arctic Ocean from two expeditions in 2015. These cover melt during late spring north of Svalbard and freeze-up during late summer / autumn across the Eurasian and Makarov basins. Our results are presented against a background of the anomalously warm atmospheric conditions during summer 2015 followed by unusually low temperatures in September. 4-24 h averages of the measurements generally show elevated dissipation rates at the base of the mixed-layer. We found highest levels of dissipation near the Eurasian continental slope and smaller peaks in the profiles where Bering Sea Summer Water (sBSW) lead to additional stratification within the upper halocline in the Makarov Basin. The elevated levels of dissipation were associated with the relatively low levels of vertical eddy diffusivity. We discuss these findings in the light of the anomalous conditions in the upper ocean, sea-ice and the atmosphere during 2015 and present estimates of vertical fluxes of heat, salt and other dissolved substances measured in water samples.

G02-P06

Sea-ice thickness from moored ice-profiling sonar in the Canada Basin, Arctic Ocean

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Time-series ice-draft data were obtained from moored ice-profiling sonar (IPS), in the Arctic Canada Basin, where reductions in sea-ice cover have been particularly significant since late 1990s. Time-series data show seasonal and spatial variabilities of ice draft at four mooring stations (Stns. NAP, BGOS-A, BGOS-B, BGOS-D) from summer 2013 to summer 2014 (Figure 1). Spatial difference of ice-draft in the Canada Basin is largely affected by circulation of sea ice forced by anticyclonic Beaufort Gyre. The overall mean draft at Stn. BGOS-D is the largest, because thick ice is advected from the north. Ice draft observed at Stn. NAP is generally the smallest during summer, because melting ice in the southern Canada Basin flows west to Stn. NAP. Modal draft distributions exhibit two modal values from October to December at BGOS-A, BGOS-B, BGOS-D (Figure 2). Thinner and thicker modes correspond to newly formed young ice and multi-year ice remaining from summer melting season, respectively. In contrast, only thinner mode is evident at NAP, because sea ice melts away at this station during summer 2013. The evolution of modal ice thickness observed can be explained mostly by thermodynamics growth.

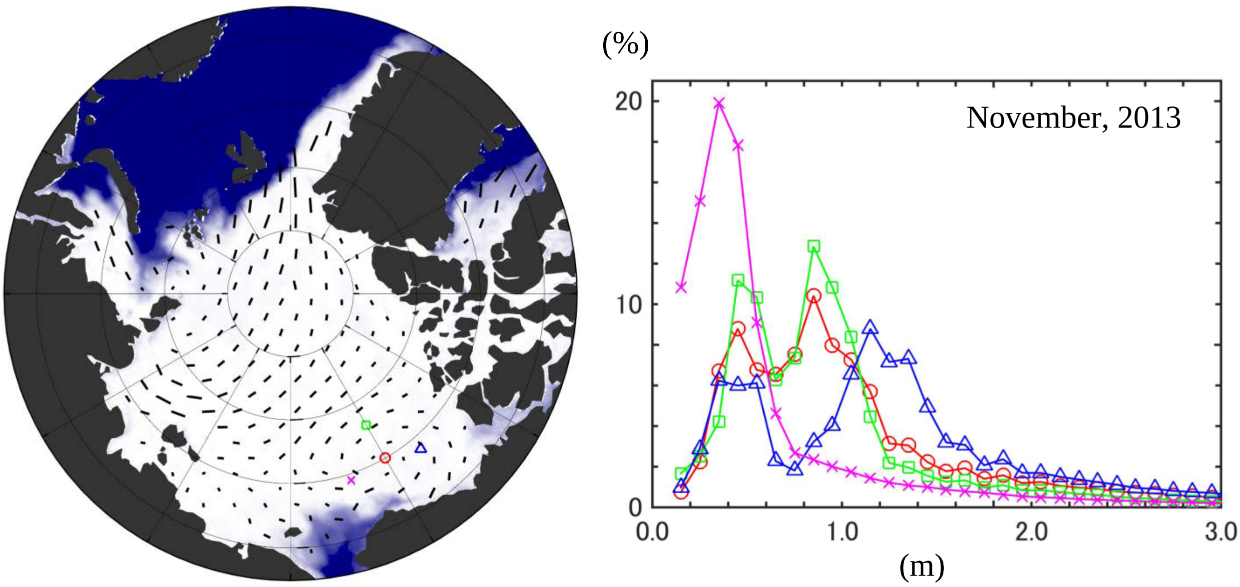

Figure 1 (a) Monthly averaged sea-ice extent and ice draft from AMSR-E satellite data in November 2013. Cross, circle, square and triangle mark locations of the IPS moorings at Stns. NAP, BGOS-A, BGOS-B and BGOS-D, respectively. (b) Histograms of ice draft (in 0.2 m bins) for each mooring site.

G02-P07

Sea Ice Variability in the Mid-twentieth Century from MRI-ESM2

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Sea ice in the Arctic rapidly decrease over the recent decades and the climate models reproduce well the recent sea ice decline [1]. But sea ice variability before satellite era is less understood due to a lack of observation and the large uncertainty of the climate models. The purpose of this study is to argue about the variability of sea ice before the satellite era.

We are conducting the series of experiment for CMIP6 using MRI-ESM2 which is developed by Meteorological Research Institute (MRI). Figure 1 shows the time series of the sea ice thickness, extent and volume in March and in September from a tentative historical run by MRI-ESM2. In the mid-twentieth century (1930-1960), the sea ice is relatively lower than the previous period. This less sea ice period corresponds to a warming known as the early twentieth century Arctic warming [2].

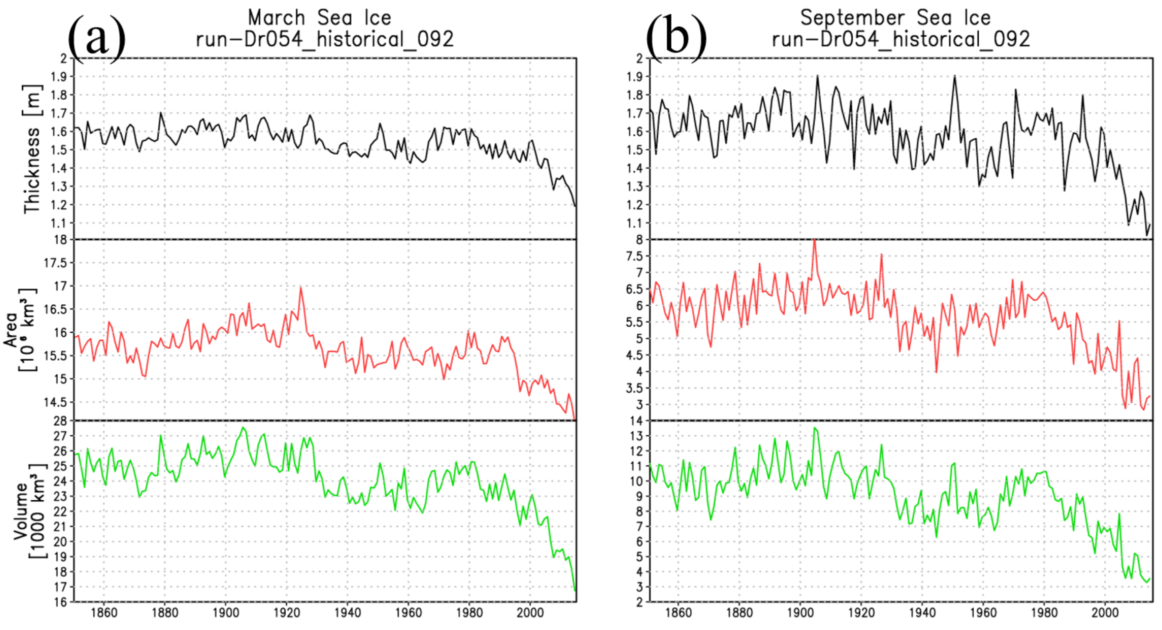

Figure 1. Time series of the sea ice thickness (upper panels), extent (middle panels) and volume (bottom panels) in March (a) and in September (b) from a tentative historical run by MRI-ESM2.

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Short-term sea ice forecasting during extreme Arctic cyclone in August 2016

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Recently, cyclones are quite active and dramatically influence the sea ice distribution in the Arctic region. Therefore, precise prediction of sea ice distribution during the cyclones is crucial for safe and efficient navigation in the Arctic Ocean. A high-resolution (about 2.5 km) ice-ocean coupled model is developed for forecasting the short-term sea ice distribution along the Northern sea route. The experiment was run from 1 August 2016 to 6 August 2016 under the extreme cyclone in the Laptev Sea. The atmospheric forcing data used for the model was European Center for Medium-Range Weather Forecast Interim reanalysis data. The correlation score of ice–edge error and sea ice concentration distribution quantifies forecast skill and skill scores are computed from 1 August 2016 to 6 August 2016. The average forecast skill of ice-edge error in the ice-ocean coupled model is 10.09 km with the 15% thresholds of ice concentration for the ice edge. That is in good agreement with the requirement of an operational ice navigation system (10 km).

G02-P09

Ice-Band Pattern Formation in Winter Marginal Ice Zone

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In polar ocean marginal ice zone (MIZ), melting and freezing are repeated through one year. MIZ is significant place because it may be easy to affect by the seasonal evolution of sea-ice areas. However, it is still difficult to predict accurate location of MIZ using numerical models. Therefore, we consider that understanding of elementary processes in MIZ is important.

Ice-band structures (**Fig. 1a**) are often observed over MIZ in winter polar seas. Ice bands have regular band spacings from the center of one ice band to the neighbor one, and the long axis of ice bands slightly lie to left (right) with respect to the wind direction in the Northern (Southern) Hemisphere. In this study, we focused on ice bands with about 10km-scale regular band spacings. First, the following two main questions were discussed using 1.5-layer theoretical model: 1) What determines the regular ice-band spacing? 2) Is there a favorable wind direction for the ice-band formation? In consequence, 1) was explained by the resonance condition when the band propagation speed coincides with the internal wave phase speed. On the other hand, 2) was shown by the ice-band growth rate with respect to the wind direction (**Fig. 1b**). Therefore, the maximum growth rate direction is the favorable for ice-band formation.

Based on the above results, we further investigated the ice-band formation in the continuously stratified ocean. Basically, a theory constructed with 1.5-layer ocean model is adequate for the continuously stratified ocean as well. In addition, there are the vertical baloclinic mode solutions in the continuously stratified ocean model. Therefore, the resonance condition, in which the phase speed of the internal waves and the ice band speed coincide with each other, always holds provided that the mode number is large enough. This implies that if the wind speed is slower, the resonance mode is shifted to the higher mode. This feature is distinctly different from a 1.5-layer model because the resonance does not occur if the internal wave phase speed is faster than the band-pattern propagation speed in the 1.5-layer ocean.

Further, satellite images also confirmed that the band spacing of the ice-band pattern in the polar seas is consistent with these theoretical values and numerical results (**Fig. 1c**). Thus, for considering the realistic ocean model, it may be important to resolute the ice bands.

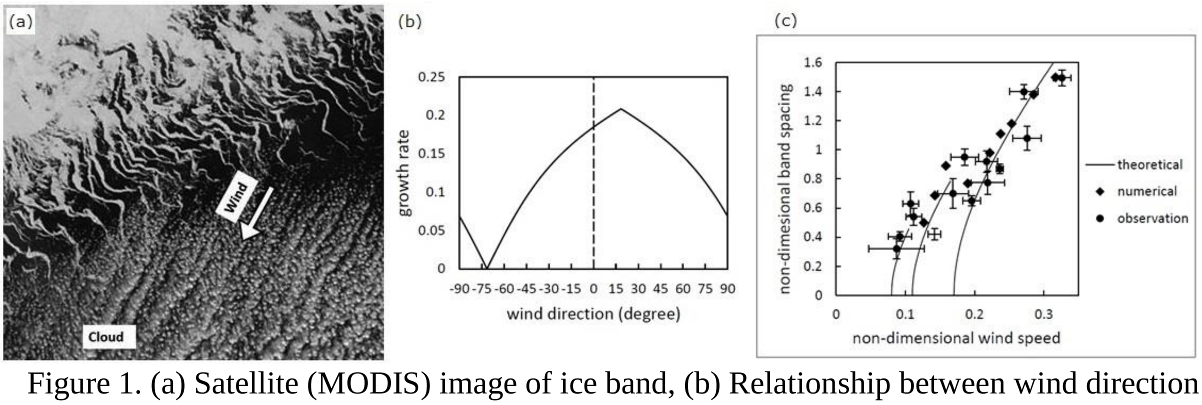

Figure 1. (a) Satellite (MODIS) image of ice band, (b) Relationship between wind direction and ice-band growth rate, (c) Relationship between wind speed and band spacing.

G05-P01

Long-term monitoring carbon balance at a black spruce forest in interior Alaska

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For accurately evaluating carbon, water, and energy balances in the Arctic and subarctic regions, we have conducted a long-term observation of CO_2, CH_4, water vapor, and energy fluxes at a black spruce forest on permafrost in interior Alaska, using the eddy covariance method since 2003. Here, we present a long-term CO_2 balance and its interannual variation.

The long-term CO_2 balance was -1 g C m^{-2} yr^{-1} between 2003 and 2016, showing that the forest acted as a neutral CO_2 balance. From 2003 to 2011, the CO_2 balance changed from the annual sink to source (R^2=0.79, n=9) associated with an increased ecosystem respiration due to an autumn warming [1]. However, during a later period after 2012, no significant trend was observed. The observation also indicates that interannual variations in ecosystem respiration explained half of the variations in the CO_2 balance (R^2=0.47, n=14). In contrast, gross primary productivity (GPP) did not explain the variations in the CO_2 balance (R^2=0.14, n=14). This result indicates that sensitivity of respiratory processes, such as microbial decomposition, was the major driver of the CO_2 balance at this forest. Consequently, monitoring soil respiration and microbial processes are the important target in our future studies, for accurately estimating CO_2 balance under warming climate.

GPP tended to increase from 660 g C m^{-2} y^{-1} at earlier period (2003-2007) to 730 g C m^{-2} y^{-1} at a later period (2012-2016). The model analyses suggested that approximately 25 g C m^{-2} $decade^{-1}$ increase was explained by the CO_2 fertilization effect associated with rising atmospheric CO_2 concentration [2]. This result suggests that approximately 30% of the increased GPP could be explained by the CO_2 fertilization effect.

For promoting future studies using our data, we have shared our flux and environmental data through our web-site (http://atmenv.envi.osakafu-u.ac.jp/data/uaf_data/). The study was supported by Arctic Challenge for Sustainability (ArCS) project, and by the JSPS KAKENHI, Grant Number 26281012.

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G05-P02

Seasonal variation of photoassimilate allocation in xylem of black spruce in interior Alaska

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Seasonal fluctuation of photoassimilate allocation in radial growth of black spruce (*Picea mariana*) growing in interior Alaska was elucidated by carbon stable isotope pulse labeling experiment[1]. We labeled $^{13}CO_2$ in end of May and mid July 2016. The trees were harvested mid September and discs were cut from the middle and base of stem and root base. Continuous tangential sections were cut out radially every 25 μm. Each section was divided into two peaces in longitudinal direction, and one was treated by starch extraction. The stable isotopic ratio was measured with a mass spectrometer. The results indicated that, spring photoassimilate was mainly used for all over the annual ring of the present year. In stems, whereas was mainly used for the early wood in root. On the other hand, summer photoassimilate was mainly used for outermost part of the late wood. In stems, whereas was mainly used for the middle of the late wood in root. Higher concentration was observed in the stem for May labeling, whereas was observed in the underground parts for July labeling.

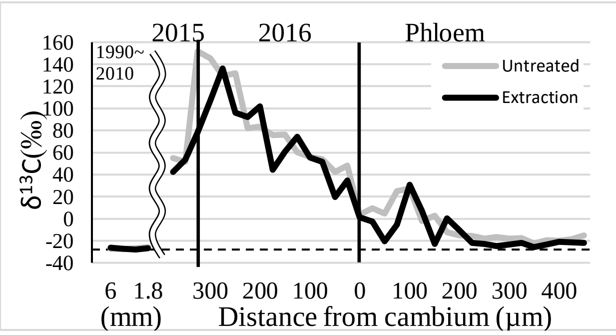

Figure 1. Variations in $\delta^{13}C$ values in trunk at 106cm above the ground. Labeled in May.

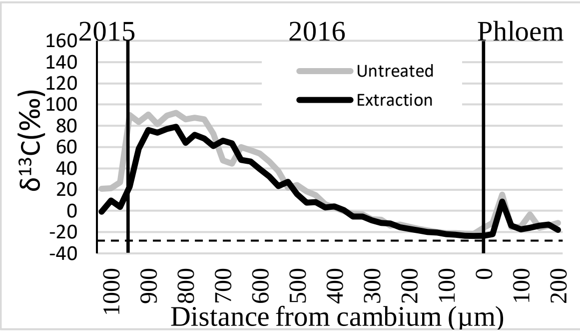

Figure 2. Variations in $\delta^{13}C$ values in roots. Labeled in May.

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G05-P03

Underground competition may be occurred among *Picea mariana* trees in central Alaska

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On the upland of central Alaska, *Picea mariana* is dominant on the north facing slope. However, their forest canopy is not closed in the lower part of slope, where active layer is very thin and the soil temperature is lower. The hypothesis which can explain their limiting growth are (1) nutrient resource limiting, (2) large allocation to root systems (3) severe underground competition. Here, we survey the course root (diameter>1 mm) distribution and analyzed inter-tree competition to examine the competition limiting hypothesis.

The study site is located in CPCWR of the University of Alaska Fairbanks. We set a squared plot (6 m x 6 m) on the lower part of north-facing slope. There were nine young trees, but its canopy was not closed. We divided the plot into 576 grids, 0.25 m squares. Ground level was measured before and after organic layer removals on each grid vertex. Most of all course roots of *P.mariana* were speeded just on the mineral soil. We take a photo of each tree's root in every grid. Length of course root was calculated by point grid counting method.

The spatial distribution of thick root length was shown in Figure 1. There were little grid where any root was absent, suggesting that root system of *P.mariana* occupied the underground, while their canopies could not. According to the GLM analysis (gannma distribution, log-transfer function), tree size ($p=0.0024$) and thickness of organic matter layer ($p=0.0188$) had positive effects on root length in each grid, while distance from tree stump ($p<0.0001$) and other root within grid ($p=0.0007$) had negative effects. This result supports the hypothesis of the severe underground competition. The root-root competition under poor resources condition may control the stand structure and dynamics of *P.mariana*.

We thank to Akira Yoshikawa for his helpful suggestions in the field. This study was supported by MEXT/JSPS KAKENHI Grants: Number 26304026 and 15K14752.

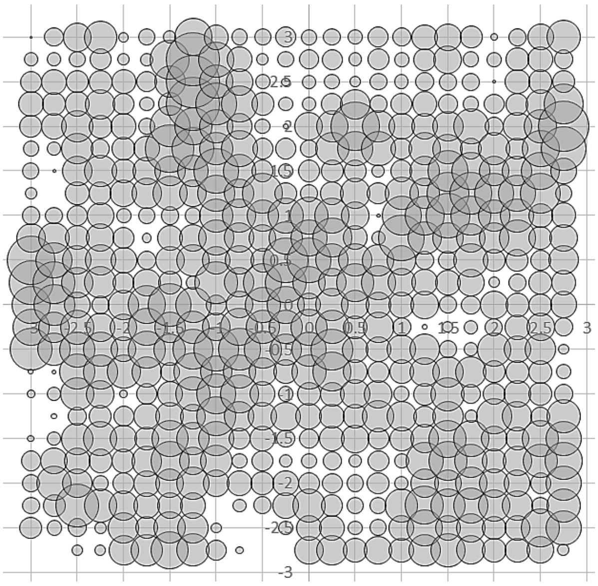

Figure 1. Course root length distribution of *P.mariana*
Coarse root covered 98.4% of plot. Size of each circle represents coarse root length.

Climate responses of radial growth of *Larix sibirica* and *Pinus sibirica* growing in Mongolian permafrost

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The climate responses of *Larix sibirica* and *Pinus sibirica* growing in Mongolian permafrost area were analyzed by dendrochronological techniques. We selected upper and lower sites in a north facing slope where the active layer depth is 2.5 m. The inclement cores were taken from both trunks and roots of *L. sibirica* and *P. sibirica* trees growing in the both sites. The correlation between the chronologies and meteorological data revealed that precipitation of previous May negatively correlated with ring width of both trunk and root for all the sites except for *L. sibirica* growing in upper slope. Precipitation of the current summer did not reveal significant positive correlation. The negative effect of precipitation can be attributed to waterlogged condition which affect negatively to transpiration of trees [1]. The "ponding stress" or "low temperature stress" on roots at the lower slope might be most important limotting factor at the sites. There is few water stress of summer on the two species even the site is located in rather dry region. The research indicated that underground condition which regulated by permafrost is one of the important environmental factor on tree growth in Mongolia.

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G05-P05

The annual change of defoliation intensity by *Lymantria disper* and its size dependency of *Larix sibirica* in Mongolia

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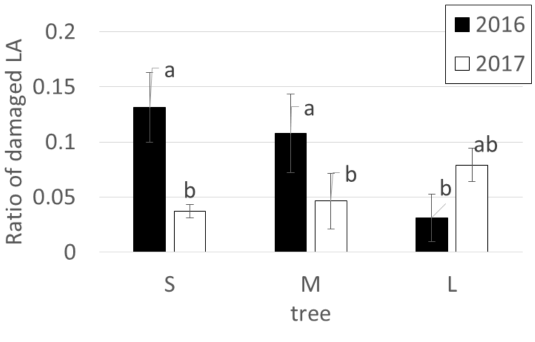
Insect damage is one of disturbance factors in Mongolian forest ecosystem as well as wild fire, illegal logging and grazing [1]. For instance, 369,300 ha of Mongolian forests were defoliated by *Lymantria dispar asiatica* larvae during 2003-2004 [2]. When damage is catastrophic, the damaged area and tree mortality gives valuable information. On the other hand, when the damage is not so severe, the damaged intensity of each tree is more important. Thus, we surveyed the amount of defoliation of larch tree in 2016 and 2017 and examined the tree size dependency on insect damage.

The study site was Udleg Experimental forest, National University of Mongolia (48°15'N, 106°51'E, level: 1338 m), 50 km north from Ulaanbaatar. Three sample trees were selected from canopy layer: S (DBH=14 cm, H=21 m), M (DBH=17 cm, H=23 m) and L (DBH=21 cm, H=21 m). Five branches were collected from each sample tree in 2016 and 2017. On each sample branch, the numbers of damaged and un-damaged short and long shoot were counted; the border of damaged was defined 50% defoliation in each shoot (Picture 1). Leaf area of several un-damaged short and long shoot was also measured, respectively. The damage intensity of each branch was calculated as the ratio of actual and pre-damaged leaf area.

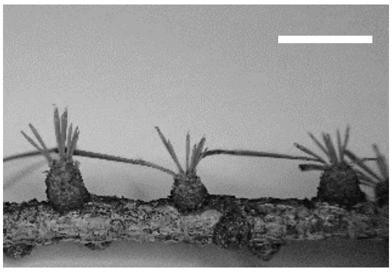
The average damage intensity was 2.5-12.5% in 2016 and 4.0-7.5% in 2017. Obvious size dependency was found in 2016, but not significant in 2017 (Figure 1). Our results suggest that not only damage intensity but also the size dependency changes, annually.

We thank to Dr.Y.Matsuura, Dr. K.Shichi (FFPRI, Japan), Mr. Y.Kubota and Mr. K.Kurosaka (Shinshu Univ., Japan). This study supported by MEXT/JSPS KAKENHI Grant: Number 26304026.

Figure 1. The damaged intensity of leaf area of branch on small: S, intermediate: M and large: L trees in 2016 and 2017. Bars represent standard deviation. Values with the same characteristics were not different, significantly.



Picture 1. The damaged short shoots by *Lymantria disper* larvae. White-colored scale represents 1 cm.



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Arctic willow ecology and its feedback to river conditions using C, N stable isotope

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In northeast Siberian Arctic, rapid warming have been observed (Serreze and Barry, 2011; ACIA, 2004; IPCC, 2013) and Yana-Indigirka-Kolyma lowland located there has a large area. River changes is one of key parameters to control material cycling through water level changes. From our former work (Morozumi, in preparation), we found willow growing widely along river, so that willow there can be good records of river condition. Foliar δ13C and δ15N values has been recognized as integrated indicators of environment.

This study was conducted in taiga-tundra ecosystem along Indigirka river (70.63°N, 147.91°E). Three transect sites were set up along mainstream and also tributary. In each site, sampling was made at three points along a transect from river to land. Willow current year shoot were collected, other samples including river water, soil water, willow stem were collected weekly in summer, both 2015 and 2016. In the end of July in both year, there are also widely random sampling of willow current year shoot.

In 2015 with normal river water level, N content ranged from 1.5% to 3.9% and δ^{15}N from -5.6‰ to 5.3‰ showed clear spatial variation with high values near river and low values on land. No clear difference was observed for willow foliar δ^{13}C which ranged from -31.1‰ to -25.3‰ in this year. In 2016 under higher river water level, same trend as 2015 was found in foliar δ^{15}N (from -6.84‰ to 4.91‰) in large area and showed clear spatial variation from water logging points (0.6±2.6‰), near water points (-2.3±1.05‰) and land points (-3.8±0.9‰). Willow foliar δ^{13}C(-31.6‰ to -25.7‰) and N content (1.4% to 4.3%) didn't show difference in 2016. We also found that thaw depth was deepened because of waterlogging. The correlation between foliar N content and δ^{15}N with thaw depth were conducted in both 2015 (all possitive) and 2016 (possitive with δ^{15}N and negative with foliar N content). We finally concluded that severe flooding do harm to willow growth through N leaching and submergence, but the suitable flood (especially after large flooding) will bring benefits to willow via deepening thaw depth and adding extra nutrients. This was also proved by A and gs measurements.

This study showed physiology and phenology of willow growing in Indigirka lowland and tried to reveal the relationship with river and willow growing from stable C and N isotopic aspect.

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G05-P07

Time-lag effect of forest productivity response to climate change over the circum-Arctic deduced from satellite images and tree rings

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Arctic and sub-Arctic ecosystems are exposed to a larger magnitude of warming in comparison with the global average, as a result of warming-induced environmental changes. Understanding the sensitivity of forest productivity to climate change in these ecosystems is an important factor in the accuracy of future projections of the terrestrial carbon cycle, and also of global climate. However, it is not certain how these ecosystems respond to these changes. Remotely sensed spectral vegetation indices, such as the normalized difference vegetation index (NDVI), and tree rings have been used to investigate vegetation productivity and it's response to climate change. Even though both indexes are widely regarded as robust and useful long-term indicators of past forest ecosystem response to climate change, those are often compared each other with local or region spatial scales, but rarely for wider spatial scale, e.g., circum-arctic scale.

Here, we compared past 30 years spatio-temporal variation of Global Inventory Modeling and Mapping Studies (GIMMS) satellite derived normalized difference vegetation index NDVIg, its recent successor version NDVI3g, and tree-ring width index (RWI) on International Tree-Ring Data Bank (ITRDB) over circum-arctic region (>50N) with respect to relationship with climate change. The comparison was conducted for linking those indices each other and for obtaining better estimate of vegetation activity response to climate change.

In this study, we found a consistent positive response to summer temperature from NDVI products and RWI in subarctic forest ecosystems and west coast region of Canada. On the other hand, we observed no such consistent positive response in continental dry or relatively warm regions over southern boreal forest ecosystem such as inner Alaska and Canada, southern part of east Europe, and southern section of Lena river basin of eastern Siberia. In these regions, NDVI products and RWI tend to show no significant and negative response to warming, respectively. Such negative response to warming of RWI was basically found with a one year time-lag, namely RWI shows higher correlation with summer temperature of previous year than current year. Although relatively few in number, considering the one year time-lag also increase percentage of sites with the negative response to summer temperature for NDVI products. Our results clearly show that considering the one-year time lag significantly affects spatial pattern in forest productivity-climate change relationship over circum-Arctic region and it should be incorporated into future carbon cycle studies. Otherwise, future projection of forest ecosystem carbon uptake may be overestimated under expected future further warming.

A Statistical Downscaling Framework for Mapping Global to Regional Environmental Impact

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Abstract

Gaining informative insights into interactions between terrestrial and space phenomena and understanding their dynamics has continued to intrigue scientific research communities across the globe. Despite ubiquitous enhancements in data acquisition, sharing and modelling technologies, many questions remain unanswered and the new developments are calling for equally sophisticated real-life applications, including those focusing on tackling environmental challenges for global sustainability. In recent years, knowledge extraction from data has become increasingly popular, with many numerical forecasting models - typically falling into two major categories - Chemical Transport Models (CTMs) and conventional statistical methods. However, due to data and model variability, data-driven knowledge extraction from high-dimensional, multi-faceted data in such applications require generalisations of global to regional or local conditions. Typically, generalisation is achieved via mapping global conditions to local ecosystems and human habitats which amounts to tracking and monitoring environmental dynamics in various geographical areas and their regional and global implications on human livelihood. Statistical downscaling is technique that has been widely used to extract high-resolution information from regional scale variables produced by CTMs in climate model. Conventional applications of these methods have relied, predominantly, on dimension reduction techniques to reduce the spatial dimension of gridded model outputs without loss of essential spatial information. The downside of the foregoing approaches is two-fold - the complete dependence on the unlabelled design matrix and on the underlying distributional assumptions. We propose a novel statistical framework for dealing with data and model variability. Its mechancis derive from a downscaling approach based on training and testing multiple algorithms on multiple samples which allow to narrow down global environmental phenomena to regional discordance through a three-stage process - dimensional reduction, prediction, comparison. Practicalities of the framework are illustrated through simulations and application to real ground level ozone and temperature data. Hourly ozone observations and recorded atmospheric temperatures were obtained from various environmental stations maintained by the US Environmental Protection Agency (EPA) covering the summer period (June-August, 2005). The ozone readings represented 94 different stations spanning across a large geographical area in the South-Eastern part of the USA.

The paper seeks to relate regional patterns of ozone and temperature to local observations which we accomplish by discretising the actual observed values and using downscaled variables as predictors. Its novelty derives from the use of ensemble unsupervised and supervised models to map regional to local air quality and temperature patterns based on repeated sampling and performance assessment of multiple versions for different techniques - notably, Principle Fitted Components (PFCs), Random Forests (RFs) and Neural Networks (NNs). An algorithm for selecting optimal performance is followed in assessing the foregoing models and our results show that given air quality data of similar structure, the algorithm can be used to order the models in terms of optimality. We demonstrate the algorithm's potential for deployment of different other models and we highlight the procedure's scope for extension to other applications, focusing on how to carry out comparisons; address inconsistencies; draw conclusions in cases of partial agreement and how to account for the effect of data and model variability.

Key Words: *Chemical Transport Models, Downscaling, Ensemble Modelling, Principal Fitted Components, Neural Networks, Random Forests, Supervised Modelling, Unsupervised Modelling*

INTERACT goes viral: an advanced community steps into a global role

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INTERACT is a circumarctic network of 82 terrestrial field bases in all arctic countries and adjacent high alpine and forested areas. INTERACT is building capacity for identifying, understanding, predicting and responding to diverse environmental changes throughout the wide environmental and land-use envelopes of the Arctic.

During the first phase of the EU FP7 programme INTERACT, more than 500 scientists were granted access to the field through the Transnational Access programme. Their science was presented in a book and mass outreach course. The project also developed best practices in station management, a standardised presentation of the stations and an overview of monitoring/research projects from 2000 until present through its Station Managers Forum. This information has been published in several books available on INTERACT's web site (www.eu-interact.org). Three joint research activities developed standardised monitoring system for surface energy balance, technology for monitoring of phenology and an integrated database system for research stations – the INTERACT GIS.

INTERACT is now an advanced community grant in EU Horizon2020 programme. Now we will further develop the Transnational Access programme with access to twice as many stations. Also, physical access has been complemented with virtual (free access to metadata and data collected by the research stations) and remote (observations carried out by station staff) access. New Station Managers' Forum activities include safety at research stations, reducing emissions from research stations and improving access to data from the research station (taking INTERACT GIS to the next level). In addition, joint research activities will develop standardized monitoring schemes for biodiversity, drone technology in the field, local adaptation schemes and procedures for action when a hazard occur. We will also develop guidelines for storing real data through our Data Forum.

Figure 1. INTERACT Research Stations is represented in all arctic countries and adjacent high alpine and forested areas.

G05-P10

Soil organic carbon storage regime in circumpolar forest ecosystems

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Soil organic carbon (SOC) storage is one of the focusing interests for terrestrial field scientists. We estimated 117 soil profile data (89 profile data on the Figure 1) in circumpolar forest ecosystems (boreal forest), including continuous permafrost (eastern and central Siberia, northern Northwest Territories, Canada), discontinuous permafrost (Interior Alaska), sporadic permafrost (Northwest Territories, Canada), and permafrost-free region (northern Finland and Estonia). The SOC storage regime in northeastern Eurasia (central and eastern Siberia) was larger than that of boreal forest ecosystems in North America (Interior Alaska and NWT, Canada). Soils in northeastern Eurasia, where continuous permafrost developed, often showed high SOC contents in whole horizons of active layer. Long-term soil formation process without continental ice sheet glaciation has critical effects on SOC storage regime. Soils derived from fluvial parent materials showed lower C/N ratios of soil profile, compare to soil C/N ratios of residual rock fragment parent materials. Larch forest soils in central Siberia derived from weathered basalt lava flow (ca. 250 M yrs. ago) had averaged C/N 19, however, larch forest soils derived from fluvial sediment in Yakutsk and Kolyma lowland showed averaged C/N 14. Upland black spruce forest soils derived from weathered schist rock fragment in Interior Alaska had higher C/N ratios 20, however, soils of glaciolacustrine deposit origin in NWT Canada also had lower C/N ratio 15. We selected two different representative soil series of permafrost-free region in circumpolar forest ecosystems, near Lapland and in peaty lowland in Estonia. Highly rock content soils of Lapland showed lower SOC with higher C/N. Scots pine forests on peaty soils showed extremely high SOC with higher C/N ratio. Soil characteristics among circumpolar forest ecosystems varied in terms of SOC regime and C/N ratio.

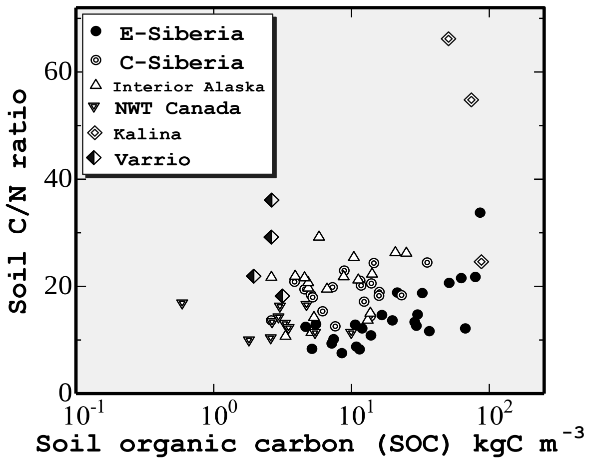

Figure 1. Estimated SOC regime among circumpolar forest ecosystems.

Biodiversity studies through international collaborative initiatives in ArCS (Arctic Challenge for Sustainability)

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The Arctic climate is undergoing rapid changes, which coupled to major changes in human economic and social activities, is expected to greatly affect biodiversity. The general objective of our research projects is to understand Arctic biodiversity in its present condition and try to predict its responses and status under various climate change scenarios.

We present here a summary of the various research activities planned and/or conducted in recent years under the ArCS program. Our studies are conducted from the genetic to the ecosystem level, as well as using models varying from microorganisms to large mammals.

In the Eastern Siberia region, we use GPS-satellite telemetry to investigate the behavioral ecology of wildlife such as reindeer. The data we obtain will be utilized to assess protected areas for the animals and/or for ensuring the safety of local communities.

St. Lawrence Island, located on the south of the Bering Strait, has a large abundance of seabirds. One of the most visible impacts of climate change for the island is the change in sea ice conditions. In addition, it is predicted that melting sea ice in the Arctic will make the Northern Sea Route passable. Although these impacts will most probably affect seabirds, little is known about seabird behavior on the island. Seabird behavior is being investigated using bio-logging techniques. Our goal is to assess the effects of changes in sea ice and ship traffic on the seabirds.

Canada has the world's widest range of Arctic ecosystems, from forest tundra to polar desert ecozones. We investigate the structures and functions of terrestrial ecosystems using an extended latitudinal gradient to better understand the diversity of key biological communities (including microbial) and related ecosystem services.

We also lead research about the slowest fish in the world, named the Greenland shark. The Greenland shark lives in the Arctic sea, but little is known about the ecology of this species. We investigate how they respond to cold water and the effects of climate change on the species.

Diversity of Fungi along Primary Successional and Elevational Gradients near Mount Robson, British Columbia

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The diversity of fungi was investigated along primary successional and elevational gradients near Mount Robson (53°03-09'N, 119°06-12'W), British Columbia, Canada. A total of 108 samples of dead leaves were collected during the fieldwork in August 2010, including 63 samples of *Dryas drumandii*, *Salix* spp., and *Picea engelmanii* from the foreland of Robson glacier (1670-1710 m a.s.l.) and 45 samples of *P. engelmanii* at 870, 1020, 1260, 1460, and 1670 m a.s.l. Pyrosequencing of fungal rDNA ITS1 regions [1] and assembling the sequences with a 97% similarity criterion [2] yielded a total of 330 operational taxonomic units (OTUs) of fungi, resulting in the identification of 124 OTUs (38% of 330) to family, 99 (30%) to genus, and 45 (14%) to species. Of 59 fungal families identified, Herpotrichiellaceae was the most OTU-rich family, including 12 OTUs, followed by Corticiaceae (9 OTUs), Teratosphaeriaceae (5 OTUs), and Tricholomataceae (5 OTUs). The most frequent OTU was Phacidiaceae sp. that was found in 90% of the samples examined, followed by Agaricomycetes sp. (73%), Dacrymycetales sp. (71%), and two unidentified Ascomycota (67% and 69%). Of 330 OTUs, 257 were detected on three plant taxa along the primary successional sere at 14, 60, and 102 years after the retreat of Robson glacier. The mean number of OTUs was significantly lower on *P. engelmanii* than on *D. drumandii* and *Salix* spp. and was significantly greater at the site 60 years after the retreat than at the site after 102 years. The OTU compositions were not significantly different among plant taxa or sites differing in the years after glacier retreat. The mean number of OTUs was significantly and positively correlated with C/N ratio of dead leaves, implying the litter quality control on the richness of fungal assemblages during the primary succession after the glacier retreat. A total of 238 OTUs were detected on dead leaves of *P. engermanii* from five sites along the elevational gradient. The mean number of OTUs was not significantly different between five sites, whereas the OTU compositions were significantly different between the sites, mainly attributed to the turnover of minor OTUs with low frequencies. Our results suggested the diversity of fungal assemblages near Mount Robson were sensitive to environmental changes that could lead to glacier retreat or shift in the elevational range. Results will also be preliminarily given on the phylogenetic and functional diversity of fungi along the primary successional and elevational gradients.

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G05-P13

Bacteria community differences between glacier and glacier foreland soil, and their transportations in Ny-Ålesund, Svalbard

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Svalbard Archipelago is one of places, where especially affected by temperature warming and decrease of sea ice and glacier in high latitude arctic. Large part of terrestrial area is covered with tundra, and microbial communities and productivities on tundra ecosystem is likely to be changed by recent environmental changes. In early succession stage of glacier foreland soil near glacier terminus, biological soil crust (BSC), which is topsoil formed by cyanobacteria, algae and fungi, is common and important for supplying nutriment and keeping water for settle of vascular plant. On glacier surface, cryoconite granule, which is around 1 mm diameter granule formed mainly by filamentous cyanobacteria, is common and important for carbon and nutrients production. Though both environments are adjacent, and products of glacier would be supply to glacier foreland soil by glacier terminus retreat and/or meltwater run off. However, ecological studies focusing on the relationship between glacier and glacier foreland is still not described well. In order to understand similarity and dissimilarity of bacterial community between these two typical Arctic environments, we analyzed bacterial meta-16S rRNA gene on glacier (Austre Brøggerbreen) and glacier foreland soil. Though bacteria communities are quite different between glacier and glacier foreland soil, BSC and non-BSC soil near glacier terminus (120m from 2016 summer terminus: 2007 terminus) is much similar than soil far from glacier (260m: 2000 terminus). Cyanobacteria is most dominated phylum in glacier and second dominated following proteobacteria in glacier foreland. Cyanobacteria genus *Leptolyngbya* is most common cyanobacteria on glacier and top5 *Leptolyngbya* exact sequence variants (ESVs) are unique only in glacier environment, otherwise some ESVs, which detected only from lower glacier left site, are also detected in wide range of glacier foreland. In this presentation, we will discuss more detail taxonomy relationship between glacier and glacier foreland, and also potential dispersal processes (airborne and waterborne transportation).

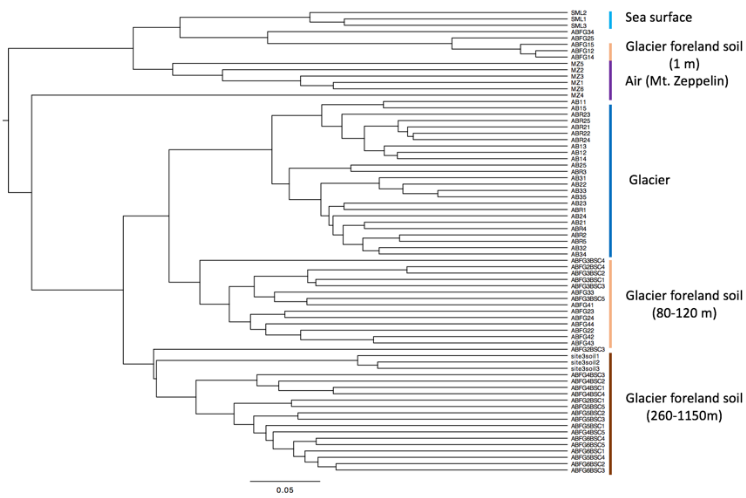

Figure. Dissimilarity of bacterial communities of glacier, glacier foreland soil, sea surface and air.

G05-P14

Annual development of mat-forming filamentous algae *Tribonema* sp. in hydro-terrestrial habitats in the Arctic

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Eukaryotic algae play an important role in polar terrestrial and seasonally cold ecosystems in temperate regions. They are widespread here, including extremes, and frequently produce visible biomass. Their combined biomass represents a sizeable pool of global fixed carbon, influencing mineral cycling and energy flow, and affects the mineral and biological development. *Tribonema* sp. (Tribonemataceae, Xanthophyta) together with others dominants is one of the most important component of these low temperature adapted communities. High Arctic environment is characterized by extremely low and fluctuating temperatures, lack of liquid water and both high and low levels of solar irradiance during summer and winter seasons. This reflects on the viability of the *Tribonema* sp. populations. However, no research concerning the exact amounts of surviving *Tribonema* sp. in the High Arctic hydro-terrestrial environment has been conducted yet. *Tribonema* sp. was chosen as a model eukaryotic alga due to its significant presence in the Svalbard archipelago, where the samples were collected. Its viability was studied in both summer and winter seasons together with whole year habitat's microclimatic conditions measurements. For viability measurements, a multiparameter staining protocol was used. SYTOX green, CTC and DAPI stains were used to enable current viability assessment using fluorescence microscopy. Although the viability in summer season was higher, winter season viability was remarkably high with more than two thirds of studied cells showing signs of activity after thawing. This suggests that *Tribonema* sp. has developed a high degree of resistance to cryoinjuries and its populations are resilient. This research sheds some light on the state of High Arctic algal population survival and opens new research questions in the realm of specific ecophysiological adaptations.

The Laptev Sea Region Of Freshwater Influence: Oceanography And Ecosystem

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The Arctic Ocean ecosystems are experiencing dramatic changes, with vast seasonally ice-free waters in most of the Arctic shelf seas. The Eastern Arctic features vast shelves that receive enormous river runoff rates that provide a first-order contribution to the Arctic Ocean freshwater budget. The Arctic regions of freshwater influence (ROFI) generally feature ecosystems characterized by strong stratification, distinct biogeochemical signatures and freshwater-adapted species. River water distributions are mainly controlled by summer winds, which lead to exceptionally strong variability in the frontal zones. Detailed shipboard expeditions to the Laptev Sea in the Siberian Arctic in 2013 and 2014 complemented by oceanographic moorings highlighted the impact of contrasting atmospheric conditions on physical and biogeochemical processes on the shelf. Locations within the ROFI maintained water column stratification until spring, while waters outside the ROFI were well-mixed by early winter. Riverine runoff is rich in CDOM and solar radiation is absorbed in the upper few meters, which leads to enhanced warming and the concentration of chlorophyll in the surface in the ROFI. In contrast, deep chlorophyll-maxima are found in the mid-waters outside of the ROFI, along with higher temperatures that are maintained well into the freezing period and thus present a source of heat that can further delay freeze-up. Recent years featured early ice break-up along with extremely warm ocean temperatures, which will be amplified under a continuing global warming and could ultimately result in subpolar conditions in this Arctic region. The Siberian interior shelves cannot be viewed as isolated systems, but are well connected through river plumes that either spread into the transpolar drift, or alternatively propagate along the coast into the East Siberian Sea which underlines the larger-scale importance of these vast Arctic river systems.

Oligotrophic trend in the Pacific Arctic Ocean over the last three decades

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Over the past three decades, the nitrate stock in the upper water column of the cnetral Arctic gradually decreased, accompany by the rapid loss of Arctic sea ice. Nitrate in the euphotic zone is insufficient for phytoplankton growth and thus limited the biological drawdown of CO_2. The nitrate distributions at the isosurface 30 m during 1987-1996, 1997-2006 and 2007-2014 are compared in the Arctic Ocean. The result shows clear evident of Arctic oligotrophic trend in the past 30 years, with the average nitrate concentration in the Pacific Arctic sector decreased from 3.0 ± 2.0 μM during 1987-1996 to 1.8 ± 1.3 μM during 1997-2006, and further decreased to 0.8 ± 1.3 μM during 2007-2014. The combined effects of increasing freshwater discharge and biogeochemical processes are the major causes for the oligotrophic trend.

G6S6-P03

Spring phytoplankton bloom at Bering Strait in 2017

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The Bering Strait, the single gateway governing water exchange between Pacific and Arctic Ocean, would play a key role in understanding biological process at/around this strait, requiring time series observation. This report presents preliminary of our analysis using satellite observations and in-situ mooring measurement conducted from 2016 to 2017 with support from "Arctic Challenge for Sustainability" project in Japan. Analysis of Aqua/MODIS chlorophyll *a* concentration and AMSR2 sea ice concentration (SIC) indicates occurrence of spring phytoplankton bloom as shown in a sharp peak at 130-135 Julian day, or equivalently mid May in upper panel of Figure 1. This is seen when SIC rapidly drops from 50% to 0%, thus this can be regarded as ice edge bloom. This mid May bloom is one month earlier than normal year (Fujiwara et al. 2016), which is consistent with the fact that rapid retreat of sea ice is observed around this region in spring 2017 (Thomas 2017). This bloom is also detected by moored chlorophyll fluorescence sensor at 50 m at 120-150 Julian days as shown in lower panel of Figure 1. However, unlike the satellite time series, spike-like peak is not discernible in this in-situ data. These facts indicate the ice edge bloom at the near-surface is not the only factor that brings higher level of chlorophyll *a* concentration at the bottom, implying the presence of not negligible contribution of northward flow that caries highly productive water from the south.

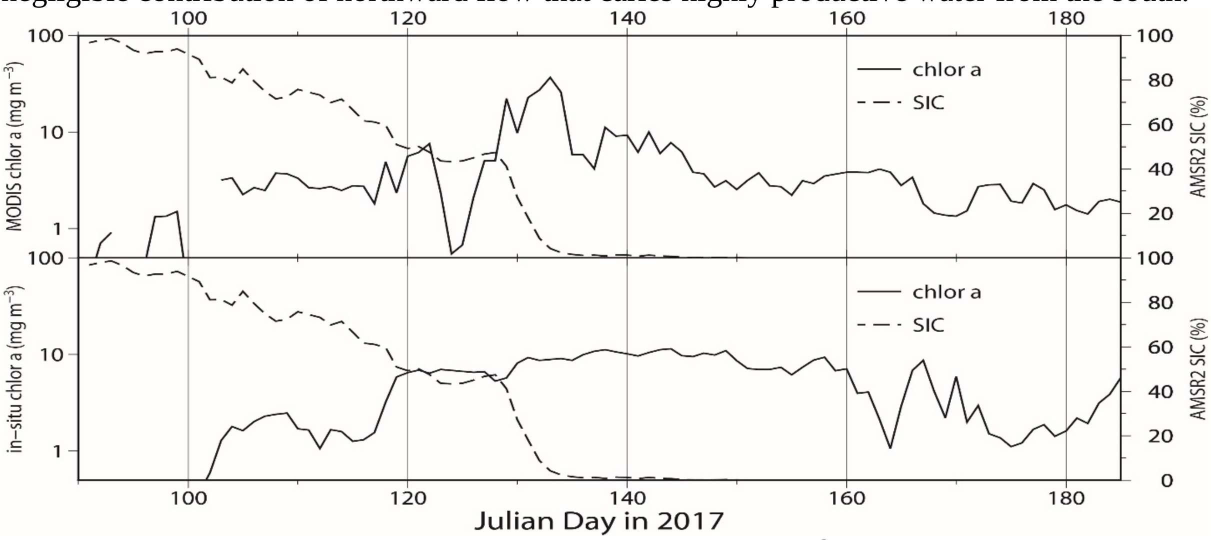

Figure 1. Time series of chlorophyll *a* concentration (mg m^{-3}, solid lines) estimated from Aqua/MODIS and moored chlorophyll fluorescence sensor together with AMSR2 sea ice concentration (%, dashed lines) at Bering Strait in 2017.

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Pigment indicated Phytoplankton communities in the West Arctic Ocean in summer season

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Nutrients and photosynthesis pigments were investigated in the Western Arctic Ocean during the Chinese Arctic Research expedition cruises in summer season. In order to get the structure of phytoplankton communities, CHEMTAX software with pigment data was performed to estimate the contributions of eight algal classes to the total chl *a*. The result showed that on the Chukchi shelf, the Pacific Ocean inflow mainly controlled the chl *a* biomass and phytoplankton communities due to the nutrient supplement levels. High chl *a* was found and diatom dominated on the high nutrient Anadyr Water and Bering Shelf Water (AnW and BSW) controlled regions, while, on the region occupied by low-nutrient Alaska Coastal Water (ACW), the chl *a* biomass was low with pico- and nano- phytoplankton dominated, such as prasinophytes, chrysophytes and cryptophytes. Over the off-shelf region, the ice cover condition do a profound effect on the physical and nutrient concentrations of the water masses, in consequence had a greater impact on the structure of phytoplankton communities. Diatom dominated in ice cover region with its contribution to chl *a* biomass *up to* 75%. Southern Canada Basin, an Ice-free Basin (IfB) with the lowest nutrient concentrations and most freshened surface water, the lowest chl *a* biomass was found in the surface water as a consequence of the depleting nutrients and strengthening stratification which impoverish the upper layer and reduce the biomass in the surface water, causing surface water "desertification".

Acknowledgement:We thank all crews of the icebreaker ‘Xuelong’ and the scientists during the Chinese National Arctic Research Expeditions for the great help in sample collection. We thank Prof. Jinping Zhao for providing the CTD data and Dr. Wenli Zhong for Water masses comments. This study was supported by the National Natural Science Foundation of China (Nos 41276198, 41076135, 41776205), Chinese Polar Environmental Comprehensive Investigation & Assessment Programs (CHINARE 2014-03-04; CHINARE 2014-04-03).

G6S6-P05

Sea ice history of the Pacific Arctic Region: Evidence from fossil diatom records

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Arctic sea ice plays a vital role in the global climate change by its high albedo influencing the energy balance and by preventing heat and mass exchange between ocean and atmosphere. To understand the mechanism behind and to forecast the future environment changes, it is essential to know the past sea ice variability in the Arctic Ocean, where sea ice is undergoing rapid retreat. However, such research in the Pacific Arctic Region (PAR) is sporadic and thus the sea ice history in this area remains unclear.

This study aims to reconstruct the sea ice history in the PAR for the past centuries by analyzing the diatom compositions of four multicores retrieved in the Bering and Chukchi Seas, characterized by seasonal sea ice coverage, during the 7th Chinese National Arctic Research Expedition (CHINARE-7) in 2016. The sea ice history is generated by the variability of the sea ice diatoms and a diatom-based transfer function newly developed in the study area. The sediment cores cover the last century, allowing for the comparison of the diatom based sea ice estimates with the local and global instrumental records. Moreover, comparisons between the sea ice reconstructions derived from different proxies are also made to discuss the advantages and disadvantages of these methods.

Settling particle flux and the possible influence of surface atmospheric forcing in the southern Northwind Abyssal Plain

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Recent sea ice retreat and hydrographic environment change affects biogeochemical cycles and marine ecosystems in the western Arctic Ocean. We deployed bottom-tethered mooring with sediment trap in the southern part of Northwind Abyssal Plain (Stations NAP10t-12t: 75°N 162°W, NAP13t: 74.5°N 162°W) to monitor time-series variation of settling particle fluxes in changing hydrographic condition. Studied settling particles are usually composed of abundant lithogenic silt-clay minerals suggesting lateral advection of shelf matters to basin. The physical oceanic model suggested that the annual maximum of settling particles observed at Station NAP10t in November-December 2010 reflected lateral advection of oceanic cold eddy with shelf materials developed off the Barrow Canyon [1]. This suggests significant relationship between settling particle flux and hydrographic condition of upper water masses at Station NAP. Total mass flux at Stations NAP10t-12t ranged from 5.0 to 263.3mg m^{-2} day^{-1}. Mean daily flux of total mass at shelf side station NAP13t was 1.5 times as high as that of NAP10t-12t. Interannual variation at the same position was observed at NAP10t-12t for three years. The relatively low particle flux was observed in 2012 and early period of 2013. The northward current volume transport of oceanic Beaufort Gyre in the Northwind Ridge shows a delay response to surface forcing with the time lag of about 3 years [2]. The logarithm of three months running-mean of settling particle flux at Stations NAP10t-12t roughly corresponds to three months running-mean of Arctic Oscillation Index with time lag of about 30 months (r = 0.73), although longer time-series data of settling particle flux are required to finally confirm this relationship. The contents of particulate organic carbon in the setting particles at NAP10t-12t, and NAP13t ranged from 1.6 to 21.7wt%, and from 3.5 to 14.9wt%, respectively. The mole ratio of particulate organic carbon and nitrogen at NAP10t-12t and NAP13t ranged from 6.2 to 11.9, and from 6.4 to 9.8wt%, respectively.

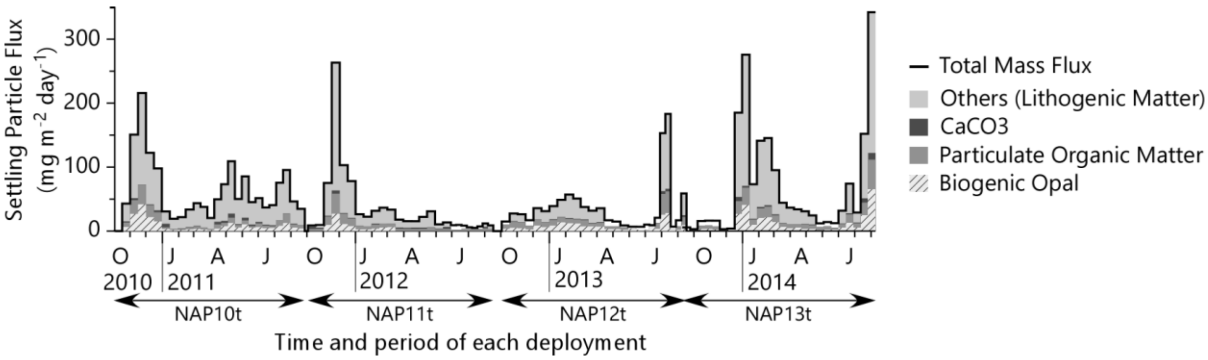

Figure 1. Settling particle flux at 186-222 m depth at Stations NAP10t-13t. The graph is accumulation of each bulk component. The black line at the top of graph shows total mass flux.

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G6S6-P07

Seasonal changes in population structure of four dominant copepods collected by a sediment trap moored in the western Arctic Ocean

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Seasonal changes in abundance, population structure, lipid accumulation and gonad maturation of four dominant copepods (*Calanus hyperboreus*, *Metridia longa*, *Paraeuchaeta glacialis*, *Heterorhabdus norvegicus*) were assessed using zooplankton swimmer samples. Zooplankton were collected using a sediment trap moored at a depth of 222 m in the western Arctic Ocean from October 2010 to September 2013. *Calanus hyperboreus,* mostly comprising C6F, exhibited two seasonal abundance peaks: one in April-May and another in September-October. *Calanus hyperboreus* C6F samples were dominated by lipid-rich specimens year-round, and their gonadal development was observed from February to April. *Metridia longa* were high in abundance in April-July. Gonad maturation of *M. longa* C6F occurred in March-October, and early copepodid stages (C1-C2) occurred in September-October. *Paraeuchaeta glacialis* was abundant from July to October. In contrast to the former two species, lipid-rich, mature *P. glacialis* C6F occurred year-round. *Heterorhabdus norvegicus* C6M also occurred throughout the year, possibly because *H. norvegicus* has functional feeding appendages, even in C6M. Environmental parameters, such as ice coverage, daylight hours, sea surface chlorophyll *a*, and total particulate mass fluxes, were quantified. Among the assessed environmental parameters, daylight hours affected seasonal changing timings of copepod abundance, population structure and life cycles the most.

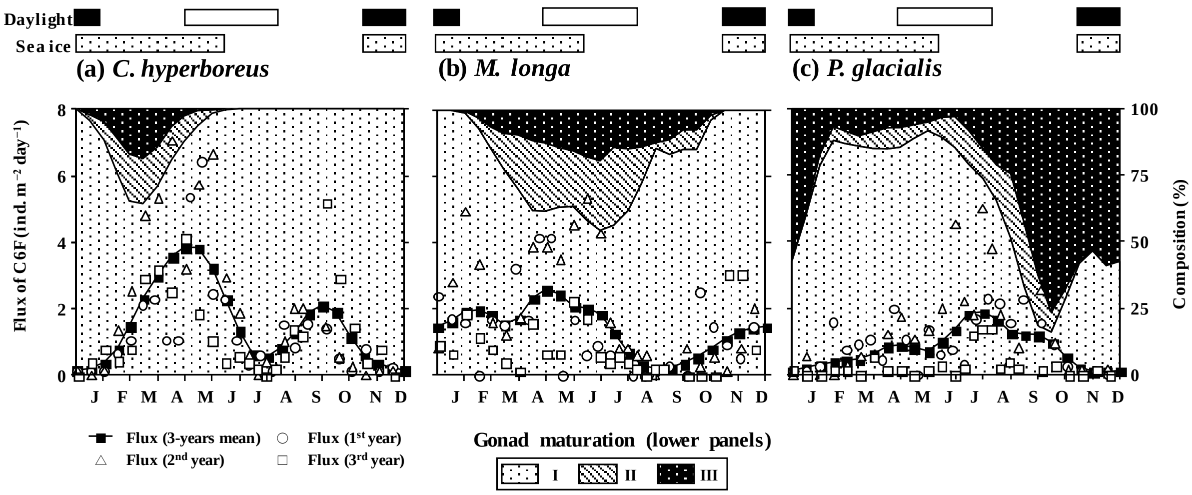

Fig. Seasonal changes in flux of adult females (C6F) and gonad maturation composition (stage I−III) of *Calanus hyperboreus* (a), *Metridia longa* (b) and *Paraeuchaeta glacialis* (c) at St. NAPt in the Chukchi Sea. Values are means of the three years (October 2010 to September 2013). For comparison, seasonal timings of midnight sun (open), polar night (solid) and ice cover (dotted, >90% sea ice concentration) are shown by bars atop abscissa.

G6S6-P08

Spatial and inter-annual changes of zooplankton community structure in the western Arctic Ocean during summers of 2008−2015

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Reduction of summer sea ice coverage has occurred in the western Arctic Ocean recently. Changes in the coverage and retreat timing of sea ice are expected to have great impact on marine ecosystem. Under such situation, inter-annual changes in spatial distribution of zooplankton community structure have also occurred. However, little information is available on this issue. In this study, we evaluated inter-annual changes in spatial distribution of zooplankton communities in the western Arctic Ocean during summers of 2008, 2010, 2012, 2013, 2014 and 2015. Zooplankton samples were collected by vertical hauls of a NORPAC net (mouth diameter 45 cm, mesh size 335 μm) from 150 m (for stations with >150 m bottom depth) or 5 m above the bottom (for stations with <150 m bottom depth) to the sea surface at 22−63 stations in the western Arctic Ocean during 29 August−13 October of 2008, 2010, 2012, 2013, 2014 and 2015. At each station, temperature and salinity were measured with a CTD. Zooplankton samples were immediately preserved with 5% buffered formalin. In the land laboratory, wet masses of zooplankton samples were measured, and enumeration and species (for calanoid copepods, copepodid stage) identification were made under stereomicroscope. Based on zooplankton abundance, cluster analyses (Bray-Curtis connected with UPGMA) were made. Species diversities (*H'*) were also calculated based on zooplankton abundance. Through the whole period, zooplankton abundance ranged between 2889 and 274021 ind. m^{-2}, and was greater in the shelf region. Zooplankton biomass ranged from 1 to 263 g WM m^{-2}, and showed similar spatial pattern with the abundance distribution pattern. Based on cluster analysis, four zooplankton communities; termed Basin, Shelf Break, Northern Shelf and Shelf were identified. Horizontal distribution of each zooplankton community was well corresponded with the depth. Copepod species diversity was high at Shelf, Shelf Break and Basin, while was low in the Northern Shelf. Horizontal distribution of Shelf community varied with year. Shelf community was characterized by high abundance of the Pacific species, especially copepod *Metridia pacifica,* which transported from Bering Sea. These results suggest that the earlier sea ice reduction may enhance transportation of the warm Pacific Water which provide more Pacific species and induce high species diversity in the western Arctic Ocean.

G6S6-P09

Horizontal and vertical distribution of appendicularian community and population structure in the Bering and Chukchi Seas during summer of 2007

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Horizontal and vertical distribution of appendicularian community and population structure of dominant species in the southeastern and northern Bering Sea shelf and Chukchi Sea were studied during summer of 2007. Results were compared with those in 1983-1996, and their feeding impact was also calculated. *Oikopleura vanhoeffeni* was the dominant species in this region, and stage I with smaller tail length (TL) specimens (< 2 mm) were dominated. Mean daily clearance rate was at 16.4 ml ind.$^{-1}$ day^{-1}, which corresponded as population daily clearance rate on water column at 0.003-25.5% day^{-1}. Dominance of stage I and smaller TL specimens suggest that main spawning of *O. vanhoeffeni* was occurred before summer in 2007. On the other hand, large-sized individuals (>14 mm TL) dominated in 1983-1996. Considering the generation length of *O. vanhoeffeni* (ca. one year), main spawning of *O. vanhoeffeni* would not occurred before summer for 1983-1996, thus, large individuals were dominated. In 2007, *O. vanhoeffeni* considered to have spawning earlier, then newly-recruited small individuals would occur numerically. Recently, the timing of sea ice retreat is becoming earlier in this region, and the fastest ice-free timing was reported for 2007. The earlier sea ice retreat may induce faster timing of primary production and other biological phenology. Thus, early spawning of *O. vanhoeffeni* in 2007 may considered to induce dominance of smaller specimens at that year.

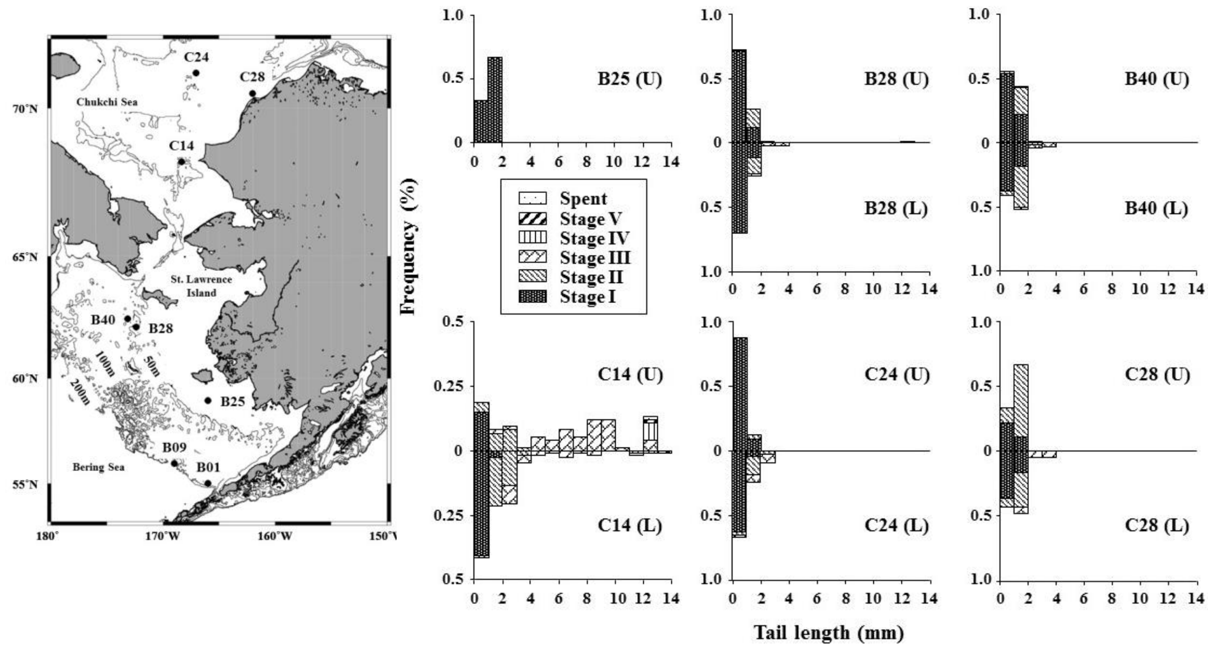

Figure. Location of sampling stations (left) and tail length and gonad maturation frequencies of *Oikopleura vanhoeffeni* at upper (U) and lower (L) layer of each station (right).

G6S6-P10

Nitrogen isotope ratio of Amino acid in zooplankton, *Calanus Hyperboreus* in the Western Arctic Ocean, as a Biogeotracer.

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Nitrogen stable isotope ratio is regarded as nitrogen tracers in the ocean. Recently, nitrogen stable isotope ratio of amino acid in zooplankton, *Calanus Hyperboreus* is used as alternative nitrogen tracer, since nitrogen isotope ratio of source amino acid in large zooplankton provides time integrated nitrogen source information.

In this study, we characterized various water mass in the western Arctic Ocean using oxygen stable isotope ratio of seawater and analyzed nitrogen stable isotope ratio of amino acid in the zooplanktons to identify variation in the nitrogen source among the different water masses. Based on the salinity, the study areas are classified as the Bering Sea (31.85±0.62 psu), the Chukchi Sea (25.17±1.17 psu) and the East Siberian Sea (27.42±0.77 psu). Also, the oxygen isotope ratio in the Chukchi Sea (–3.98±0.41‰) and the East Siberian Sea (–2.86±0.47‰) are seemed to be more affected by meteoric water than the Bering Sea(–1.80±0.51‰).

The nitrogen isotope ratios of bulk tissue in zooplankton were similar between the Chukchi Sea (11.28±0.6‰) and the East Siberian Sea (11.23±0.24‰), while it showed relatively lighter value (10.09±1.53‰) in the Bering Sea. Meanwhile, nitrogen isotope ratios of phenylalanine, as a representative source amino acid indicates generally lighter nitrogen isotope ratio, showing different values in the Bering Sea (5.24±0.57‰), the Chukchi Sea (5.77±1.73‰) and the East Siberian Sea (6.32±1.67‰).

In the present study, the differences in the nitrogen isotope ratios among various water mass, might be correlated with the influences of meteoric water, which is closely related to the enhanced freshening by sea ice melting as well as river discharge in the western Arctic Ocean. These results can provide useful information to understand nitrogen cycles in the Arctic Ocean.

The Pacific Arctic Region: A Window into Shifting Benthic Populations in Response to Ecosystem Change

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A key ecological organizing principle for the northern Bering Sea and the adjoining southern Chukchi Sea in the Pacific Arctic is that the shallow, seasonally productive waters lead to strong coupling of spring-summer pelagic production to the underlying sediments as sea ice retreats. Both *in situ* production and advection of upstream phytodetritus to these regions support persistent biological hotspots that connect benthic prey to diving marine mammals and seabirds, such as gray whales, walruses, and spectacled eiders. Times-series data over the last 30 years indicate that these regions have experienced a northward shift in macrofaunal composition and a decline in core benthic biomass that matches patterns of reduced sea ice, warming seawater, and changing sediment grain size that relates to varying current patterns. This presentation will discuss these data in the context of both process studies from the region and results from the Distributed Biological Observatory (DBO), an international network of time series transects that is providing a framework to evaluate status and trends on a latitudinal bases in the Pacific Arctic region.

G6S6-P12

Hyperborean microphytobenthos (*Vaucheria* sp.) of coastal tidal flats, central Svalbard

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Arctic tidal flats are unique habitats with frequent disturbance of the seabed and random recolonization of very unstable fine sediment. Adventfjorden tidal flat, located near Longyearbyen (Spitsbergen) is a unique area where these processes occur. Main component of microphytobenthos carpet in this tidal flat is microalga *Vaucheria* sp. (Vaucheriaceae, Xanthophyceae), which cover here large area of several hectares. In 2016 and 2017 we have performed measurements of photosynthetic activity of *Vaucheria* sp. in two types of microcosmos as well *in situ* using variable chlorophyll fluorescence and gasometry approaches. These ecophysiological measurements were followed by detail ecological study (morphological and molecular diversity of *Vaucheria* sp., their area distribution, impact of tide and distance from sea on *Vaucheria* sp. distribution together with chemical and physical water and sediment ecological properties). This community of tidal flats in central Svalbard represent the observation of long-term sediment stabilization and biological enrichment of high Arctic tidal zone.

Fate of particulate matter in the epi-benthic layer around the Bering Strait during autumn

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Bering Strait is a gateway between the Arctic and the Pacific waters. Geographic and oceanographic features such as bathymetry and primary productivity differ between Pacific side (Bering Shelf and southern Chukchi Sea) and Arctic side (northern Chukchi Sea and Arctic Basin). The Pacific side shows generally shallower bathymetry (<70 m) and higher primary productivity (>800 g C m^{-2} $yr.^{-1}$ [1]) than the Arctic side. Although ecological and biogeochemical importance of particle transportation between these waters, little attention has been paid to quantify the transportation processes from south (i.e., Pacific side) to north (i.e., Arctic side). To quantify the processes, we deployed two mooring observatories equipped with an Acoustic Doppler Current Profiler (ADCP) and a fluorescence/turbidity/temperature sensor at 65° 4' N, 169° 38' W (south of the Bering Strait) and 66° 16' N, 168° 54' W (north of the Bering Strait). Those oceanographic instruments were set at 3 m above the bottom. An averaged turbidity (FTU) at northern site was higher (4.5) than at southern site (2.5), although an averaged chlorophyll concentration was equivalent between those two sites (1.1 mg m^{-3}). Current speed at northern site (10–80 cm s^{-1}) was higher than southern site (10–40 cm s^{-1}). These results suggest a difference in process of horizontal particle transportation between the two study sites. The possible processes are 1) re-suspended particles from the sea bottom and sinking/suspended particles from surface layers were horizontally transported northward at the northern site and 2) less sediment re-suspension occurred and sinking/suspended particles from the sea surface were horizontally transported to northward at the southern site.

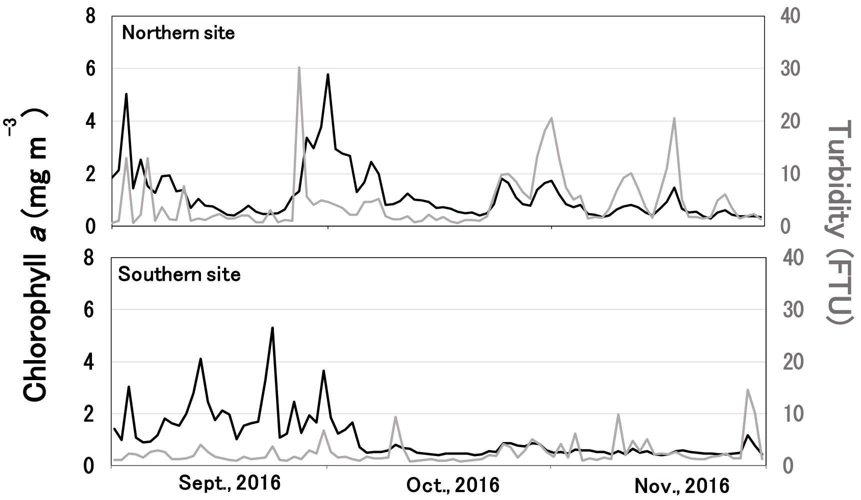

Fig. Temporal variabilities of chlorophyll *a* (black line) and turbidity (gray line) at 3 m above the bottom in waters around the Bering Strait.

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G6S6-P14

Cancelled

G09-P01

Applying national climate scenario: future hot weather projection and its population exposure in South Korea.

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Heat waves, often caused by consecutive severe hot weather events, are responsible for the majority of the medical costs associated with climate change in South Korea. In this study, we obtained a regional climate change scenario (RCP4.5) for South Korea, with a 7.5 × 7.5 km horizontal resolution and extending up to 2100, by dynamically downscaling from the results of the Community Earth System Model (CESM) with the Weather Research and Forecast (WRF) model. We analyzed hot weather events (daily maximum temperature greater than 33℃) in the summer season (June–August), with a focus on changes in their extent and frequency. According to our analysis, the area exposed to hot weather events in August will expand to cover ~70% of the nation in the middle of this century, with a rate of increase of 0.24% per year. We calculated the population exposed to hot weather events in Korea, considering both the spatial coverage and the number of event days, and the population exposure was projected to increase almost three-fold (from 26% of the national population during the 2010s to 72% during the 2090s). In particular, the exposure of the elderly population (>65 years old), who are particularly vulnerable, was expected to rapidly increase, with ~22% of the national population (~10.4 million over 65-year-olds) affected in the middle of this century when we considered the future projection of rapid population aging in Korea. Our projection of extensive hot weather events starting from the middle of the 21st century suggests the need for urgent government long-term measures and enforcement to ensure an early response to extreme weather events in Korea.

G09-P02

Daggers and the Change in Value of Copper: An Analysis of Northern Athabascan Culture from the 18th to 20th Century

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Y-shaped daggers (Fig.1) are attributed to 18th-20th Century's Athabascan/Dene cultures. Almost all these daggers were made from copper and iron. Sometimes, a wooden pole was attached to them to make a bear hunting spear.

In this study, we investigate the distribution and usage of such daggers. In relation to distribution, we will point out the possibility that the Hare (especially K'asho Gotine Dene Band) may have used them. Previous studies [1, 2] have not mentioned it. We also discuss such daggers as prestige goods in addition to their practical advantage as a hunting implement.

Researchers of indigenous North American metallurgy have already suggested that both practicality and prestige were attributed to Athabascan copper artifacts in general until former half of the 20th century [3]. The previous studies tend to focus on copper as trade items when they discuss prestige of such items. In this study, we argue that Athabascan copper daggers can be considered as practical-yet-prestigious goods not only because copper was one of their valuable trade items but also because it enabled people to hunt grizzly bears and other potentially dangerous animals. In many Athabascan societies, where hunting and fishing are primary modes of subsistence, traditional spear hunting of grizzly bears used to bring a fame to successful hunters, and it was the Y-shaped handle of copper daggers that ensured the bear hunter's safety.

Finally we analyze the change in value of copper from the viewpoint of fur trade between Euro-American/Canadian and indigenous peoples.

Figure 1. Y-Shaped Copper Daggers and Sealskin Sheath:
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Investigation for annual route changes of reindeer migration in Siberia using satellite remote sensing

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Hunting of wild reindeer has been important to nomads living in the Arctic Circle around Siberia. Wild reindeer have a recurrent migration every year, however, the annual travel-route has been changing recently, so the nomads cannot expect the route in their traditional experience. One of authors (Tatsuzawa) has investigated the route by installing GPS transmitter to some reindeer. Previous works indicated that the reason of the annual route changes must be a global warming, forest fires, thunders, and floods, but they only discuss based on measurements in specific area. The main reason of the route changes, however, remain unclear. The purpose of this study is to investigate using satellite remote sensing why the reindeer inhabiting the Siberia alter the travel route annually. We focus on 1) the annual change of vegetation (NDVI: normalized difference vegetation index) around Lena river, and on 2) the annual change of soil water content (mNDWI: modified normalized difference water index) which can reflect the precipitation of the area. First, we analyzed NDVI using MODIS images that can be observed over a wide area, filmed in July and August; the reindeer started to travel in 2010. We have compared the seasonal changes of the NDVI/ mNDWI images with the trace obtained by GPS data from 2010 to 2012.

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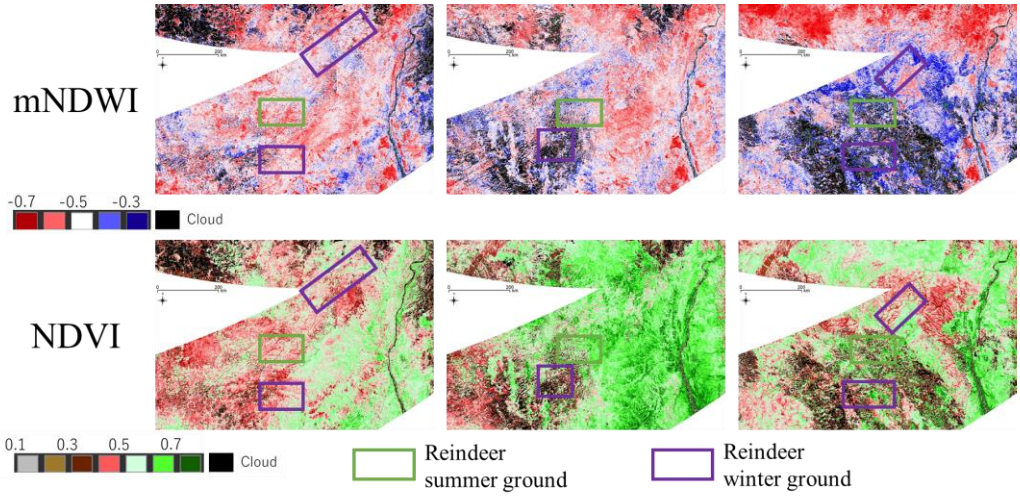

Figure 1. mNDWI/NDVI mapping around Lena River, Siberia on August 29th

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G09-P04

International Cooperative Study and Actions for Conservation of Asian Black Brant *Branta bernicla orientalis*

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[7]*Miyajima-numa Wetland Center, Japan*
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[9]*Niigata Wetlands Network, Japan*
[10]*Notsuke Peninsular Nature Center, Japan*
[11]*National Institute of Polar Research, Japan*

Asian Black Brant *Branta bernicla orientalis* is relatively small population and poorly studied. There are few information about the breeding site, staging site and also migratory route. In order to achieve the conservation of Asian Black Brant and their habitat, it is essential to understand the life history and migratory strategy and also identify the international important sites. On the assumption of contributing the development of International Single Species Action Plan (SSAP) for Asian Black Brant, following items were discussed in the meeting. 1. Summarize the issues for Asian Black Brant population(s). 2. Identify the required research and actions. 3. Develop the cooperative research.

As results of our exchanges of information and discussions, the following threats of Asian Brant goose were clarified. As for the breeding area, impacts from the climate change and hunting pressure in Russia. In its staging area, they have impacts from spring and autumn hunting in Russia. As for wintering sites, development of coastal area especially in western part of Korean and China have occurred, although important wintering sites have not identified yet. So we must collect more information about threats in each area and compile in SSAP.

To conserve Asian population, it is essential to identify the population structure of them. Need to promote the cooperative research to improve the understanding of migratory ecology and develop the conservation actions under the cooperation among relevant countries such as bilateral meeting. To clarify the conservation unit and promote the appropriate management through relevant country determine the conservation unit for Asian population. This would also contribute to solve the Taxonomical issue about *B. b. orientalis*.

G09-P06

The Finns in Siberia in 1917: Collaboration and Inclusiveness in the Community-Driven Heritage Project

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This paper is a report on the research project which revives the heritage of the Finnish Geological Expedition in Siberia in 1917. The paper aims to highlight the role of inclusiveness and collaboration in the project which was originated not in the museum depositories, but in a community of people who are connected to the century old story through family ties or landscapes. The main applied data collection method is the participant observation aided with the diachronic construction of landscape narratives that are based on the photographs—archival and current-day—and envoiced as stories of the expedition members (from publications, diaries, and memories of their family members) and of people who inhabit the same places today.

The photographic archive of the expedition, diaries and reports of participants are valuable for a detailed account on history, geography and ethnography of encountered peoples and places. Equally interesting is the process of acquisition of the archive by the expedition in 1917 and repatriation of indigenous knowledge which is embodied in this archive a century later; the process which benefits both home and host communities in the case of this particular heritage project.

Figure 1. Carl-Johan Lindén stands next to the photograph of his father Erik Lindén which was taken in Siberia in 1917. Photograph by Stanislav Krupar, Czech.

Atmospheric water cycles in the Arctic and Antarctic during the past four decades

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Atmospheric water cycles over the Arctic and Antarctic have been investigated in the previous studies and there are some similarity and dissimilarity in the two polar regions. The Arctic and Antarctic are areas of moisture flux convergence through the year. That is, the precipitation (*P*) exceeds the evaporation (*E*) and the net precipitation (*P-E*) is positive. As a result, the atmospheric moisture transport is a primary input of water into the polar regions. Meanwhile the climatological seasonal cycles of *P-E* over the both regions are dominated by transient moisture flux associated with cyclone activities, the interannual variations are governed by the stationary flux associated with the Arctic Oscillation (AO) and the Antarctic Oscillation (AAO). In addition, recent climate changes influence the polar water cycles. Our analyses using an atmospheric reanalysis up to recent years indicated that there were no significant long-term changes in the poleward moisture transport into both the Arctic and Antarctic during 1979-2016 (Fig. 1, [1]). On the other hand, the water vapor (precipitable water) were clearly increasing over the Arctic and gradually decreasing over the Antarctic during the same period. As expected, the increasing trend of water vapor was due to the large warming over the Arctic. There were two reasons for the gradually decreasing trend of water vapor over the Antarctic. The first one was the positive trend of AAO in summer and the second was deepening trend of the Amundsen low in autumn. The trends in water vapor and temperature further suggest that both polar regions were getting dryer in several seasons, while it needs to be examined using other dataset.

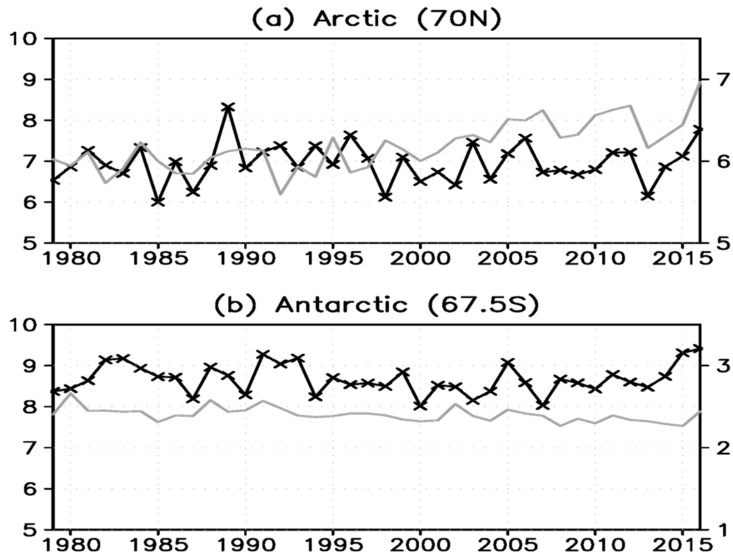

Figure 1 Time series of annual mean zonal mean poleward moisture flux (black line with crosses, kg/m/s, left axis) and precipitable water (gray line, mm, right axis) from 1979 to 2016 over (a) the Arctic and (b) the Antarctic. These results are based on ERA-Interim. Adapted from Oshima and Yamazaki (2017)

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S1-P02

Maintenance mechanism of a long-lasting polar low observed over the Barents Sea in January 2011

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This study documents the life cycle of an unusually long-lasting polar low (PL) observed in January 2011, through a comprehensive analysis of in situ shipboard measurements, satellite and reanalysis products, and numerical simulations. Figure 1 shows a sequence of cloud top pressure levels overlaid on sea level pressure. The PL lasted for more than 3 days, which was atypical, since only 10% of PLs lasted more than 1 day [1]. The maintenance mechanism of this PL was analyzed, with special emphasis on condensational heating and related moisture supply. During the development phase, strong condensational heating extended from the low to the upper troposphere and reached its maximum in the middle troposphere. Horizontal moisture transport accompanied with northward migration of a preceding low was important during this phase. During the mature phase, however, low-level clouds played a significant role in maintaining the PL. Evaporation from the sea surface compensated moisture loss caused by divergence of the horizontal moisture transport, and was essential for the moisture supply. The simulated PL decayed rapidly when surface evaporation was switched off after the development phase. These results indicate that increases in horizontal moisture transport and surface evaporation in the Arctic have the potential to affect the lifetime of PLs.

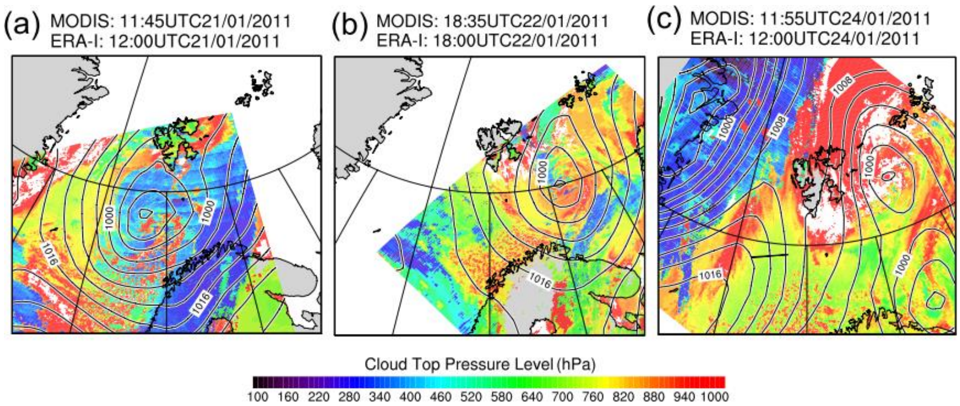

Figure 1. Cloud top pressure level (areas shown in color) overlaid on sea level pressure (contours) in hPa at around (a) 21/12:00, (b) 22/18:00, and (b) 24/12:00.

This work was supported in part by Arctic Challenge for Sustainability and the Japan Society for Promotion for Science through a Grant-in-Aid for Scientific Research (17H02958, 16H04046, and 16H01844).

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Navigable speed related to ice condition along the Northern Sea Route

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[3]*Kitami Institute of Technology, Japan*

So far, many ice class cargo vessels have sailed the NSR, some were under icebreaker support and some were independently. Authors investigated those sailing records by monitoring satellite AIS. And ice concentration along the actual sailing route was detected by satellite monitoring[1]. Ice thickness along the sailing route was also investigated by using TOPAZ4[2] data assimilation database. The sailing speed varies widely but envelope line of sailing speed correlate with the product of ice concentration and ice thickness(Figure 1). Based on this, authors examined the "Ice Index", which is a parameter of which Yamaguchi[3] advanced based on the "Ice Numeral" of Transport Canada[4]. In calculating the Ice Index, surface average temperature was retrieved from NCEP/NCAR Reanalysis 1[5], but multi-year ice and ice ridge factors were neglected. As a result, Ice Index and envelope of sailing speed showed good relationship. This could be an estimation method for navigable speed in ice infested waters.

This study has been carried out under the support of ArCS and GI-CoRE(Hokkaido University).

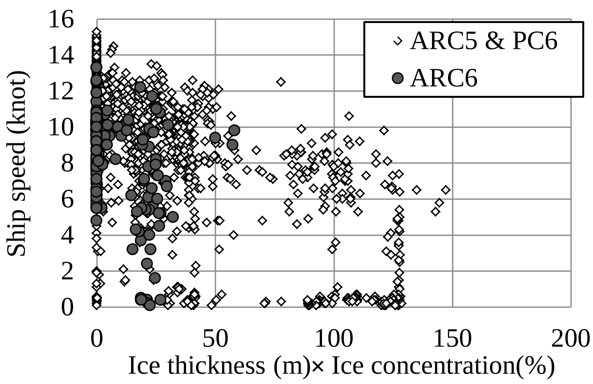

Figure 1. Ship speed and ice condition

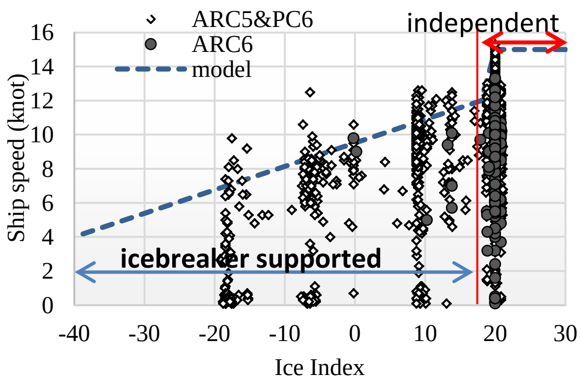

Figure 2 Ship speed and Ice Index

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S7S8-P02

Development of Online Arctic Sea Route Search System on ADS

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In recently years, the amount of sea-ice extent in the Arctic region has decreased drastically. The period when ships can cruise in the Arctic Ocean is becoming longer, and commercial use of the Arctic Route has attracted much attention. However, a possible route depends on the distribution of sea ice, and when the selection of a route is mistaken, there is also a risk of leading to a serious accident. For this reason, prediction of a suitable ice navigation system is required for ship operation. For the purpose to realize the use of the Arctic Sea Route, a research group in Yamaguchi Laboratory studies the optimum route search [1-3](Choi et al. 2014, Nakano 2015, Yamaguchi 2015). In the study, efficient search program using heuristic path planning algorithms was developed, and ship navigation support system was built.

In this paper, as a part of data utilization of ADS (Arctic Data archive System), we implemented the route search system that can be easily used by anyone. By using this system, the optimal route search can be performed only by the easy operation from a web screen, and it becomes possible to make the cruise plan based on that result.

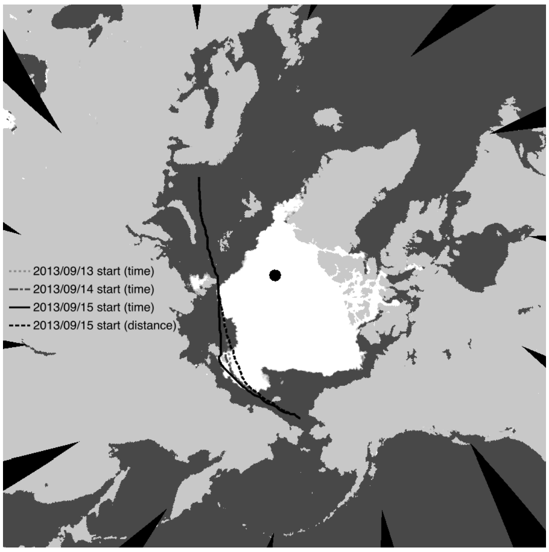

Figure 1. Example route search calculation results.

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S09-P01

Activities of the Polar Environment Data Science Center

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[1] Polar Environment Data Science Center, Research Organization of Information and systems, Joint Support-Center for Data Science Research, Japan

Polar Environment Data Science Center (PEDSC) has been established in the Joint Support-Center for Data Science Research (DS) of the Research Organization of Information and Systems (ROIS) in 2017. Purpose of the PEDSC is to promote collaboration with and effective utilization of the data obtained by the research activities in the polar regions, and to play a role as a center of the data activities of polar science to contribute to the global environment research. Activity of the PEDSC is closely related with the research activities of the National Institute of Polar Research (NIPR) in the Antarctic and Arctic regions in various research fields of Space and Upper Atmospheric Sciences, Meteorology and Glaciology, Geoscience, and Bioscience. Various data have been obtained by such various activities in various forms as digital sequential data, material samples, image data, etc., and have been recorded, stored, and archived in various databases in various forms. One of the first targets of the PEDSC is to survey the current status of the various databases and construct a synthetic database to access to the various databases easily, and to open the various data to users obviously. In our presentation, an abstract of the activities of the PEDSC now and in future will be introduced.

S09-P02

Introduction on "Polar Data Journal"

Akira Kadokura[1,2*], Yasuyuki Minamiyama[2], Masaki Kanao[1,2], Takeshi Terui[2],
Hironori Yabuki[1,2], Kazutsuna Yamaji[3]

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[2]*National Institute of Polar Research*
[3]*National Institute of Informatics*

The National Institute of Polar Research (NIPR) has launched Polar Data Journal, a new data journal in January, 2017. Polar Data Journal is a free-access and peer-reviewed online journal. It is dedicated to publishing original research data/datasets, furthering the reuse of high-quality data for the benefit to polar sciences.

Polar Data Journal aims to cover a broad range of research disciplines involving polar regions, especially the earth sciences and life sciences domain. The journal primarily publishes data papers, which provide detailed descriptions of research data/datasets (e.g., Methods, Data Records, and Technical Validation). It is not required that the data papers published in this journal depict any new scientific findings; hence, the journal also welcomes submissions describing valuable existing data/datasets that have not been published to date.

Some key features of the new journal are as follows:

- Polar Data Journal is a peer-reviewed journal that aims to provide high-quality data to researchers.
- It is a free-access journal.
- Polar Data Journal is thoroughly edited using an online editing system for quick publishing.
- The journal content is reviewed by an editing committee, which will disclose the reviewer's reports in each article of a volume.

The platform of Polar Data Journal is powered by WEKO (JAIRO Cloud), which is developed and operated by the National Institute of Informatics (NII), Japan.

For more information, please visit https://pdr.repo.nii.ac.jp.

S09-P03

Operation of the infrastructure system in Arctic Data archive System

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[2]Research Organization of Information and Systems, Japan

In the Arctic Environmental Observation Center in the National Institute of Polar Research, operations began on the Arctic Data archive System (ADS) in March 2012. ADS has deployed a various Web services to promote the mutual use of scientific data and developped new Web applications since 2012. We also operate ADS's infrastracture system including the system update, renewal the hardware, and installing software. The infrastracture system has been used mainly the open source software, and these environment has been built on the virtual environment by XenServer. These hardware is the x86 PC server machine. We maintenace the system with the regulaly software updatea, regulaly backup, and monitoring with security. The hardware has the function of the availability and redundancy, because we are focus on the reliability of the system. In this 5 years, ADS has benn operated without major trouble or failure. But there are some small faults and problems of the system. In our presentation, we want to introduce the current status of ADS's infrastracture system, and provide the case study information for handling scientific data.

IUGONET Tools and Services for Upper Atmospheric Research

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We introduce the activity of Inter-university Upper atmosphere Global Observation NETwork (IUGONET) project [1], which is a Japanese inter-university project to develop the infrastructure for upper atmospheric research and promote interdisciplinary study. The project was established in 2009 by Tohoku University, Nagoya University, Kyoto University, Kyushu University, and National Institute of Polar Research, which have been conducting the ground-based network observations of the Earth's upper atmosphere, the Sun, and Planets.

We present the analysis software [2] and metadata database for the upper atmospheric data, developed by the IUGONET project. Our data analysis software is based on Space Physics Environment Data Analysis Software (SPEDAS), which is a grass-roots software written by Interactive Data Language (IDL) and was originally developed by scientists and programmers of the Space Sciences Laboratory at the UC Berkeley, the Institute of Geophysics and Planetary Physics (IGPP) at UCLA and other contributors. Since it can deal with various kinds of data from multiple satellite and ground-based missions, it is suitable for interdisciplinary study like the complex Earth's upper atmosphere. The metadata database, named IUGONET Type-A, provides one-stop web service for researchers to search data, get the information of data (metadata), view plots of data, find interesting phenomena, and interactively plot data with SPEDAS. In addition, it shows how to analyze the data and smoothly leads users to more detailed data analysis using SPEDAS. We regularly have data analysis workshops in Japan and sometimes in other countories to explain how to use our data and tools.

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January 17

Poster session

G3
Rivers, Lakes, Permafrost and Snow Cover

G4
Ice Sheets, Glaciers and Ice Cores

G7
Geospace

G8
Policies and Economy

S2
Synergies for "New Arctic" Climate Prediction, Observation and Modeling

S4
Biogeochemical Cycles and Biodiversity of Terrestrial Ecosystems under ArcticWarming

S5
Synoptic Arctic Survey – An Ocean Research Program for the Future

S14
Synthesizing Local Interactions between Permafrost and Human Societies

G03-P01

Predicting the effects of climate change on stream water temperatures across pan-Arctic river networks: a conservation perspective

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[1]Arctic Research Center, Hokkaido University, Japan
[2]University of Copenhagen, Denmark
[3]Wilfrid Laurier University, Canada

Climate change has already altered the distribution of species globally, resulting in the reshuffling of biodiversity across ecosystems, with far-reaching impacts on ecosystem functioning and human well-being. A process that is most likely to accelerate into the future. Anticipating such responses is crucial for improving adaptive conservation and management. Freshwater systems are disproportionately important both as a resource and ecological asset. Further, because of their linear dendritic arrangement, they are particularly exposed to the impacts of climate change. This situation is especially acute in the Arctic, where warming trends are currently more than doubling those at lower latitudes, and river networks drain northwards limiting elevational responses to the effects of warming. To date, however, no global assessment of the threats of climate change to Arctic rivers has been attempted. Here, we introduce a recently started collaborative effort to address this issue. Regional air-water transfer models, based on temperature data from hundreds of stream monitoring stations and catchment-level environmental predictors linked to heat transfer processes in streams, and downscaled climate projections will be used to predict future climatic changes seamlessly across the Pan-Arctic river networks (Fig. 1). Summarized in the form of easy-to-interpret and ecologically-meaningful climatic metrics, this information will be then assessed regarding the potential sensitivity of Arctic rivers given their current biodiversity, conservation (existing network of protected areas) and management (CAFF biomonitoring network) status.

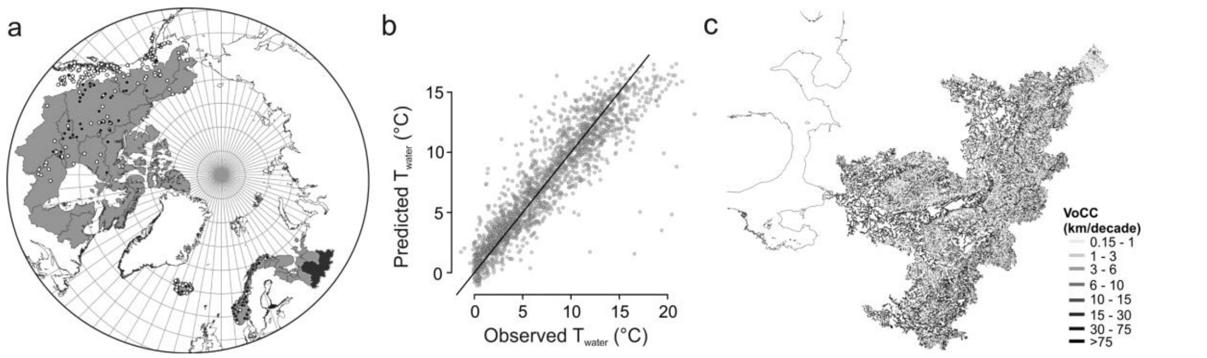

Figure 1. (a) Studied Pan-Arctic watersheds and network of monitoring stations (points on the map) used for the development of regional air-water temperature predictive models. (b) Predicted against observed mean monthly stream water temperatures during the ice-free season by a cross-validated multiple regression model using air temperature, month, latitude, elevation, distance from coast, Strahler stream order, permafrost dominance and glacier influence as predictors. (c) An example of the metrics that will be used for projecting reach-scale changes in climatic conditions within each river network (Dvina River watershed darkened in a): the velocity of climate change gives the rate of movement of isotherms along streams. Changes (1960-1990 to 2041-2060) projected for the RCP8.5 high-emission scenario (MIROC5 model).

G03-P02

Long-term trends of snow cover extent and duration in the Northern Hemisphere derived from imagery collected by polar orbiting optical satellites

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[2]*University of Toyama, Japan*
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[6]*National Institute of Polar Research, Japan*
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Long-term trends of snow cover extent (SCE) and duration (SCD) in the Northern Hemisphere (NH) were derived from the application of a consistent objective snow cover mapping algorithm to satellite-borne optical sensors (NOAA/AVHRR and NASA's optical sensor MODIS) from 1982 to the present. We estimated NH SCE (hereafter JASMES SCE) from weekly composited snow cover maps and evaluated the accuracies of snow cover detection using in-situ snow data obtained from two data sources: Global Historical Climate Network-Daily (GHCND) data provided by NOAA/NCDC and the Russian in-situ snow survey data from the Former Soviet Union. As benchmark SCE product, we also evaluated the accuracy of SCE maps from the National Oceanic and Atmospheric Administration Climate Data Record (NOAA-CDR) product. The evaluation showed that JASMES SCE has more temporally stable accuracies. Seasonally averaged SCE derived from JASMES exhibited negative slopes in all seasons which is opposite to those of NOAA-CDR SCE in the fall and winter seasons. The spatial pattern of annual snow cover duration (SCD) trends exhibited noticeable asymmetric pattern between continents with the largest negative trends over a month/three decades seen over western Eurasia.

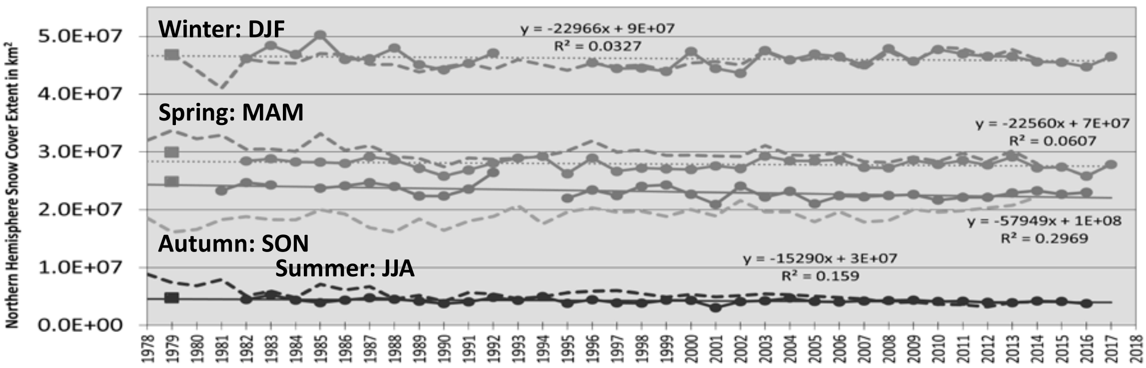

Figure 1. Time series of seasonally averaged NH SCE derived from JASMES (solid lines) and NOAA-CDR (broken lines)

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Observed asymmetric warming in the sub-arctic regions (Mongolian Plateau) and on the Qinghai-Tibet Plateau from 1961 to 2011

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The majority of the QTP and the MP are underlain by permafrost and seasonally frozen ground. We have examined trends in air temperature and freezing/thawing index for the Qinghai-Tibetan Plateau (QTP) and the Mongolian Plateau (MP) during the last 51 years. The non-parametric statistical analysis results reveal a clear picture of climatic warming in both regions. Generally the magnitudes of warming trend on the QTP and MP are similar for annual air temperature and freezing/thawing index. While the characteristics of seasonal warming are different in those two regions. The warming of QTP is mainly due to winter warming, which is consistent with the conclusions previous studies drawn. While the warming of MP is primarily caused by autumn warming, characterized by a slightly winter cooling trend during the last two decades. The different features of seasonal warming on both plateaus would be expected to result in diverse impacts on the ground thermal regime.

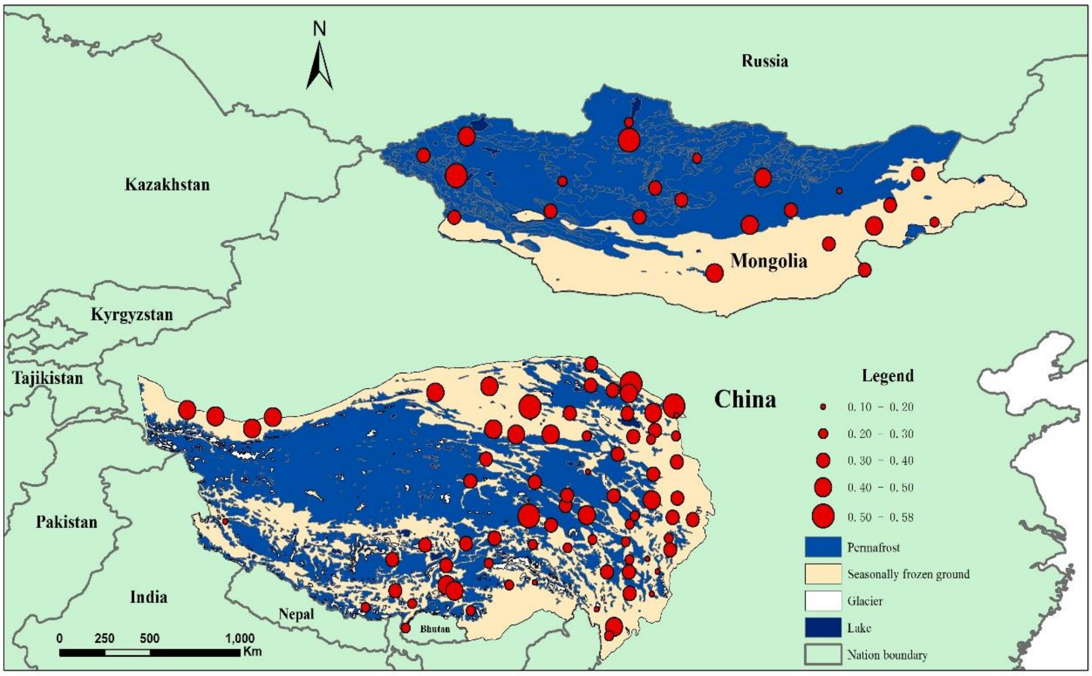

Figure 1. Permafros distribution on the QTP and MP. Spatial patterns of trends for mean annual air temperatures on the QTP and MP over the period 1961-2011.

Multiple-scaled permafrost observations over Mongolia

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[3]*Institute of Geography and Geoecology, MAS, Mongolia*
[4]*Sonic Corporation, Japan*

Mongolia is the only country where permafrost directly sustains the livelihoods of inhabitants, since discontinuous to isolated permafrost overlap considerably with springs, forest and highly productive pasture. Toward comprehensive understanding of such heterogeneous dynamics of permafrost and eco-hydrological system, we have been establishing multi-scaled observations, areal coverages of which are from point to country-wide. In this presentation we review scientific achievements resulted from these observations.

Point measurements at Nalikh and Udleg stations quantified one-dimensional fluxes of energy, water and CO2. We found importance of nonconductive heats to warm and cool active layer which is extensively distributed over dry and cold regions [1]. At the Udleg site seasonality of CO2 and energy fluxes above Larch forest growing over warm permafrost were documented [2]. By basin scaled observation at Terelj, we illustrated considerable difference in soil wetness underneath the permafrost and immediately adjacent permafrost-free slopes. Furthermore comparable energy balance measurements on these slopes indicated thermal properties of the forest soil and shading by forest cover as primary determinants of permafrost preservation [3, 4].

In order to generalize abovementioned knowledge of relation between the state of permafrost and land cover, the country-wide scaled borehole network was established. The network includes more than 80 deep (> 10m) boreholes, covering continuous, discontinuous, sporadic and isolated permafrost zones [5]. Also it provided some evidences of permafrost degradation since 1960s. The network proved that permafrost parameters (mean annual ground temperature, depth of annual amplitude, active layer thickness) are statistically significant with permafrost zones, climate and land cover types. These findings are now under application for making new maps of permafrost distribution.

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G03-P05

Suprapermafrost taliks in the Shestakovka River watershed, continuous permafrost environment, investigated by GPR and ERT techniques

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Melnikov Permafrost Institute, Russia

Continuous permafrost is usually considered as impermeable frozen ground. It is often assumed that surface flow and flow in the shallow active layer (AL) are main sources of river runoff in permafrost basins. Although existence of taliks is acknowledged, their distribution, genesis, evolution and role in surface-subsurface water interactions remain unresolved issues. The research objective is to estimate taliks distribution, depth and geometry in the Shestakovka River research watershed, Eastern Siberia, using electrical resistivity tomography (ERT) and ground-penetrating radar (GPR) geophysical techniques.

The Shestakovka River watershed with area 170 km^2 is located in 20 km to south-west of Yakutsk within the erosion-denudational slope of the ancient accumulative plain with absolute elevation of 150-280 m. The permafrost thickness is 200-400 m. The upper 40 m of the section are represented by quartz-feldspar sands with rare inclusions of silty sandy loam and loam. The climate is cold and dry with mean annual air temperature -9.5°C, precipitation 240 mm/year. Dominant landscapes are pine (47% of the watershed area) and larch (38%) forest. AL thickness in the pine forest could reach 3-4 m. Water-saturated suprapermafrost taliks were occasionally found on the gentle slopes covered by pine forests. Larch forests are characterized by cold permafrost with AL thickness up to 1 m.

To estimate the talik abundance fourteen profiles 300 m long each were selected on the gentle slopes covered by pine forests. GPR measurements in May 2017 showed that there are water-saturated suprapermafrost taliks at eight profiles out of fourteen. Typically taliks were discovered in the depth interval from 2.5 to 10 m. If assume that selected profiles are representative for pine forest landscape of the watershed we conclude that 28% of the watershed area could be occupied by taliks. The high fraction of taliks containing suprapermafrost groundwater suggests possible importance of groundwater pathways for the river runoff generation even for the small watershed in continuous permafrost zone.

Six profiles (five with taliks and one without) were selected for more time-consuming ERT measurements and repeated investigations in September 2017 when AL thickness reaches maximum. Joint interpretation of GPR and ERT results, taliks depth, geometry and relations of talik distributions to topography and landscape features will be discussed in the paper.

Understanding of groundwater storages and its seasonal dynamics could advance concepts of runoff generation that underlay hydrological, hydrogeological and permafrost modelling strategies and future projections.

Acknowledgement. The study was partially supported by Russian Foundation for Basic Research, projects No 17-05-00926, 15-35-21146 and 16-35-60082 mol_a_dk.

G03-P06

Identification and Mapping of Permafrost Using Satellite Images in the Mountainous Regions of Cryolithozone (on the Example of the Elkon Mountain in Southern Yakutia)

S.V. Kalinicheva[1*]

[1]*Melnikov Permafrost Institute SB RAS*

In the mountainous regions of the cryolithozone, the study of permafrost is complicated by a complicated dissected relief of the territory. In this connection, at the present stage of scientific and technological progress, the introduction of methods that allow remote study and research of permafrost becomes urgent. In particular, this is a method of landscape indication, the essence of which is to recognize the hidden components and properties of the landscape through physiognomic components. The relevance of this method in the study of the permafrost of mountain regions is due to the fact that the main factors (landscape components) that affect the formation of the temperature regime of rocks (on which the thawing or frozen state depends) are clearly reflected in remote sensing materials.

In this paper, we develop a technique for detecting permafrost and thawed rocks using satellite imagery, which is an algorithm for complex indication of permafrost, consisting of six indicators, such as terrain elevation, slope and exposure of slopes, snow and vegetation cover, and radiation temperature (thermal infrared radiation of the surface) recorded in the thermal channel Landsat. The last parameter (indicator) is relatively new in the study of permafrost, but not well studied.

The developed technique is suitable for research cryolithozone in mountain regions with a dissected relief. In view of this, parts of South Yakutia were chosen as the study area. For the first time, according to the proposed method, the study was conducted in the region of the Elkon mountain located in the northern part of the Aldan Shield. This method also carried out a study in the area of the Olekma-Charsky plateau. The repeated approbation of the developed technique confirmed the possibility of its use for research and mapping of permafrost in the mountainous regions of the cryolithozone.

Effect of surface snow albedo on surface air temperature in northern high-latitude regions

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[1] *Japan Agency for Marine-Earth Science and Technology, Japan*

In northern high-latitude regions, because of snow cover, surface albedo during fall-spring seasons is large. As snow cover decreases due to global warming, global warming may be intensified by snow- albedo feedback. Thus, it is important to examine and understand the role of the snow albedo in the climate.

In this study, we investigates the effect of snow albedo on surface air temperature in northern high-latitude regions. We have a sensitivity experiment using a climate model (MIROC 5.2), in which the snow albedo is made smaller than in the control experiment. Then, we analyze the result of the sensitivity experiment and evaluate the role of snow albedo.

Experimental results show that when the snow albedo was approxmately 0.1, the surface temperature in spring increased by more than 10 ° C in the northern high-latitude regions compared to the control experiment (Fig. 1). In addition, as the snow-covered area retreated to the north early, it resulted in a relatively high temperature rise in the mid latitude region such as the southern part of Siberia.

This study is supported by JSPS KAKENHI 16K01230, Integrated Research Program for Advancing Climate Models (TOUGOU) from the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan, and the Arctic Challenge for Sustainability (ArCS) project. The Earth Simulator at JAMSTEC was employed to perform the MIROC simulations.

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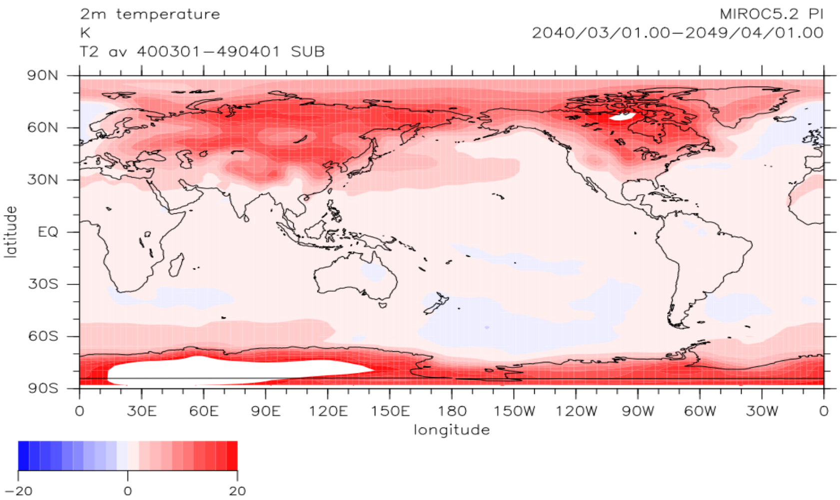

Figure 1. Difference of monthly mean surface temperature in March between low snow albedo run and control run. Unit: [K]

Quantifying Permafrost Extent and Condition at Department of Defense Installations in the Arctic

C.A.J. Edlund[1*], D. Prigge[2]

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The United States Department of Defense (DoD) is planning over $500M in military construction on Eielson Air Force Base (AFB) within the next three fiscal years. This construction program will expand the footprint of facilities and change the storm water management scheme at Eielson AFB, which will have second order effects on the underlying permafrost layer. These changes in permafrost extent will drive engineering decision making and will help shape the overall strategy for military readiness in the Arctic. Although many studies have attempted to predict climate change induced permafrost degradation, very little site-specific knowledge exists on the anthropogenic effects to permafrost at this location. In 2016, the permafrost degradation rates at Eielson AFB were modeled using the Geophysics Institute Permafrost Laboratory (GIPL) 2.1 model and limited available geotechnical and climate data. Model results indicated a degradation of the discontinuous permafrost layer at Eielson AFB of up to 7 meters in depth over the next century.

In order to further refine an understanding of the geophysics at Eielson AFB and help engineers and commanders make more informed decisions on engineering and operations in the arctic, this project established two permafrost monitoring stations near the future construction sites. Installation of the stations occurred in July 2017. Permafrost was located and characterized using two Electrical Resistivity Tomography surveys, as well as direct frost probe measurements. Using this data, the research team optimized the placement location and depth of two long term ground temperature monitoring stations, and then installed the stations for data collection. The data set generated by these stations are the first of their kind at Eielson AFB, and represent the first systematic effort in the DoD to quantify permafrost condition before human activity in order to fully understand the effect of that human activity in the future.

Annual variation of bare ice extent on the Greenland Ice Sheet from 1979 to 2016

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Surface albedo reduction on the Greenland Ice Sheet (GrIS) has been remarkable in recent years. Expansion of bare ice area is one of the factors for significant darkening on the edge part of the GrIS surface. The expansionary trend of the bare ice extent has been revealed from the analysis using MODIS satellite images (Shimada *et al.*, 2016). However, the behavior of the GrIS surface state before the 2000 has not been investigated. In this study, we aim to investigate the annual variation in the bare ice area from 1979 using a long-term satellite data set. We used daily composite reflectance data sets from AVHRR and MODIS described in Hori *et al.* (2017). The reflectances of AVHRR were corrected for the sensor gain degradations. The near-infrared reflectance ($\lambda = 0.86\mu m$) was used for bare ice detection. We investigated the difference of the result revealed with the same threshold in the near-infrared reflectances between the two both satellite data sets. Figure 1 showed the variations of the monthly maximum bare ice extent derived from MODIS and AVHRR from April to September in 1979 to 2016. In the period of duplicate observation (during 2000-2008), the bare ice extent derived from MODIS (E_{BM}) was smaller than the bare ice extent derived from AVHRR (E_{BA}). The root mean square error was 65,958 km^2 and the bias was -35,262 km^2. There is a significant correlation between E_{BM} and E_{BA} ($r = 0.92$, $P < 0.01$). These results shows that the AVHRR could overestimate the bare ice extent. In order to analyze the long-term variability, the threshold has to be adjusted and the bias has to be removed.

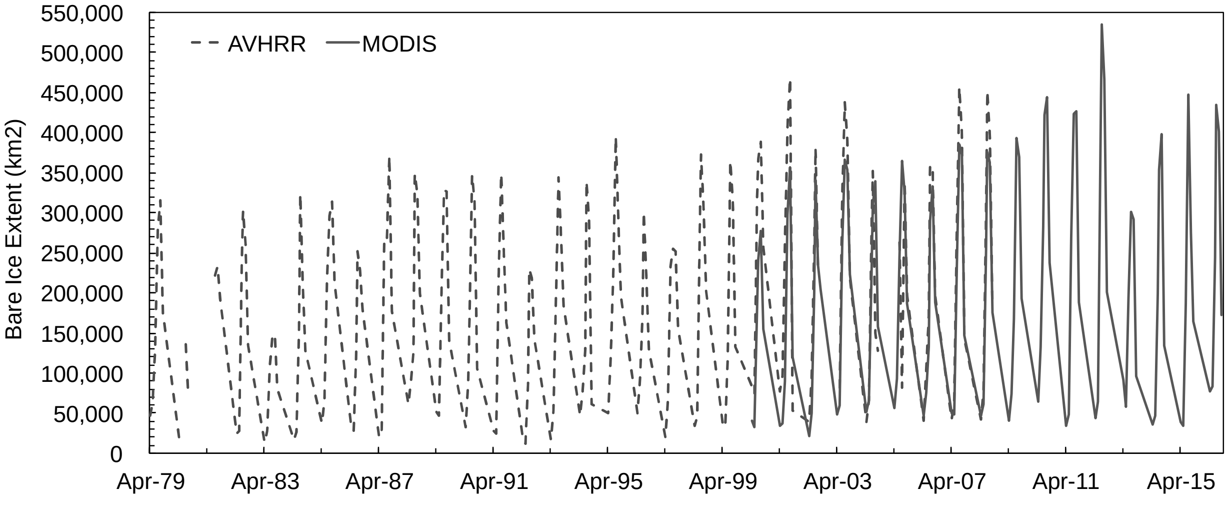

Figure 1. Monthly maximum bare ice extent variations derived from MODIS and AVHRR

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G04-P02

Floods of a proglacial stream in Qaanaaq, northwestern Greenland

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Increase in runoff from the Greenland ice sheet and peripheral ice caps have great influence on coastal environment. However, only a few studies have focused on its impact on the human activity in Greenland. On 21 July 2015 and 2 August 2016, a proglacial stream flooded in Qaanaaq, a village in northwestern Greenland, which resulted in the destruction of a road between the village and Qaanaaq Airport. These floods were caused by increased runoff from the nearby Qaanaaq Glacier. Possibly, these floods are the results of recently changing climate in the Arctic region. In this study, we investigated these floods in 2015 and 2016 by using meteorological data observed at the village, Qaanaaq airport and 944 m a.s.l. of the glacier [1], and the output of regional climate model NHM-SMAP [2]. Model output at 5 km mesh grid points was downscaled to a 300-m grid, using a previously proposed method [3]. The result is used to estimate daily runoff from Qaanaaq Glacier.

The flood on 21 July 2015 resulted from a combination of the substantial amount of meltwater from Qaanaaq Glacier and the lack of snowpack in the upper part of the glacier. The highest temperature in 2015 was observed at Qaanaaq airport and there was no rainfall on that day. At the upper part of the glacier, the greatest amount of melting in 2015 was calculated on that day by the model. In 2015, snow at 944 m a.s.l. of the glacier disappeared earlier than in 2013–2016. The lack of snowpack in the upper region was a likely reason of the greater amount of runoff because less amount of meltwater was absorbed by snowpack. Snow accumulation in a period of 2014/2015 was less than the other periods in 2012–2016 [1], and it is a possible reason of the early disappearance of the snow. Runoff computed for 21 July 2015 was the second greatest in 2015. The flood on 2 August 2016 resulted from substantial amount of rainfall. Daily precipitation of 89.6 mm with hourly maximum of 23.4 mm was recorded at the village on that day. This hourly rainfall was the greatest since the observation started from June 2014. The rainfall probably covered a large part of the glacier because the model calculated the largest daily rainfall in 2016 at the upper part. Estimated daily runoff on the flood day was the third largest in 2016.

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Glacier-ocean interaction: oceanographic observations in fjord near a calving front of Bowdoin Glacier, northwest Greenland

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The Greenland ice sheet discharges freshwater into the ocean through land- and marine-terminating outlet glaciers. Catchment areas of marine-terminating outlet glaciers cover 88% of the Greenland Ice Sheet [1]. Because of such large scale, the corresponding discharge is of pivotal importance for coastal environments of Greenland. The boundary region between a glacier and a fjord is an important area to understand ice sheet/glacier-ocean interaction. On one hand, this is there the ocean heat contributes to subaquaous melt of the glacier calving front. On the other hand, this is there glacial meltwater has a strong impact on the chemical material cycle and marine ecosystems of the fjord. Despite the importance, the ice sheet/glacier-ocean interaction in Greenland is not yet well understood because of the difficulty of oceanographic observations in this boundary region. In the summer 2017, we conducted oceanographic observations in Bowdoin Fjord in northwestern Greenland. The calving front of the 3-km-wide Bowdoin Glacier is located in a fjord 210 m depth [2]. We installed temperature, conductivity, and pressure sensors in the fjord directly from the edge of the calving front, by lowering the sensors using 200-m long cables. The instruments successfully recorded changes in water properties of the fjord at the boundary of the glacier for ten days (Figure 1). Fjord water was sampled for chemical analysis and hydrographic data were collected near the calving front using a ~5-m long boat. We also sampled zooplankton with a ROV (Remotely Operated Vehicle) and deployed a mooring system in the fjord approximately 1 km off the calving front. Here we present an overview of research activities in this summer 2017.

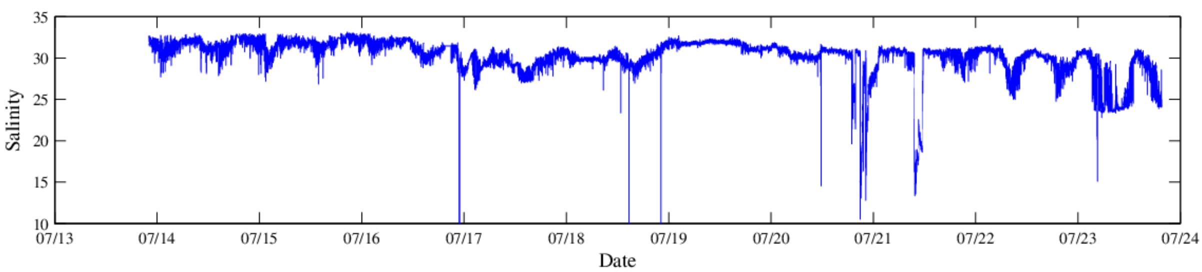

Figure 1. Salinity at a depth of 5 m in the fjord in front of Bowdoin Glacier.

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Greenland Ice Sheet Monitoring Network (GLISN) project and global seismology

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The Greenland Ice Sheet Monitoring Network (GLISN) project[1]—a collaboration between Canada, Denmark, France, Germany, Italy, Japan, Norway, Poland, South Korea, Switzerland, and the United States—provides real-time broadband seismological observations to help address critical, poorly understood aspects of the Arctic system (Figure 1). Geodetic observations are also included at selected stations. Seismic data from GLISN record changes at high temporal resolution and reflect deformation and structures internal to the ice and solid Earth. These data complement existing observations from satellite and airborne remote sensing, ice-penetrating radar, and GPS geodesy. Launched in 2009, the GLISN project completed installation of all 33 initially planned seismic stations in August 2013. Most GLISN stations in Greenland are installed on bedrock along the ice-free coast at sparsely populated settlements to take advantage of existing power and communications infrastructure. Four stations are installed in the ice. Additional stations surrounding Greenland—in Canada, Iceland, and on several Norwegian islands—allow scientists to gain a broad view of Greenland's structure and changes in the ice. The GLISN project has already provided valuable data for multiple studies. Data from the network (Figure 1) have been used to improve analysis of glacial earthquakes, which result from calving events of about 1 cubic kilometer each. GLISN stations have also been used in automatic detection of calving events by measurement of tilt associated with seiches (standing waves) in the fjords where many glaciers terminate.

Figure 1. GLISN network

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Deglaciation history of the Greenland ice sheet inferred from Glacial Isostatic Adjustment modelling

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Satellite geodetic observations (gravity change observed by GRACE, crustal uplift rate by GNSS and large-area mapping of ice flow using InSAR) are powerful tools for estimating precise ice sheet mass balance [e.g., 1]. Recent results from the analysis of these geodetic data show that the melting rate of the Greenland Ice Sheet (GrIS) is faster than previously thought [e.g., 2]. However, since the geodetic and geographical observables related to solid-Earth sciences include the process of ongoing viscoelastic relaxation in response to redistribution of ice and water masses on the Earth's surface, which is called as glacial isostatic adjustment (GIA), the separation of GIA component from data using the numerical modelling technique is important for the reasonable interpretation on ice sheet change derived from these observations. On the other hand, ice elevation change around the summit of GrIS deduced by ice core analysis also include the crustal deformation induced by ice thickness change through last deglaciation [e.g., 3]. In addition, crustal deformation in Greenland has been influenced by not only GrIS change and also Laurentide ice sheet history expanded in North America. So precise estimation of crustal deformation indeced by ice load change is also very important for interpletation of the ice height change derived from ice core analysis.

In this presentation, we carry out the GIA modelling to evaluate the crustal deformation in Greenland. In comparison between predictions and observations, we show the effect of past and present changes of GrIS on the geophysical signals which include the present-day uplift rate, gravity change, geomophological indicators of past sea-level and elevation changes around the summit of GrIS deduced by ice core analysis. Moreover, we discuss the consistent models of deglaciation history of the GrIS to explain geophysical and glaciological observations.

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G04-P06

Design of a climate/ice-sheet coupled model (MIROC-IcIES) for Greenland ice-sheet simulation

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Numerical modeling is an important technique for projection or reconstruction of ice sheets under past or future climate changes. Since climate and ice-sheet systems interact each other, development of a numerical model to couple a climate model and an ice-sheet model is expected recently, as well as stand-alone models. The recent intercomparison project of ice-sheet models ISMIP6 [1] includes a protocol of intercomparison of coupled models for future projection of hundred-year scales.

We are developing a coupled model of a climate model MIROC and an ice-sheet model IcIES. In this study a coupling design of the model is described. A temperature-index model (such as the positive degree-day model) is introduced to compute the surface mass balance on the ice sheet at first, which will be expected to replace by land-surface models. Changes in discharge from the ice sheet and ice-sheet topography are introduced in the climate component. Preliminary results will be presented to study the effect of the interaction.

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Changes in the Greenland Ice Sheet 1980-2014: Model results versus observations

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Climate change is affecting the melt and dynamics of the Greenland ice sheet resulting in increasing mass loss from the ice sheet. Many different processes influence the ice melt and dynamics and estimates of future ice loss rely on the ability of models to capture the various processes to a satisfying degree. Given the intricate structure of the outlet glaciers of the Greenland ice sheet, model resolution has proven to be an important element in order to achieve satisfying flow fields [1]. The quality of the model drivers, that is, fields of temperature and surface mass balance, is essential as well in order to provide realistic conditions for the ice sheet model. Data from climate models is a common method to obtain drivers for an ice sheet model. However, climate model resolution remains a challenge, particularly in terms of correctly distributing orographic precipitation. Significant changes in precipitation patterns over Greenland are quite evident when changing the resolution of a regional climate model due to increasingly accurate representations of e.g. coastal mountains [2]. In this study, the Greenland ice sheet is simulated at very high resolution (2km) with the Parallel Ice Sheet Model (PISM) [3], driven by temperature and surface mass balance fields from the regional climate model HIRHAM5 [4] at 5km resolution. The regional climate model HIRHAM5 is driven by ERA-Interim reanalysis data and is used to force the ice sheet model PISM from 1980 to 2014 with monthly fields of 2m temperature and surface mass balance. The simulated changes in ice sheet extent and dynamics are compared to observational data sets from a number of satellites in order to validate the model performance. At this temporal and spatial resolution, seasonal and annual changes in ice mass and dynamics are visible and comparisons with various observational datasets are an indispensable tool for pinning down proper model configurations in terms of e.g. bedrock hydrology, thereby making it possible to firmly anchor model projections of future ice loss in an observational basis.

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Sea surface temperature changes during the Last Glacial Maximum: A model-data comparison

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Over the Last Glacial Maximum (LGM, ~21ka BP), the presence of vast Northern Hemisphere ice sheets caused abrupt changes in surface topography and background climatic state. However, there is a large uncertainty of the LGM ice sheet reconstructions, especially the Laurentide Ice Sheet (LIS). Here to assess the role of LIS uncertainty on the LGM climate, we have performed simulations with 6 different LIS reconstructions in an Earth System Model (COSMOS). Model–data comparisons can help to understand the origin of their mismatches in both reconstruction of past climate change and model simulations, and thus give a test for climate projections as derived from climate models. The sea surface temperature (SST) of the LGM as simulated by climate models have been compared with the sea surface temperature reconstruction by MARGO project members, (2009) based on microfossil-based (planktonic foraminifera, diatom, dinoflagellate and radiolarian) and geochemical (alkenones and planktonic foraminifera Mg/Ca) palaeothermometers from marine temperature proxies. Significant mismatches between modeled and reconstructed SST have been observed. This mismatch exists even if we take into account seasonality and different water depths at which the recording organisms may have lived. Among the five LIS reconstructions, Tarasov LIS reconstructions show the highest correlation with reconstructed SST. Our results show that Mg/Ca show winter biased and foraminifera, dinoflagellates and alkenones are summer biased. Mg/Ca records fit best with surface layer. The rest represents subsurface layer. Therefore, it has been speculated that considering different habitats depth and growing seasons of the planktonic organisms used for SST reconstruction could provide a better agreement of proxy data with model results on a regional scale and can reduce model–data misfits is determined. Observed mismatch between modelled and reconstructed climate is related to seasonal and depth bias.

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G04-P09

Multibeam bathymetric and sediment profiler evidences for pockmarks and ice grounding scours on the Chukchi borderland and Beaufort Sea

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Multibeam bathymetry and subbottom profiler data collected from the Japanese R/V Mirai in 2008 provide convincing evidence for ice grounding scour and mega pockmarks on the Chukchi borderland and Beufort Sea, Arctic Ocean. The data presented here were collected hull-mounted multibeam echo sounder and 12 kHz subbottom profiler. The multibeam bathymetry soundings were compiled into digital terrain models with a Polar Stereographic projection and its grid resolution of the digital terrain models are 25 to 100m. The size of pockmarks and scours are measured on the digital terrain models to determine pockmarks diameter and scour width. We also measured scour direction and displayed them as a rose diagram. In this study, we obtained a bathymetric dataset of approximately 610000 km2 in the area. The running time of the seabeam system was more than about 700 hours. Seabeam data were converted and visualized by CARIS (Geospatial Software Solutions) and ArcGIS (ESRI).

G04-P10

Sea ice variability for past 155kyr including the last interglacial (Eemian) on the Chukchi Sea; Implication for future warming Arctic

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Records of the spatial and temporal variability of Arctic Ocean sea ice are of significance for understanding the causes of the dramatic decrease in Arctic sea-ice cover of recent years. However, the late Pleistocene sea ice history of the Arctic is still poorly understood. In this context, the newly developed sea-ice proxy IP_{25}, a monounsaturated highly branched isoprenoid alkene with 25 carbon atoms biosynthesized specifically by sea-ice associated diatoms and only found in Arctic and sub-Arctic marine sediments, has been used to reconstruct the recent spatial sea-ice distribution. In our study, the sediment core was collected in water depth of 998 m of Northwind ridge in the Chukchi Sea by R/V Mirai and collected core length was about 9 m. The age model was reconstructed by foraminiferal δ18O and their age of core bottom reached to 155 kyr [1]. For the first time, a comprehensive data of sea ice proxy IP_{25} was obtained from 22 to 155 kyr where was probably characterized by a permanent ice cover until early last century. Obtained IP_{25} data showed variable sea ice conditions over all periods, even in the Eemian warm period of 125 kyr which is similar to future warming Arctic condition. That is, average temperature on the Earth in the Eemian were rather enhanced – probably several degrees above today's level. Therefore, The Eemian is often used as a model for contemporary climate change to test further future warming Earth climate system. Our IP_{25} data from the Eemian may help our understanding for mechanism of contemporary sea ice variability and future warming Arcitic condition.

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G04-P11

General characteristics of a high-accumulation dome ice core, southeast Greenland

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On May 2015, we drilled a 90.45 m ice core in a high accumulation area of the southeastern Greenland Ice Sheet. The drilling site (SE-Dome; 67.18°N, 36.37°W, 3170 m a.s.l.) is located 185 km north of the town of Tasiilaq in southeastern Greenland [1]. Then we measure physical and chemical properties of the SE-Dome ice core. Based on the measurements, we show the general characteristics of the SE-Dome ice core. I) As for dating of the ice core [2], we propose a dating method based on matching the $\delta^{18}O$ variations between ice-core records and records simulated by isotope-enabled climate models. We applied this method to a $\delta^{18}O$ record from the SE-Dome ice core. The close similarity between the $\delta^{18}O$ records from the ice core and models enables correlation and the production of a precise age scale, with an accuracy of a few months. II) As for physical property [3], the ice was –20.9 ºC at 20-m depth. The close-off density of 830 kg m^{-3} occurs at 83.4–86.8-m depth, which is about 20-m shallower than that obtained from empirical models, indicating that the firn with a higher density is softer than that from empirical result. We interpret that the high accumulation rate creates a high overburden pressure in a short time. The relative softness of the firn may arise from 1) there being not enough time to form bonds between grains as strong as those in a lower accumulation-rate area, and similarly, 2) the dislocation density in the firn being relatively high. III) As for chemical property [4], we measured the major ion fluxes, and obtained records of annual ion fluxes from 1957 to 2014. We find a high average NO_3^- flux (1.13 mmol m^{-2} yr^{-1}) in the ice core, which suggests a negligible effect from post-depositional NO_3^- loss, indicating the SE-Dome region is an excellent location for reconstructing nitrate fluxes. For the non-sea-salt (nss) SO_4^{2-} and NH_4^+ fluxes, a decreasing and increasing trend from 1970 to 2010, respectively, tracks well with the anthropogenic SO_x and NH_3 emissions. In contrast, the decadal trend of NO_3^- flux differs from the decreasing trend of anthropogenic NO_x emissions.

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G04-P12

Dust analysis in a high-accumulation dome ice core, southeast Greenland

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On May 2015, we drilled a 90.45 m ice core in a high accumulation area of the southeastern Greenland Ice Sheet (67.18°N, 36.36°W). The ice core (hereafter, SE-Dome ice core) has characteristics of high accumulation rate (about 1.0m yr^{-1} w.e.) [1]. High accumulation rate enables to reconstruct seasonal fluctuation of paleoenvironment. The non sea salt (nss) Ca^{2+} flux of the SE-Dome ice core is nearly constant from 1957 to 2000, but then trends upward till the present [2]. The relatively high $nssCa^{2+}$ fluxes after 2000 may link to a local source, such as an increase in land-area exposure around the southeastern Greenland coast [2]. In this study, we measure dust concentration and size distribution with seasonal resolution, and compare them with $nssCa^{2+}$ concentration. The measurements of dust concentration and size distribution were performed using a Multisizer 3 Coulter Counter (Beckman Coulter, USA) with a 30 μm diameter aperture tube (size ranges: 0.662-18.0μm). The blank concentration using ultra-pure water (18.2MΩ・cm) is 4.23±2.26 ppb (n = 88). Figure 1 shows seasonal fluctuations during 1990/1991 (Fig. 1a) and 2009/2010 (Fig. 1b). The dust concentrations in 2009/2010 are higher than in the 1990/1991, supporting $nssCa^{2+}$ increasing trend since 2000. The fluctuation profiles show dust concentration peaks in spring with $nssCa^{2+}$ peaks (gray bars in Fig. 1). However, many dust peaks are found in other seasons without $nssCa^{2+}$ peaks. In the symposium, we will discuss the discrepancy between seasonal dust and $nssCa^{2+}$ concentrations.

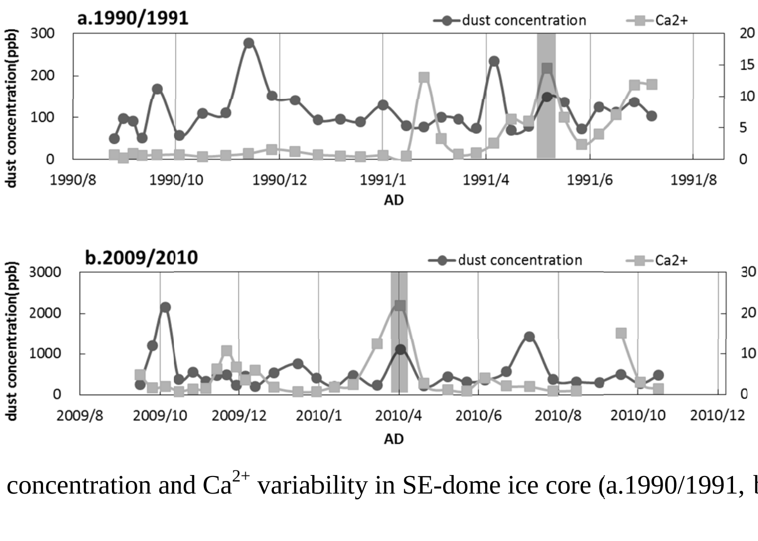

Fig.1 dust concentration and Ca^{2+} variability in SE-dome ice core (a.1990/1991, b.2009/2010)

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G04-P13

Fluctuations of total metal concentrations recorded in an ice core from southeast dome, Greenland

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Past environmental change can be estimated by ice core records. In this study, we investigated fluctuations in the total concentration of metals in the high accumulation ice core drilled in southeast dome, Greenland, to reconstruct the past 60-years of environmental change in the Arctic. A 90.45 m long ice core was cut at 5 cm intervals in order to measure the total (dissolved + particulate) metal concentration. The particulate matter in the sample was decomposed by the microwave acid decomposition method. Then Na, Mg, Ca, Al, Fe, Mn, Sr and Ba concentrations were measured by ICP-MS. The relative standard deviation of analysis was within 5%. 185 samples were analyzed across whole length of core (Figure.1). Core age was obtained by a dating method of [1]. Within the measurement period from 1955 to 2015, there were three remarkable trends: (1) an increase in background value from 1955 to 1975, (2) abrupt peaks in 1992 and 2010, and (3) a sharp rise in concentration from 2010 to 2015. These trends are generally common among all the elements. The change in (1) was thought to be due to the large release of anthropogenic substances to the atmosphere in this period. Since coal use was popular at this time, it is considered that the metal component in the fly ash generated by a combustion of coal pushed up the background value of the total metal concentration. The two peaks in (2) coincided with the eruption of Mt. Pinatubo in 1991 and the eruption of Mt. Eyjafjallajökull in 2010, respectively. The standard deviation of the Mg / Al ratio and the Ca / Al ratio in the two peaks was smaller than the standard deviation at other times, so that the supply of substances from a specific source area was greater at the peaks. As for (3), a rapid retreat of glaciers has been reported in Greenland in recent years [3]. Therefore it is considered that the supply of local terrestrial materials following the exposure of the coastal area due to retreat of glaciers contributes to this abrupt change.

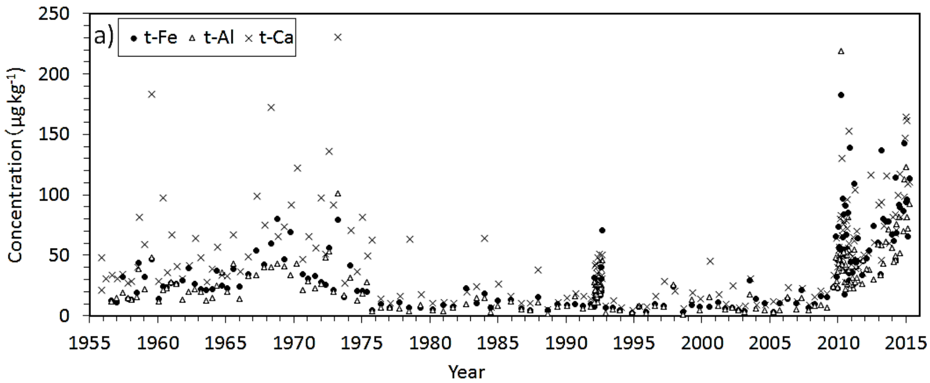

Figure 1. Fluctuations of t-Fe, -Al, -Ca in the ice core.

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Recent annual snow depositions and seasonal variations of major ion concentrations in snow pits at the EGRIP, Greenland

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East Greenland Ice Core Project (EGRIP), which is an international ice coring project led by University of Copenhagen in Denmark, commenced in 2015 to clarify the variations of climate and ice sheet in Greenland. We are participating in the project under the Arctic Challenge for Sustainability project (ArCS), and cooperative research is underway with various countries. In 2016, we dug two pits with depths of 4.02 and 3.18 m at the EGRIP camp (75°37′N, 35°59′W) to estimate recent annual snow depositions and examine seasonal variations of major ion species in the snow samples. Snow sampling and snow density measurement were carried out at 0.03 m interval in those pits. We analyzed those snow samples for Na^+, K^+, NH_4^+, Mg^{2+}, Ca^{2+}, Cl^-, NO_3^-, SO_4^{2-}, methanesulfonic acid (MSA) and stable isotopes of water ($\delta^{18}O$ and δD). Clear seasonal variations in the $\delta^{18}O$ and δD values were observed in the depth profiles, which suggested that snow had accumulated regularly every year. Also, the seasonal cycles of stable isotopes indicated that the 4.02 and 3.18 m deep pits included snow depositions corresponding to ten years from 2006 to 2016 and seven years covering 2009–2016, respectively. The annual snow depositions ranged from 58 to 202 mm water equivalent (w.e.), showing the mean value of 138 mm w.e. for the 4.02 m deep pit. The mean value in 2009–2016 was 146 mm w.e. On the other hand, the deposition for the 3.18 147 deep pit varied from 126 to 188 mm w.e., averaging 147 mm w.e. The mean values of the depositions examined in this study were higher than the average value of 0.11 m ice equivalent for the period 1607–2011 estimated by an ice core study in the same region [1]. Seasonal variations of concentrations in the major ion species were observed, which were similar to those previously reported for Greenland [e.g. 2-3]. The concentrations of Na^+, K^+, NH_4^+, Mg^{2+}, Ca^{2+}, Cl^-, SO_4^{2-} recorded an annual peak in the layers between winter and the next summer. Concentrations of NO_3^- showed one peak in summer, while occasionally appearing another peak in winter to spring layers. In addition, concentrations of MSA appeared one peak in late summer to autumn.

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G04-P15

Variations in mineralogy of dust in an ice core obtained from Northwestern Greenland

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Snow and ice on glaciers and the ice sheet in the Arctic contain windblown mineral dust derived from local sediments as well as distant deserts. Dust deposited on the ice sheet in the past can be obtained by ice core drilling, and the variations in its sources and transportation processes can be reconstructed by particle analysis of ice cores. In this study, we analyzed morphology and surface chemistry of mineral dust particles in an ice core drilled in Northwest Greenland with Scanning Electron Microscope (SEM, QUANTA FEG 450) and Energy Dispersive X-ray Spectrometer (EDS).

The ice core was drilled at the SIGMA-D site (N77°64', W59°12' [1]) of 2100 m a.s.l. in 2014. The length is 222.72 m and the estimated age at 113 m depth is 350 years before present . The ice samples were collected every five years in plastic bottles and freeze dried on a polycarbonate filter to concentrate micro-particles. Then, the filter was coated with platinum (Pt) for SEM analysis.

SEM-EDS analysis revealed that the silicate minerals were most dominant insoluble particles in the ice core. Here we report the temporal variations in size distributions and compositions of the minerals.

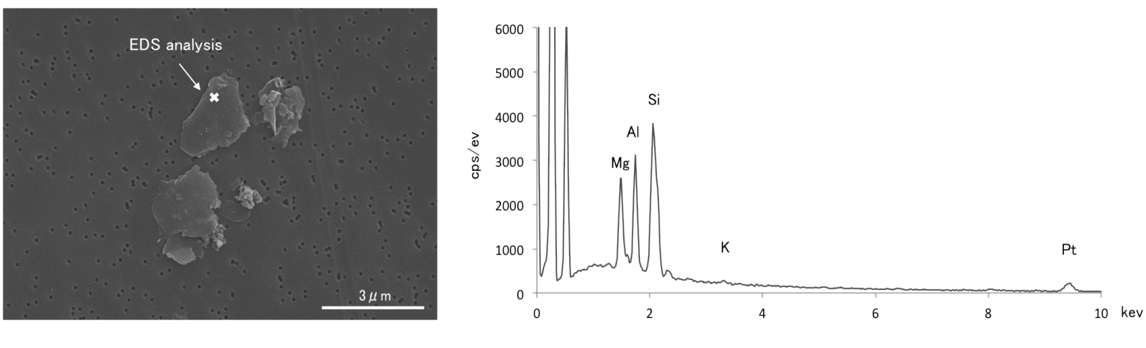

Figure 1. SEM image and EDS spectra of mineral dust in SIGMA-D ice core

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G07-P01

Toward Cutting Edge Atmospheric and Geospace Science in the Arctic with EISCAT_3D: Kickoff of the Next-Generation Incoherent Scatter Radar Project

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The European Incoherent Scatter (EISCAT) radar system in northern Feno-Scandinavia and Svalbard has been playing a pivotal role in advancing cutting edge sciences in various area including atmospheric, ionospheric and geospace studies, space weather and global change. EISCAT_3D is the major upgrade of the existing EISCAT mainlamd radars, with a multi-static phased array system composed of one central active (transmit-receive) site and 4 remote receive sites to provide us 50-100 times higher temporal resolution than the present system. The core site will transmit signals at 233MHz with about 10MW power, and all five sites will have sensitive receivers to detect the returned signal using phased-array antenna with on the order of 10,000 elements. The construction of EISCAT_3D is scheduled to implement by 4-staged approach, starting from the core site with half tranmitting power about 5MW at Skibotn, Norway and 2 receiving sites at Kaiseniemi, Sweden and Karesuvanto, Finland for the 1st stage. The transmitter will be upgraded to full-scale of 10MW at 2nd stage, and another receiving sites will be constructed at Andoya, Norway and Jokkmokk, Sweden for the 3rd and 4th stages respectively.

The EISCAT associate member countries have been trying to secure their national fundings, applying to the national roadmap and budget proposal through their funding agencies. By 2015, Sweden, Norway and Finland have successfully allocated their national fundings for the construction of the 1st stage, and the UK decided a funding commitment in April 2017. After careful examinations over possible funding scenarios, the EISCAT Council has finally decided on 1 June 2017 to start the implementation of the 1st stage of EISCAT_3D from 1 September 2017 to be completed by the end of 2021 including the commissioning of the radar system.

The EISCAT_3D program in Japan was applied to the Master Plan 2017 call by the Science Council of Japan as a part of the integrated program: ’Study of Coupling Processes in the Solar-Terrestrial System’ (PI: Prof. T. Tsuda, ROIS/Kyoto Univ.), and has been successfully granted as one of 28 high-priority programs of Master Plan 2017. While applying funding proposals for EISCAT_3D to the Ministry since 2014, the National Institute of Polar Research started development of transmitter power amplifiers (SSPAs) to provide in-kind for the 1st stage of EISCAT_3D. As of September 2017, 18 SSPAs developed by NIPR have already been installed in the test sub-array system at the EISCAT Tromso site. In this paper, we will overview the recent progress on the project including our development on the EISCAT_3D transmitter SSPAs.

G07-P02

Multi-instrument observation of an isolated substorm and associated phenomena

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We studied an isolated substorm observed during the first campaign of Arase (ERG) satellite and ground-based coordinated observations. This is a rare case study of the simultaneous conjugate observation of whistler-mode chorus waves in the magnetosphere, diffuse/pulsating auroras and cosmic noise absorption (CNA) in the ionospehre, and polar mesosphere winter echoes (PMWEs) in the mesosphere. The isolated substorm occurred around 04:00 UT on March 21, 2017 in association with a southward Bz excursion during the arrival of a corotating interaction region (CIR). Several phenomena related to the substorm were observed with various instruments on board the Arase satellite and on the ground at Husafell (HUS; 65.5-degree MLAT and UT ~ MLT at HUS), Iceland, and its geomagnetic conjugate station, Syowa (SYO), Antarctica. The diffuse and pulsating auroras were observed from 04:30 UT to the sunrise by an all-sky imager at HUS. CNA that generally occurs in the ionospheric D region due to the energetic electron precipitation (E > several tens of keV) was simultaneously detected with the riometers at both HUS and SYO. In addition, PMWEs were also observed around 75 km altitude with the PANSY radar at SYO. In the magnetosphere near the magnetic equator, whistler-mode chorus waves were detected at 04:45-06:45 UT in the frequency range of 0.3 - 3 kHz at Arase. We discuss possible scenarios to quantitatively explain these phenomena observed during the substorm in terms of the coupling among solar wind, magnetosphere, ionosphere, and mesosphere.

G07-P03

Periodicity of PsA main pulsation and burst of chorus: a statistical comparison

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Pulsating aurora (PsA) is a kind of diffuse aurora which switches on and off with a period ranging from a few seconds to a few tens of seconds by quasi-periodic electron precipitation from the magnetosphere. Previous studies have suggested that the temporal variation of PsA is caused by the wave-particle interaction between whistler-mode chorus waves and high energy electrons in the magnetosphere. Especially, it has been indicated that there is one to one correspondence between the amplitude variation of the chorus waves and the luminosity modulation of PsA. In the past, however, statistical studies on the correspondence between the periodicities of the chorus waves and PsA have not yet been conducted due to the lack of high time resolution satellite/ground-based measurements.

To compare the chorus wave amplitude and the luminosity variation of PsA in the statistical fashion and confirm the relationship between these two phenomena, we perform a statistical analysis of the periodicities of PsA and chorus waves by using high time resolution ground-based and satellite observations.

For this purpose, we make use of All-skyWATEC Imager (AWI) which has been operative in Tromso, Norway (69.6N, 19.2E) and EFW/EMFISIS sensors onboard the Van Allen Probes (VAPs) satellites. AWI is composed of small high sensitivity cameras (WAT-910HX), fish-eye lens, and optical filters which have different transparent wavelengths. All-sky auroral images are taken with a temporal resolution of 1-2 Hz. The two wave sensors onboard the VAPs provide so-called filter bank data (FBK data) which has a temporal resolution of 8 Hz. Because of its high time resolution data acquisition, the FBK data enable us to analyze the periodicity of burst of chorus.

In the statistical analysis, we have employed all-sky images taken from November 2010 to March 2013 in Tromso, and the EFW/EMFISIS FBK data obtained from June 2014 to January 2015. We computed the average and mode period of the main pulsation of PsA, and they were estimated to be 15.6 sec and 9.0 sec, respectively. We also derived the distribution of the modulation period which has two peaks at 7.0 - 12.0 s (Peak 1) and 14.0 - 21.0 s (Peak 2). We find that the periodicity of PsA is not dependent on their shape and luminocity. It was also indicated that the period of Peak 2 becomes slightly longer in the later MLT sector. Regarding the statistics of chorus burst, we analyzed a few chorus events by using the FBK data, and found that the periodicity of the chorus bursts shows good agreement with the periodicity of main pulsation derived by the current statistics. We will derive the average and mode period of chorus bursts and identify the distribution of periodicity in the statistical fashion.

In the presentation, we discuss the casual relationship between PsA and chorus burst based on the statistical results.

G07-P04

Electric filed modulations induced by auroral patches observed with EISCAT and KAIRA radars

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A pulsating aurora (PsA) is a quasi-periodic modulation of the auroral luminosity with a period from a few seconds to a few tens of seconds. It is well known that the intensity of the PsA is typically excited by the precipitation of electrons in the energy range from a few keV up to a few tens of keV. The high energy electrons release their energy into the ionosphere by modulating the ionospheric parameters such as electron density. In a previous study, ion velocity variations harmonized with PsA were observed by SuperDARN radar. The main cause behind this phenomenon has been considered to be the polarization of the electric field, which is generated by the enhancement of the ionosphereic conductance inside PsA patches. A previous EISCAT radar observation has revealed the response of electron density and Hall conductance to the appearance of the pulsating auroras. However, it is still not clear what is the exact relationship between the variations of the direction of the electric field, the ionosphereic conductance, and the optical pulsation.

On November 9, 2015, the EISCAT Tromsoe UHF and VHF radar operated with the KAIRA instrument installed at Kilpisjarvi, Finland. This simultaneous observation provided the electric field, the electron density/temperature, and ion velocity/temperature with a temporal resolution of 5-sec from the E region to F region. Auroral patches were captured by the all-sky camera at Tromsoe from 02:40 to 03:10 UT. We found that the electron density increased in the lower E region (below 110 km) inside of these auroral patches. Thus, the edges of the PsA patches seemed to be polarized by the Hall conductance enhancement. The ion velocity of the northward direction was increased during the PsA patches passed above Tromsoe. This indicates that the eastward electric also increased at that time. This electric field modulation was consistent with the polarization of the electric field created by the enhancement of the Hall conductance. In this presentation, we will summarize these results and explain the generation mechanism of the polarization electric field caused by the Hall conductance enhancement in the E region.

G07-P05

Comparison of northern and southern polar cap patches: a statistical analysis with all-sky imagers

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Polar cap patches are defined as region of plasma density enhancements in the polar cap F region ionosphere. The electron density inside patches is 2 to 10 times larger than the background level. The production of patches is believed to be caused by intermittent intake of high-density solar EUV plasma on the dayside by the anti-sunward convection. However, we still do not know if this process is always working and creating patches or not.

In the past, the optical observations of patches were carried out only in the northern hemisphere. This is because it has been difficult to install/operate relatively large and expensive equipment in the severe environment in Antarctica. In this study, we make use of so-called WATEC imagers which are inexpensive and handy airglow imagers. The WATEC imagers have been operative at McMurdo (77.5 S, 166.4 E, -79.9 MLAT) and South Pole (90.0 S, -74.7 MLAT) stations. By applying several noise reduction processes (e.g., image integration) to the original raw images, we succeeded in visualizing polar cap patches in the southern hemisphere. In this study, we try to reveal statistical properties of Antarctic polar cap patches and discuss their generation mechanisms by comparing it with the past observations in the northern hemisphere.

G07-P06

Radiation dose nowcast during the ground level enhancement on 10 September 2017

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Ground level enhancement (GLE) event occurred on 10 September 2017, associated with X8.2 solar flare exploded at western limb. We report the initial estimates of the possible radiation dose at flight altitudes as obtained from the WASAVIES [1]. We succeeded to manually conduct the nowcast using WASAVIES, and the maximum radiaion dose at 11 km flight altitude during the polar route was estimated as approximately 2.0 μSv/h, which was lower than the radiation dose of 6.0 μSv/h due to galactic cosmic rays. The best-fitted power-law index of the initial energy spectrum of protons is estimated as -6.0, which is softer than average. The best-fitted "injection parameter" of WASAVIES is also estimated as 3.0, which is longer time scale than average. We did not see significant north-south assymetry for this event. We discuss potential problems and solutions of the atutomatic forecast using WASAVIES for future GLE events.

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G07-P07

Temporal and spatial variations of storm-time ionospheric irregularities in high- and mid-latitudes on the basis of GPS total electron content data analysis

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It has been well-known that an enhancement of the ionospheric irregularity is caused by auroral particle precipitation and high-speed plasma convection. Recently, Cherniak and Zakharenkova [2016] reported strong ionospheric irregularities during a super storm that occurred on March 17-18, 2015 that were associated with storm-enhanced density (SED) formation at mid-latitudes and evolution of the SED plume to the polar tongue of ionization (TOI). However, since they did not analyzed the GPS data with high time resolution, detailed temporal and spatial evolution of the ionospheric irregularities during geomagnetic storms remains unknown. In this study, we analyze long-term global observation data of Total Electron Content (TEC) and Rate of TEC Index (ROTI) provided by NICT in order to clarify the temporal and spatial evolution of storm-time ionospheric irregularities. The ROTI data are often used to identify small-scale (3-30 km) irregularities of plasma density. The two dimensional horizontal maps of ROTI and TEC can be obtained from worldwide GPS data every 5 minutes and 30 seconds respectively. In the present analysis, we used geomagnetic indices (Kp and Dst) provided by WDC for Geomagnetism, Kyoto University in order to identify several storm events.

We investigate behavior of ROTI during a large geomagnetic storm that occurred on March 17, 2015 with the minimum Dst index of -235 nT. This magnetic storm commenced at 05:00 UT on March 17. An intense ROTI enhancement was observed over North America at 07: 45-11: 00 UT on 17th and from 18:00 UT on 17th to 01:00 UT on 18th. At 07:45-11:00 UT, the enhanced ROTI region extends in the longitudinal direction and equatorward up to 41 degrees (GLAT: geographic latitude). From comparison with the UV data of wavelength 135.6 nm by the DMSP satellite, it is inferred that the ROTI enhancement is caused mainly by particle precipitations at auroral region. From 18:00 UT on 17th to 01:00 UT on 18th, SED was observed over North America, and the enhanced ROTI region coincides with the inner and polar sides of SED. We further investigated behavior of ROTI during another geomagnetic storm that occurred on January 22, 2012. The minimum Dst index of this storm is -70 nT. In this case, although SED appeared from Europe to Iceland at 10:30-14:30 UT, there was no ROTI enhancement associated with this. In order to clarify a statistical view of storm-time ROTI behavior, we investigated local time and latitudinal dependence of ROTI on the Kp index. The average ROTI map for each Kp with 1-hour time interval was obtained using the ROTI data from 2012 to 2014. The ROTI enhancement corresponding to particle precipitation was always found irrespective of Kp index. The equatorial boundary of enhanced ROTI region expands to the lowest latitude at 00:00 LT (local time) and shrinks to the highest latitude at 12:00 LT. There were no ROTI enhancement in mid-latitudes. The equatorial boundary tended to expand to low latitude as the Kp index increases.

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G07-P08

Statistical study of Ionospheric Conductivity (Solar Zenith Angle) Dependence of the Subauroral Polarization Streams using the SuperDARN Hokkaido East HF Radar

Y. Zhang, N. Nishitani, and T. Hori

We investigate characteristics of the subauroral polarization streams (SAPS), focusing on the solar zenith angle (SZA) dependence using the Hokkaido East radar and the Buckland Park radar of the Super Dual Auroral Radar Network (SuperDARN), National Oceanic and Atmospheric Administration (NOAA) Polar Operational Environmental Satellites (POES) system and Meteorological Operational Satellite Program of Europe (MetOp) system data. The time span for the present study is from 2008/1/10 to 2016/12/31, which contains over 3180 days, and we limited the time range of the analysis to 3-8 UT (12-17 LT for the fields of view of the two radars). From the data of the Hokkaido East radar, we found 60 SAPS events over seasons except for summer, and from the data of the Buckland Park radar, we only found 17 events in winter. And for each event we examined the SZA and the peak Line-of-sight velocity observed in the SAPS, in order to identify the threshold of the possible SZA and illuminated ionospheric altitude for SAPS to be generated. The present work is the first statistical study addressing SZA dependence of SAPS in detail. As a result of the statistical study, we find that in northern hemisphere and southern hemisphere, SAPS tend to appear when the SZA is larger than 98.5 and 90 degrees respectively, and that the minimal threshold of illuminated ionospheric altitude for SAPS occurrence is about 100 km, which is near the altitude of the peak of Pedersen conductivity. This result suggests that the Pedersen conductivity plays an important role in the generation of SAPS in both northern and southern hemispheres. We should take into account the effect of HF propagation geometry, and EUV absorption in the atmosphere. We are planning to improve the accuracy of SZA in the future, by applying the Chisham virtual height model [Chisham et al., 2008] on the Hokkaido East radar, which can locate the position of flows more accurately.

Keywords: solar zenith angle, sub-auroral polarization stream, magnetosphere-ionosphere coupling, Pedersen conductivity, SuperDARN Hokkaido East radar

G07-P09

Ion temperature variations in the D- and E-region polar ionosphere during stratospheric sudden warming

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We analyzed ion temperature and velocity observed by the European Incoherent Scatter (EISCAT) UHF radar at Tromsoe (69.6°N, 19.2°E) during a stratospheric sudden warming (SSW) that occurred in January-February 2017. The zonal ion velocities at 85-100 km height reversed approximately 8 days earlier than the zonal wind reversal in the upper stratosphere and the ion temperature at 85-95 km decreased simultaneously with the zonal ion velocity reversal at the same altitude. We found that the time variations of ion temperature in the daytime are close to those of ambipolar diffusion coefficients derived from the the Nippon/Norway Tromsoe Meteor Radar (NTMR) data at the same altitude even when geomagnetic activity is moderate. This suggests that the D- and lower E-region ion temperature in the daytime is a good proxy for neutral temperature at the same altitude. We will explain the reliable ion temperature derivation in the D-region and its limitation, and also discuss relationship between ion temperature and vertical ion velocity variations at 85-95 km measured with the EISCAT UHF radar.

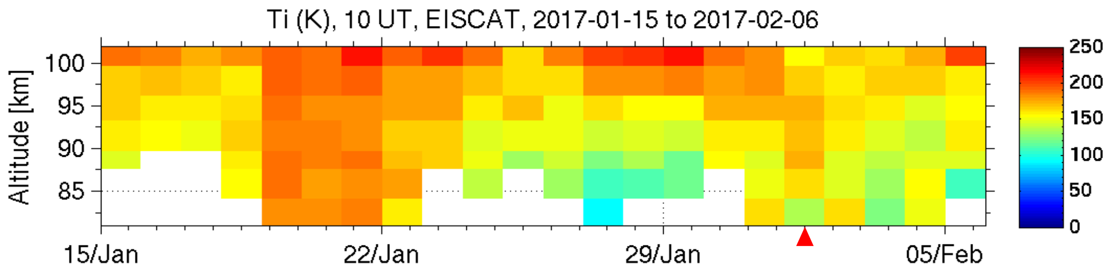

Figure 1. Ion temperature measured with EISCAT UHF radar above Tromsoe, Norway. The zonal wind reversal in the upper stratosphere over 69°N occurred on 1 February.

G07-P10

Aurora observations by an optical spectrograph at the EISCAT radar site, Tromsø, Norway

T. T. Tsuda[1*], K. Hosokawa[1], T. Kawabata[2], S. Nozawa[2], and A. Mizuno[2]

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We developed a compact spectrograph in the University of Electro-Communications. The spectrograph is capable of measuring optical emission intensity in mainly visible range with a resolution of ~1.6 nm, and the aperture, i.e. F-number, is ~4. We installed the spectrograph in European incoherent scatter (EISCAT) radar site, Tromsø, Norway (69.6ºN, 19.2ºE), and started unmanned nighttime operation on 4 October 2016. The field-of-view (FOV) of the spectrograph is pointed at magnetic field-aligned direction, and the data sampling rate is 1 Hz. Since then, aurora observations have been performed continuously during the last winter. During the period, we succsessfully obtained more than 8,000,000 data, which include many kinds of aurora, e.g., pulsating aurora. In the presentation, we will introduce the spectrograph and report initial results from the aurora observations in EISCAT Tromsø site.

G07-P11

Model calculations on Na layer variation induced by auroral energetic particles

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Metallic atom and ion layers, such as Na, K, Fe, and Ca^+ layers, exist in the mesosphere and lower thermosphere (MLT). The height range of the MLT region corresponds to the ionospheric *D* and *E* regions, and in the polar region energetic particles precipitating from the magnetosphere can often penetrate into the *E* region and even into the *D* region. Therefore, the influence of energetic particles on the metallic atom and ion layers is of interest regarding changes in atmospheric composition accompanied by auroral activity or geomagnetic activity.

In this study, we have developed a numerical model to understand importance of the Na chemical process triggered by ionization, i.e. enhancements of electron and ion densities, due to energetic particle precipitation. The model describes simply continuity equations related with Na chemical reactions. To investigate the ionization effects on the Na layer, we have performed two calculations using the model. One is the case of higher electron and ion densities, i.e. the case of ionization induced by energetic particle precipitation, and the other is the case of lower electron and ion densities, i.e. the case of no ionization. Regarding the results, we found that the calculated Na density in the case of ionization was lower than that in the case of no ionization. Thus, the enhancements of electron and ion densities can induce Na density decrease through the Na chemical process. In the presentation, we will introduce our model and show the results. Furthermore, we will compare the results with previous observations.

G07-P12

Study on Na layer variation related with auroral activity using Na lidar data obtained at Syowa, Antarctic

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Metallic atom and ion layers, such as Na, K, Fe, and Ca^+ layers, exist in the mesosphere and lower thermosphere (MLT). The height range of the MLT region corresponds to the ionospheric *D* and *E* regions, and in the polar region energetic particles precipitating from the magnetosphere can often penetrate into the *E* region and even into the *D* region. Therefore, the influence of energetic particles on the metallic atom and ion layers is of interest regarding changes in atmospheric composition accompanied by auroral activity or geomagnetic activity.

In this study, we have performed a statistical investigation on the Na layer variation related with geomagnetic activity using Na density data, which were obtained by Na lidar observations from 2000 to 2002 at Syowa Station, Antarctic (69.0°S, 39.6°E). In the analysis, we categorized the Na density data according to Ap index and then compared the resulting data sets. Regarding the results, we found a decrease in the Na density at 96-100 km during higher geomagnetic activity. In the presentation, we will show these results, and discuss the local-time characteristics of the observed Na density decrease.

Japan's Official Arctic Policy, which Evolutions and Opportunities for the Japanese Business Companies in the Arctic Region?

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Arctic ice is melting at an accelerating pace, but economic, strategic and ecological risks in the Arctic have contributed to its return to regional and international politics. Despite its long polar tradition, Japan had to wait until 2015 before the government adopted an official comprehensive Arctic Policy. Moreover, while Antarctica has raised more attention in both the Japanese research (expeditions and research bases) and political area (whaling) in the past, this attention is progressively and partially shifting towards the Arctic. However, the geopolitical situation of the Antarctic and the Arctic are very different which forces the government to adapt its actions: Japan does not possess any Arctic territory and hence must cooperate with Arctic States to be integrated in debates about the Arctic.

As the new Arctic Sea Routes present new business opportunities for Japanese companies, the attitude of the Japanese government in official communications was to officially support companies interested in these opportunities [1-2]. While in the past years there was little help from the government to encourage the Japanese companies to invest in Arctic related projects (e.g., the KANUMAS project supported by JOGMEC) the situation has been slowly evolving. The meeting of President Abe and President Putin in december 2016 in Tokyo lead to an expansion in the economic cooperation between Japan and Russia with business deals between companies and government bodies from both sides which included the Arctic LNG-2 project.

However, when investigating the ongoing or planned projects of Japanese companies from different sectors for this region, we can observe that those companies are, so far, not very optimistic in making economical profit should they invest in the Arctic region [3]. The harsh meteorological conditions, high cost for maintenance and the lack of infrastructures in the Arctic tend to discourage several companies. Hence, apart from a few exceptions, Japanese companies are adopting an attitude of « wait and see », as they are also waiting for the government to support them more actively by giving some incentives to invest on Arctic related projects.

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G08-P02

Chinese soft power in the Arctic

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The impact of global warming on the melting of Arctic ice has been widely discussed in the scientific community and the media. Due to the expected climate changes dramatically in recent years the number has increased of States and commercial organizations in the development of the Arctic resources, as well as possible ways of transportation along the Northern sea route.

The China factor in the Arctic for the last decade has been particularly relevant. To achieve its geopolitical and economic interests in the Arctic China's government consistently generates and implements its Arctic policy. One of the most effective tools for achieving their political objectives in the Arctic is science diplomacy, as a kind of soft power.

An important component of the complex interests is the interest in ecology. China's growing economy and its political power are vulnerable to climate change. The melting of Arctic ice and its implications actually give China a legitimate right to engage in research activities in the Arctic.

Attempts at scientific study of the Arctic were undertaken by China in the 80-ies of the last century. In 2000-ies begins a new stage of development and the study of the Arctic – scientific research projects. China actively moved on to the practical implementation of their economic and political objectives in the Arctic. In 2004 on the island of Spitsbergen, "Polar research Institute of China" opened a scientific research station "Yellow river".

In the academic environment Chinese researchers have clearly entrenched the concept, considering China as "almost Arctic" or "Arctic" state. Researchers from China in their scientific work actively justify the status of the Arctic as an object of international law, at the time, as China itself is building a bilateral format of cooperation with the Arctic and Arctic countries and actively participates in the international Arctic organizations.

Well seen are China's attempts to influence to the countries of Northern Europe through the scientific community. In particular for this purpose the China-Nordic research centre was established. CNARC was established in Shanghai on 10th December 2013 by 10 Member Institutes, four Chinese and six Nordic, which all have capacities to influence and coordinate Arctic research. CNARC''s purpose is to provide a platform for academic cooperation to increase awareness, understanding and knowledge of the Arctic and its global impacts, as well as to promote cooperation for sustainable development.

Through various research activities, conferences and symposia, China is strengthening its political position in the Arctic and the legitimacy of their claims on access to natural resources in the Arctic. From 80-ies till present, largely due to scientific diplomacy, China has achieved its political goals in the region and became a member of the Arctic Council.

G08-P03

Arctic Tourist Taxation or Arctic Charity

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The purpose of this project is to introduce a new Arctic tourism-approach: Arctic tourist taxation. In contrast to other studies, I consider whether business (especially expensive Arctic tourism) can be connected to the direct Arctic development by governmental taxation and/or charity. Specifically, I focus on the needed changes in the understanding of the Arctic tourism in general. (Under the "Arctic tourism" I analyze Arctic territories (High-Arctic, Low-Arctic and sub-Arctic territories).

The Arctic region suffer from the lack of infrastructure, educational facilities for local habitats, territorial, social, and health development. The results of students interviews in the Russian Northern Arctic region (Yamal) have shown that teenagers (13-18 years old) show interest to the Arctic regions (77%). However, there is a lack of information about the Arctic, its value and perspectives to work and live in the Northern regions. Moreover, respondents are ready and want to get knowledge about the Arctic by outdoor seminars and conferences (62%) or have compulsory either facultative lessons with invited Arctic specialists (80%) (See Figure 1).

Principles and goals of the “Arctic tourist taxation” or “Arctic Charity” are oriented on help, initiation and promotion of the needed Arctic development by combining business and pleasure. Using qualitative method of analysis, I found the evidence of possibility to manage a “Arctic tourist taxation” as a new program of the Arctic Council or “Arctic Charity” as an independent NGO. I propose to charge tour operators and tourists by 0.5% of the tour’s price for the further development of the Arctic regions. This approach will build a “checkpoint” in front of the gate to the North. The project can be implemented not only for indigenous and non-indigenous people in the Northern regions, but also for Arctic animals’ protection and for national parks in the Northern regions.

I assume, that “Arctic tourist taxation” will not decrease the number of tourists and even attract more tourists, experts and scientists from many different countries, and more people around the world will know more about the Arctic regions. Every Arctic tourist is able to take part in the further Arctic development personally. The Arctic regions have a bright future, but the way it will be managed depends on our behavior and responsibilities.

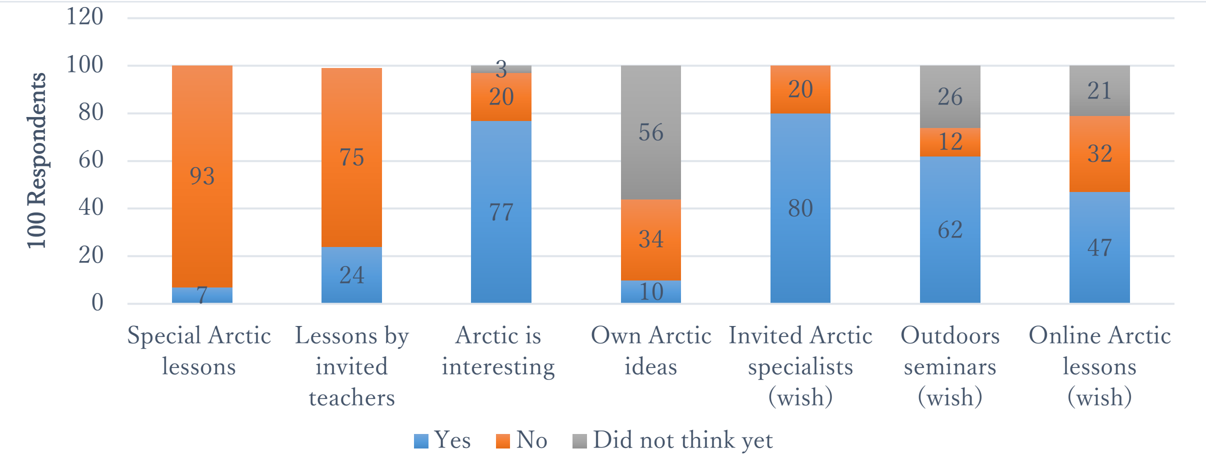

Figure 1. Results of students’ interview

Demographic Trend in the Russian High North

Tomoko Tabata[1*]

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I have analyzed the demographic trend of the Russian High North and showed that there are significant differences in this trend among these regions [1]. In this paper, I distinguish several patterns of demographic developments in these regions, taking account of natural increase (births minus deaths) and net migration (in-migrants minus out-migrants). I consider the relationship of these developments and socio-economic characteristics of the regions as well.

I examine eight regions that are included in the Russian High North (Russian Arctic zone), according to the State Program "Socio-economic development of Russian Arctic zone until 2020," adopted by Government Resolution No. 366 dated April 21, 2014. They are Murmansk Oblast, Arkhangelsk Krai, Nenets Autonomous Okrug (AO), Komi Republic, Yamalo-Nenets AO, Krasnoyarsk Krai, Sakha Republic and Chukotka AO. For the purpose of comparison, I analyze eight regions that are included in the definition of the Far North, decided by USSR Cabinet Resolution No. 1029 of November 10, 1967, in addition to above-mentioned eight regions. They are Karelia Republic, Khanty-Mansi AO, Tyva Republic, Irkutsk Oblast, Khabarovsk Krai, Sakhalin Oblast, Magadan Oblast and Kamchatka Krai. Among these 16 regions of the Far North, six regions are included in the Far East by the administrative definition of Russia.

I also examine similarities and differences between High Northern and Far Eastern regions in terms of demographic trend. In the period from 1990 to 1999, the total population of the seven regions of High North (excluding Komi Republic) decreased by 812 thousand, of which 810 thousand were due to outflow of the population to the other regions of Russia. The decrease in population in this period in the Russian Far East was 1,131 thousand, while outflow of the population was 1,137 thousand (Figure 1).

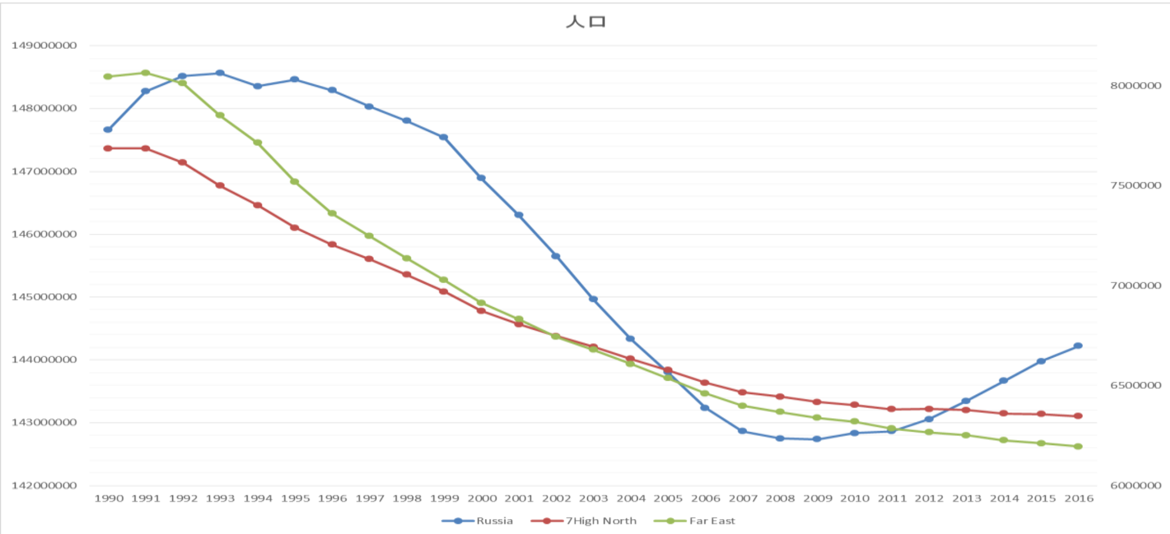

Figure 1 Population of Russia, High North and Far East

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G08-P05

Cancelled

G08-P06

Development of the Mineral Industry Economy of the Arctic and Northern Regions of the Republic of Sakha (Yakutia)

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Abstract: At the modern age of development of the extractive economy there are many opportunities for the development of this industry. First of all, considering the Republic of Sakha (Yakutia) we mean the industrial extraction of gold (20% of Russia's gold mining) and diamonds (the Republic of Sakha (Yakutia) provides more than 90% of Russia's diamond production and about 25% of the world's total production), Now underground mining of diamonds and gold by leaching from the ground is possible, this allows increasing production and make it more profitable.

13 regions of the republic belong to the Arctic and northern regions: Abyisky, Anabarsky, Allaikhovsky, Bulunsky, Verkhnekolymsky, Verkhoyansky, Zhigansky, Momsky, Nizhnekolymsky, Olenyoksky, Srednekolymsky, Ust-Yansky, Even-Bytantaisky. Of the, 7 are beyond the line of the Arctic Circle.

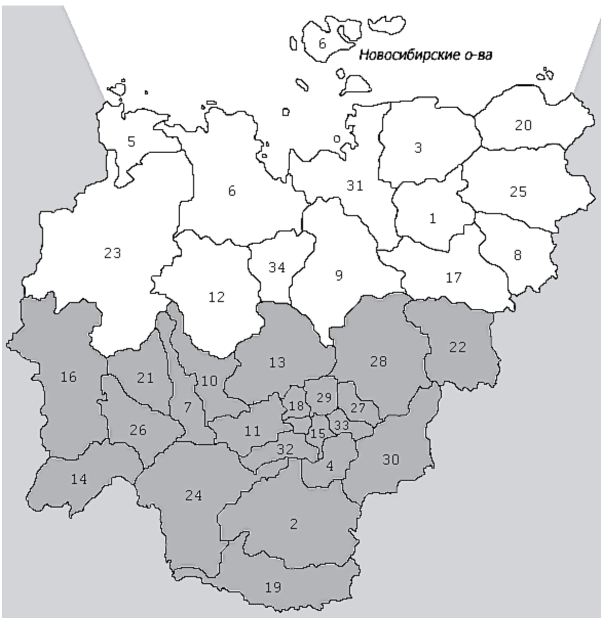

Figure 1. Map of the Arctic and northern Regions of the Republic of Sakha (Yakutia)

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S02-P01

Near real-time forecasts using a global nonhydrostatic model NICAM for the 2017 Mirai Arctic cruise

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In Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Arctic observations using the research vessel (RV) Mirai has been conducted for many years based on the recognition that the Arctic region is the key to the understanding and projection of the global change (http://arctic-climate.com/; Inoue et al. 2015; Sato et al. 2017). In August-September 2017, the Mirai Arctic cruise (MR17-05C) was executed to obtain atmospheric sounding, ocean surface, and biochemical data. In order to support field operation and to gain our understanding of the surface wind and weather phenomena associated with moist convection, near real-time forecasts using Nonhydrostatic Icosahedral Atmospheric Model (NICAM, Satoh et al. 2014) were conducted throughout the observation period. The forecast system has been developed at JAMSTEC since 2010, and has been used for tropical RV Mirai cruises (e.g., MR10-03, MR11-07, MR13-03, MR15-04; Nasuno et al. 2017). This is the first attempt to make use of the forecast system for the Arctic research. Here we report the performance of the current forecast system (14-km mesh 4-day forecasts with fixed sea ice and prescribed sea surface temperature) and discuss the next step toward the understanding of the relevant physical processes such as the air-sea interaction and precipitation and their impacts on the model performance and improvement of the forecast skill in the forthcoming cruises.

Acknowledgements
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S02-P02

How well does ERA-Interim product reproduce the upper troposphere over the Arctic Ocean ?

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Using data sets of frequent radiosonde observations and surface meteorological observations obtained during an Arctic cruise in September 2014, the reproducibility of the ERA-Interim reanalysis product was evaluated with reference to the upper troposphere. Relative humidity in the ERA-Interim reanalysis was found overestimated with a positive bias of cloud cover in the upper troposphere, which was attributable partly to the parameterization of cloud formation. Relative humidity in the lower stratosphere was also higher than observed, suggesting that a small amount of moisture was transported from the troposphere to the stratosphere via mixing induced by radiative/evaporative cooling at the level of the excessive upper cloud. Ozone profiles, based on ozonesonde observations, revealed that a positive bias of ozone partial pressure below the tropopause in the ERA-Interim reanalysis could be attributed to downward transport of ozone from the lower stratosphere into the upper troposphere via entrainment of a high-ozone air mass. The positive bias of upper cloud in the ERA-Interim reanalysis also affected downward radiation at the surface for the case of absent boundary layer clouds.

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Measurements of ice-nucleating particles over the Arctic Ocean, Bering Sea, and western North Pacific on R/V Mirai in August-October 2016

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Ice-nucleating particles (INPs) are crucial for ice particle formation in tropospheric clouds at temperatures higher than -38°C and hence play an important role in determining their radiative and microphysical properties. However, quantification of INPs in remote areas, such as ocean and polar regions, is still challenging due to low concentrations in the marine atmosphere. In this study, measurement of INPs was performed using aerosol samples collected during a cruise of R/V Mirai across the Arctic Ocean, Bering Sea, and western North Pacific from August to October 2016. We used the National Institute of Polar Research Cryogenic Refrigerator Applied to Freezing Test (NIPR-CRAFT) device to examine the immersion freezing efficiency of the collected aerosols in the temperature range of -25°C to 0°C and measured the number concentration of atmospheric INPs as a function of temperature. The INP concentrations varied over about three orders of magnitude during the cruise. Over the Arctic Ocean (i.e., >70°N), the INPs active at -25°C were <0.08 L^{-1}. In comparison with the Arctic Ocean, INPs active at -25°C were abundant over the Bering Sea and western North Pacific; 0.03-5.5 L^{-1} during the first half leg and 0.3-41 L^{-1} during the returning leg. According to on-board measurement of black carbon concentrations and model simulations, extremely high concentrations of INPs during the returning leg would be attributed to transport of smoke from fires in Siberia. The difference in INP concentrations during the cruise indicates that INPs in marine air can vary dramatically in response to long-range transport of continental aerosols, such as smoke, in addition to local emissions from the sea surface. The observed concentrations of INPs were reasonably well expressed by power law fits with the number concentration of fluorescent biological aerosol particles simultaneously measured with a Waveband Integrated Bioaerosol Sensor (WIBS-4) during the cruise, which suggests that biological aerosol particles may play a role in determining INP populations in the marine air of this case.

S02-P04

Role of ikaite precipitation in the sea ice carbon pump

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Ikaite ($CaCO_3{\cdot}6H_2O$) is a metastable phase of calcium carbonate that recently has been found in sea ice. Although it is suggested that ikaite precipitation may play an important role in air–sea CO_2 flux in ice-covered seas, its relative importance is not known due to scarcity of field measurement. We investigated ikaite precipitation in frost flower, on sea ice surface (two scenarios: flooded by seawater vs non-flooded) and in the sea ice column grown at an outdoor pool of the Sea-ice Environmental Research Facility (SERF) in Winnipeg, Canada. The results show that ikaite is highly enriched in frost flower with a concentration around 350 $\mu mol.kg^{-1}$. Ikaite is also found on the surface of sea ice, with higher concentrations on flooded sea ice (~95 $\mu mol.kg^{-1}$) than on non-flooded sea ice (~20 $\mu mol.kg^{-1}$). However, ikaite is nearly undetectable (<1 $\mu mol.kg^{-1}$) below the sea ice surface. Our results suggest that ikaite precipitation is mainly a surface phenomenon related to the cold temperatures and high salinities, which is in agreement with thermodynamic modeling by FREZCHEM. The negligible precipitation of ikaite in the sea ice column suggests its role in the sea ice carbon pump is likely minor.

S02-P05

ECV-Ice: Measuring Essential Climate Variables in Sea Ice–SCOR Working Group 152

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[5]Norwegian Polar Institute, Norway
[6]Institute of Ocean Sciences, Fisheries and Oceans Canada, Canada
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[9]University of Groningen, the Netherlands
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[19]Université libre de Bruxelles, Belgium
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Observations over recent decades suggest that sea ice plays a significant role in global biogeochemical cycles, providing an active biogeochemical interface at the ocean-atmosphere boundary. However, a pressing need exists to perform methodological intercalibration experiments in order to obtain reliable measurements of basic biogeochemical properties, including many of the Essential Climate Variables of the Global Climate Observing System. With newly emerging techniques, and pressed by the rapid changes in sea ice, the time has come to evaluate and improve our approach to study sea-ice systems. In 2016, the Scientific Committee on Oceanic Research (SCOR) launched Working Group 152 on Measuring Essential Climate Variables in Sea Ice (ECV-Ice). This working group will synthesize past intercalibration exercises and design and coordinate new experiments. Our ultimate goal is to provide the international community with standardized protocols for processing sea-ice samples and collecting data for key variables, including CO_2 partial pressure, nutrients, algal biomass and production, and gas exchange. We will also establish the effectiveness of new techniques to address sea-ice heterogeneity (often referred to as “patchiness”). These tasks will directly benefit the long-term community goal of understanding the response of polar marine environments to ongoing climate change.

Bacterial production of organic gas in cold seawater

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[2]Faculty of Fisheries Sciences, Hokkaido University, Hakodate, Japan

In order to clarify the bacterial production of organic gas (dibromomethane) in the cold water, we monitored organic gass production as well as bacterial community compositon in the methanol- and the bromoform-added seawater during 30-days incubation experiments in a low-temperature room. An organic gas of dibromomethane was higher in the substrate added treatments than that in the control where no organic substrate was added. Similarly, bacterial abundance, which was estimated from 16S rRNA gene copy number using quantitative real time PCR (qPCR), increased with time for the methanol- and the bromoform-added treatments. A PCR-DGGE analysis of 16S rRNA gene showed that bacterial community comoposition was different in the treatment bottoles, and DNA sequencing analysis of DGGE bands identified that one of the dominant taxa was close to genus *Methylophaga*, which is the methylotroph using methanol and methiammine for the productivity. These result suggest that organic gas as dibromomethane was produced by the bacteria using the methanol as an substrate and resulting the dehalogenation of bromoform. Our present results provide the clue for the bacterial production of organic gas in the cold water of the polar oceans.

The Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC)

M. Rex[1], M. Shupe[2], K. Dethloff[1], B. Rabe[1*], and MOSAiC-Team[3]

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[2]*University of Colorado, Cooperative Institute for Research in Environmental Sciences, USA*
[3]*International Team*

MOSAiC is an international initiative under the umbrella of the International Arctic Science Committee (IASC) designed by an international consortium of leading polar research institutes.

Rapid changes in the Arctic lead to an urgent need for reliable information about the state and evolution of the Arctic climate system. This requires more observations and improved modelling over various spatial and temporal scales, and across a wide variety of disciplines. Observations of many critical parameters have, to date, not been carried out in the central Arctic for a full annual cycle.

MOSAiC will be the first year-around expedition into the central Arctic exploring the coupled climate system. The research vessel Polarstern will drift with the sea ice across the central Arctic during 2019 to 2020. The drift starts in the Siberian sector of the Arctic in late summer. A distributed regional network of observational sites will be established on the sea ice in an area of up to 50 km distance from Polarstern, representing a grid cell in climate models. The ship and the surrounding network will drift with the natural sea ice drift across the polar cap towards the Atlantic.

The focus of MOSAiC lies on in-situ observations of the climate processes that couple atmosphere, ocean, sea ice, biogeochemistry and ecosystem. These measurements will be supported by weather and sea ice predictions, and remote sensing operations to aid operational planning and extend the observational results in time and space. The expedition includes aircraft operations and expeditions by icebreakers from MOSAiC partners. All these observations will be used for the main scientific goals of MOSAiC: enhancing the understanding of the regional and global consequences of Arctic climate change and sea ice loss, and improve weather and climate prediction. In particular, the results are needed to advance the data assimilation for numerical weather prediction models, sea ice forecasts, climate models and ground truth for satellite remote sensing. Furthermore, the understanding of the energy budget and fluxes through interfaces, sources, sinks and cycles of chemical species, boundary layer processes, and primary productivity will be investigated during the expedition. MOSAiC will support safer maritime and offshore operations, and contribute to an improved scientific future fishery and traffic along the northern sea routes.

A distributed atmosphere-sea ice-ocean observatory in the central Arctic Ocean: concept and first results

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To understand the current evolution of the Arctic Ocean towards a less extensive, thinner and younger sea ice cover is one of the biggest challenges in climate research. Especially the lack of simultaneous in-situ observations of sea ice, ocean and atmospheric properties leads to significant knowledge gaps in their complex interactions, and how the associated processes impact the polar marine ecosystem.

Here we present a concept for the implementation of a long-term strategy to monitor the most essential climate- and ecosystem parameters in the central Arctic Ocean, year round and synchronously. The basis of this strategy is the development and enhancement of a number of innovative autonomous observational platforms, such as rugged weather stations, ice mass balance buoys, ice-tethered bio-optical buoys and upper ocean profilers. The deployment of those complementing platforms in a distributed network enables the simultaneous collection of physical and biogeochemical in-situ data on basin scales and year round, including the largely undersampled winter periods. A key advantage over other observatory systems is that the data is sent via satellite in near-real time, contributing to numerical weather predictions through the Global Telecommunication Network (GTS) and to the International Arctic Buoy Programme (IABP).

The first instruments were installed on ice floes in the Eurasian Basin in spring 2015 and 2016, yielding exceptional records of essential climate- and ecosystem-relevant parameters in one of the most inaccessible regions of this planet. Over the next 4 years, and including the observational periods of the Year of Polar Prediction (YOPP, 2017-2019) and the Multidisciplinary drifting Observatory for the Study of the Arctic Climate (MOSAiC, 2020), the distributed observatory will be maintained by deployment of additional instruments in the central Arctic each year, benefitting from international logistical efforts.

S02-P09

Improvement of an algorithm to estimate the Arctic sea-ice thickness based on AMSR2

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An algorithm to estimate the Arctic sea-ice thickness (SIT) [1] is applied to a satellite-borne passive microwave radiometer named Advanced Microwave Scanning Radiometer 2 (AMSR2). Polarization Ratio at 36 GHz (PR36) and the Gradient Ratio between 6 and 36 GHz (GR06-36) which contain the signal of the first-year ice and multi-year ice are used to estimate the sea-ice draft. The equations are corrected by SIT derived from satellite rader altimeter SIRAL onboard Cryosat-2 (CS2) and in situ observations obtained from ice mass balance (IMB) buoys during 2012-12013. As the result, the small difference in SIT less than about 0.5m comparing with IMB thickness appeared in particular during winter. During March to September, difference in thickness between AMSR2 and IMB shows a siginificant correlation as shown in Fig.1. For the SIT from March to September, a bias correction was additionally applied to the SIT using skin temperature calculated by an atmospheric reanalysis. This correction reduces the error by 0.5 m in SIT. Figure 2 shows an example of skin temperature and difference in thicknesses between IMB and AMSR2. The diffrence was decreased during October to June. However, large errors during melting season remains due to a thick bias when refreezing of melt ponds dominate

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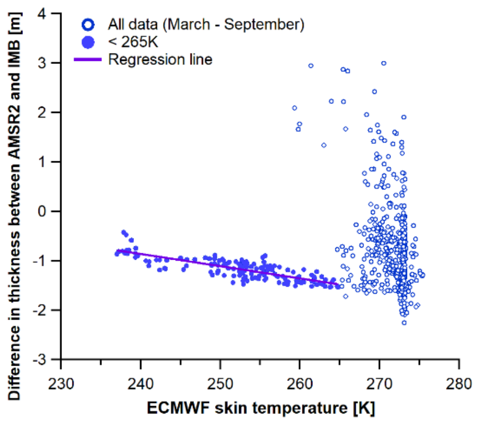

Figure 1 Relationship between skin temperature provided by ECMWF difference in thickness between AMSR2 and IMB during 2012-2013.

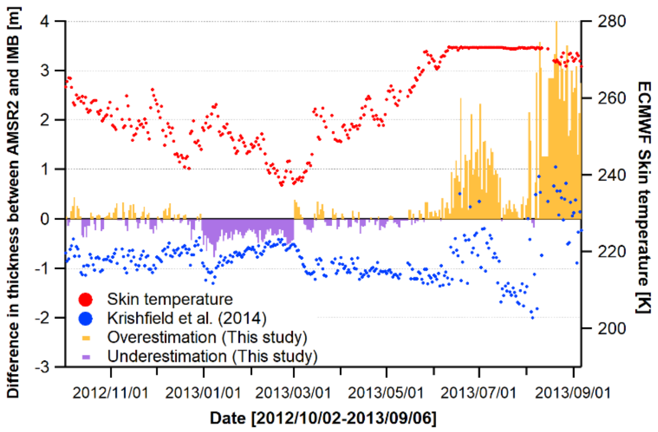

Figure 2 Time series of skin temperature, difference in thicknesses between IMB and AMSR2 and corrected AMSR2 draft with skin temperature for IMB No.2012G.

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Effect of crustose lichen on soil CO_2 efflux in sphagnum moss regime of tundra, west Alaska

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Increasing ambient temperatures across the Arctic have induced changes in plant extent and phenology, degradation of permafrost, snow depth and covered extent, decomposition of soil organic matter, and subsequently, soil carbon emission to the atmosphere. However, there is fully not understood on the effect of crustose lichen on soil CO_2 emission to the atmosphere. Although the spores of lichen are spread by wind and animals, the crustose lichen is infected to the only sphagnum moss widely distributed in the Arctic, and is terminally killed the moss. Here, we report the research findings on the soil CO_2 efflux-measurement with forced diffusion (FD) chamber system that is continuously monitored in sphagnum moss regime of west Alaska for the growing season of 2016. The environmental parameters (e.g., soil temperature and moisture) were measured at intact and infected sphagnum moss regime. The FD chamber is measured at an interval of 10-min and 30-min, which is not significant difference between both intervals ($R^2 = 0.94$; $n = 1360$; RMSE = 0.043; $p < 0.001$) based on a one-way ANOVA at the 95% confidence level. Mean soil CO_2 effluxes (standard deviation) in June, July, August, and September of 2016 were 0.47(0.22), 0.52(0.21), 0.55(0.31), and 0.32(0.54) in infected sphagnum moss, and 0.27(0.47), 0.45(0.17), 0.50(0.22), and 0.31(0.49) in intact sphagnum moss, respectively. This finding demonstrates that 1) soil CO_2 in infected sphagnum moss is one of atmospheric CO_2 source in June and July, and 2) soil CO_2 efflux is not significant difference between both regimes for August and September of 2016.

S04-P02

Quantification of annual soil CO_2 emission in unburned and burned black spruce forest of interior Alaska

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Estimation of annual soil CO_2 emission is not simple due to the winter contribution. Further, change in the snow-covered period and frequency in measuring winter CO_2 efflux leads to inadequately estimate the annual carbon budget. It is not easy to quantify the annual soil carbon emission in response to recently drastic changes of climate and environment in sub-Arctic and Arctic. Here, we report the research findings on the evaluation of winter carbon emission with 30-minute interval soil CO_2 efflux-measurement in unburned and burned black spruce forest of interior Alaska from August 1 2015 to September 30 2016. 'Warm' and 'cold' seasons are defined by snow-free and snow-covered period monitored by the time-lapsed camera and growing and non-growing seasons by the soil temperature of 0 °C, respectively. Also, annual soil CO_2 emission estimated from August 1 2015 to July 31 2016 and September 1 2015 to August 31 2016, respectively. As the results, The annual budgets of 'warm' and 'cold' seasons soil CO_2 emissions in unburned and burned black spruce soils were 258.8 and 162.2 gC m^{-2} $period^{-1}$ during August 1 2015 to July 31 2016, and were 268.2 and 165.2 gC m^{-2} $period^{-1}$ during September 1 2015 and August 31 2016, respectively. There are not significant differences of soil CO_2 effluxes between August 1 2015 to July 31 2016 and September 1 2015 and August 31 2016, based on a one-way ANOVA at the 95 % confidence level ($p < 0.05$). Cold season CO_2 emissions in unburned and burned black spruce soils were 111.5 and 34.2 gC m^{-2} $period^{-1}$ by the snow depth, and were 103.8 and 35.6 gC m^{-2} $period^{-1}$ by the soil temperature, respectively. Cold season CO_2 emissions in unburned black spruce soils contributed to 38.7 to 43.1 % of annual CO_2 emission; on the other hand, cold season CO_2 emissions contributed to 20.7 to 21.9 % of annual CO_2 emission in burned black spruce soils. Higher winter carbon contribution to the annual budget in unburned black spruce forest may be due to much warm winter 2015/16. On the other hand, it is not easy to discriminate winter carbon emission from burned black spruce forest soil to be higher or not due to changes in soil organic matter and soil microbial community by 2004 wildfire.

S04-P03

Characteristics of stem respiration for four tree species in the late successional stage, interior Alaska

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Boreal forests account for about one third of the carbon sequestered in terrestrial ecosystems, and the high latitude boreal ecosystem is consequently vulnerable to recent climate change. This study investigated stem respiration rates of mature, mixed deciduous-coniferous forests including Alaska paper birch, balsam poplar, white spruce, and black spruce in the late successional stage after disturbance during mid-July 2007. Stem respiration rates, temperature of air and soil, and PAR (photosynthetically active radiation) displayed explicitly diurnal variations for the observation period. Simulated stem respiration, normalized to air temperature, elucidated 63 % (poplar) - 69 % (black spruce) of measured stem respiration. Temperature (of air, stem, and soil) is an important parameter in controlling this stem respiration of the four studied species, suggesting temperature-dependency. Q_{10} values in the four species ranged from 1.23 to 1.98 for air and stem temperature, and from 1.86 to 3.93 for soil temperature. Response of stem respiration to temperature and PAR is likely to associate with the thickness of tree bark, reflecting the different lag time of 0.0-3.5 hours for temperature, and of 4.5-7.5 hours for PAR for the four species. This demonstrates the fast response of stem respiration in Alaska paper birch (with thinner bark) as well as slower stem respiration in balsam poplar (with thicker bark), in response to temperature and PAR in the very occasionally mixed mature forest during a late successional stage.

S04-P04

Assessment of the Present and Future Impact of Arctic Warming on the Status and Carbon Cycle of Northern Terrestrial Ecosystems

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The Arctic has undergone dramatic changes during the past 30 years and the current warming trend can have multiple impacts on different components of the climate system. To properly study such large-scale impacts and to predict future changes, contributions from global land surface models are needed. These large scale mechanistic models, in turn, need to be properly evaluated against state-of-the-art datasets, in order to reduce uncertainty in future predictions.

We simulated the past 35 years of biogeochemical and biophysical fluxes with the Community Land Model (CLM4.5), and used a unique combination of multiple datasets to evaluate land surface fluxes. The datasets consist of surface and satellite observations as well as output from atmospheric inverse modeling. We will present results from comparing net biome productivity (NBP) during the period 1980-2015 between simulations and results from inverse modeling. We have identified 4 potential drivers (climate, atmospheric CO_2 concentration, nitrogen deposition, and land use and land cover change) and we isolated their effects. To that end, we performed multiple historical simulations in different configurations, in order to identify the weight and the importance of the different processes at play. In the different experiments we kept one of the processes constant, as a proxy for a global sensitivity analysis.

We will also present results from a run simulating the period up to 2100, which was conducted to quantify - within the framework of the FP7 ICE-ARC project - the expected future changes in ecosystem productivity and the carbon budget in response to climate change. To achieve this goal, we performed a CLM offline run with a horizontal resolution of about 1x1 degrees, forced by atmospheric data from a coupled CESM simulation for the Representative Concentration Pathways (RCP) scenario RCP2.6 as the target scenario of the Paris agreement. In our presentation, we will focus on the analysis of the change of CO_2 and CH_4 flux variability with temperature and precipitation over time, and the change of the ratio of CO_2 to CH_4 fluxes.

Comparison of biogenic sulfur between cold and warm years during summer in the Bering Sea and some implications for the climate

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The interannual variations of anti-greenhouse gas dimethylsulfide (DMS) and its precursors dimethylsulfoniopropionate (DMSP) were discussed on the basis of field observations in the surface waters of the Bering Sea during summer of cold (2012) and warm (2014 & 2016) years. The spatial distribution of dimethylated-sulphur presented a declining trend from basin to continental shelf, while the high values occurred in the Bering Slope Current influenced regions. From 2012 to 2016, the Bering Sea, which is highly sensitive to climate changes on decadal and longer time scales, has undergone a warming of 2.7 °C that is closely associated with a marked decrease of sea ice over the area and could have profound influences on the ecosystem of the Bering Sea. Between the cold and warm years, phytoplankton abundance and Chl *a* elevated obviously by 3.71 and 2.41 fold, respectively, which can be attributed to increasing trends of silicate concentration and SiO_3^{2-}/DIN ratio in this diatom-dominated region. Meanwhile, bacterial abundance showed a 1.31 times rise, thereby enhancing the conversion of DMSP to DMS and DMS accumulation. As a consequence, more biogenic dimethylated-sulphur were produced in warm years, which were 1-3 fold higher than those in cold year. Sea-to-air DMS fluxes also showed a 4 times rise in summer from 2012 to 2016. During warm years, the relative biogenic sulfur contributions to the total nss-SO_4^{2-} were estimated to be in the range of 56.7%-95.6%, implying that oceanic biogenic DMS emission had a dominant contribution to the sulfur budget over the Bering Sea.

Potential impact of permafrost thaw on carbon dynamics in forest soils projected by a vertically stratified process-based model

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Forest soils store a large amount of organic matters, which can be a significant source of carbon dioxide emissions when decomposition is accelerated by increasing temperatures. Understanding carbon release from the soils is particularly critical in high latitude forests where more organic carbon would be available for microbial decomposition when soil temperature rises and permafrost thaws. The goal of this study is to estimate the amount of soil carbon and to predict carbon emissions under future climate change in the permafrost regions of northeastern Siberia. We use a model simulation and field observations to project carbon dynamics in the forest soils in this region. We are developing a simulation model on soil carbon dynamic by incorporating soil physical and biological processes such as soil temperature, moisture, decomposition by microbes, and vertical movements of organic materials. Organic litter inputs that are computed daily from an existing vegetation model are divided into three pools with different decomposability and allocated vertically at 10 cm intervals. Decomposition rates for the three organic parts are computed as a function of soil temperature and moisture content of each soil layer. Remaining soil organic materials are subsequently relocated vertically through cryoturbation, which is the movement of organic materials in the soil layers caused by freeze-thaw actions. Simulation was conducted using 158-years of historical climate records and 95-years of future climate under RCP8.5 scenarios. Simulations were conducted in the Spasskaya-Pad Scientific Forest Station in Yakutsk, Russia, where time series observed data are available. Results show that slowly decomposable materials tend to accumulate and move downward into deeper soil layers, while the amounts of easily and intermediately decomposable parts quickly reach equilibrium over time and mostly stay in shallower soil layers. Approximately 10-12 kgC m-2 of soil organic matter was estimated to be stored at that site, which is within the range of observed soil carbon stock in eastern Siberia regions obtained from observation-based global soil databases. Regional-scale distribution patterns of carbon stock were compared between the simulation results and global databases of soil properties.

Elevational gradient as a potential uncertainty factor for methane up-scaling by landscape structure and vegetation distribution in Taiga-Tundra boundary, Indigirka lowland, NE Siberia

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Vegetation cover is essential information for biogeochemical cycles, such as up-scaling of regional methane (CH_4) emission, which requires wetland extent where biogenic CH_4 is mainly released [1]. Taiga-Tundra boundary ecosystem consists of dwarf shrub tundra, sparse larch forest and polygonal wetlands which are thought to be affected by climate change. Despite the importance of these structure of the ecosystem, it is not easy to know the structure of heterogeneous landscape. As the vegetation classes have different reflectance signatures, spectral unmixing method has been applied to obtain fractions of small vegetation patches with relatively coarse resolution satellite images [2]. Additionally, digital elevation model can be used to understand the distribution of each vegetation with topographical gradient on regional scale. In this study, we combined field observation, satellite images and digital elevation models to clarify the topographical zonation of regional vegetation cover in Taiga-Tundra boundary ecosystem. ALOS AVNIR2 (JAXA) reflectance image (70 x 70 km) was used for classification of landscape unit, and then subpixel vegetation cover was estimated by linear spectral unmixing method in Indigirka lowland eastern Siberia (70°N, 148°E) in July summer.

AVNIR2 image was classified into 15 landscape units (LU), and each LU corresponded to terrains such as lakesides, polygons and terraces. Then, each LU was separated into 2 to 4 dominated vegetation classes based on vegetation map with 0.5 m resolution, and subpixel vegetation cover was estimated. Comparing to digital surface model (AW3D30 DSM, JAXA), subpixel vegetation map revealed landscape-scale distribution and zonation of vegetation cover among 0-300 m elevational differences in Taiga-Tundra boundary. Additionally, historical surface reflectance images (Landsat5 and Landsat8, USGS/NASA) were analyzed to detect year-to-year variation of vegetation in each LU. We have investigated CH_4 flux of each vegetation and land cover type there. Finally, CH_4 emission were scaled to region, and elevational gradient of CH_4-source-vegetation were assessed. This subpixel vegetation data allows us to describe regional impact of observed CH_4 emission, and expected to contribute research progression for vegetation dynamics and CH_4 emission in circumarctic region.

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S5-P01

Spatial distribution of dissolved methane and its source in the summertime western Arctic Ocean

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Recent Arctic warming and decreasing sea-ice can promote the release of the greenhouse gas methane (CH_4) from the Arctic Ocean, and can provide a strong climate feedback [1]. However, the dynamics of dissolved CH_4 in the Arctic Ocean remain uncertain, especially in the western part.

We present the horizontal and vertical distributions of concentration and stable carbon isotope ratio ($\delta^{13}C$ value) of CH_4 in the western Arctic Ocean.

All of the surface layer samples were supersaturated with CH_4 in comparison to the atmosphere. Especially high CH_4 concentrations (up to 10.3 nmol kg^{-1}) were observed at stations in the continental shelf area. In the bottom layer of the shallow stations, the CH_4 concentration was higher (up to 55.9 nmol kg^{-1}). Its $\delta^{13}C$ value was lower (down to -63.8‰) than in the surface layer, which suggests that CH_4 in the shelf water is produced mainly by methanogens in seafloor sediments. At deeper stations in the Canada Basin, the maxima of CH_4 concentration were detected at depths of 10–50 m and 100–200 m, although $\delta^{13}C$ values showed only a single minimum at 50 m depth. The shallower CH_4 maximum coincided with the DO maximum, suggesting CH_4 production by plankton activity or sinking particles. The deeper CH_4 maximum corresponded to nutrients maximum, suggesting horizontal advection of shelf water from the coastal shelf area. These results suggest that the western Arctic Ocean is an important potential CH_4 source.

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Subsurface pCO_2 minimum below halocline in the Canada Basin

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Changes in the air-sea CO_2 flux and the advance of ocean acidification are major concerns for the biogeochemistry in the Arctic Ocean. Comprehensive measurements of carbonate chemistry in surface layers and in the upper water columns were conducted onboard R/V *Mirai* in the western Arctic Ocean in late summer of 2013. In the Chukchi Sea, surface water pCO_2 was low (< 200 μatm) as a result of the enhanced biological production. In the Canada Basin, on the contrary, pCO_2 was relatively high (up to 370 μatm) and nearly in equilibrium with the CO_2 in the atmosphere. The salinity here was notably low (~26). Fractions of two source freshwaters, i.e., sea-ice melt and riverine outflow that mixed into the Canada Basin water were determined by the mass balance equation of salinity and total alkalinity. Surface water in the Canada Basin contained significant fraction of sea-ice melt (~16%) and riverine water (~10%). Here, surface water pCO_2 rapidly got close to that in the atmosphere since surface mixed layer was thin (~ 20 m). Additionally, biological production was limited due to large input of sea-ice melt that contains very low level of nutrients.

A strong halocline had been formed at around 20 m depth along with the downward decrease in the sea ice melt fraction in the Canada Basin. Subsurface pCO_2 minimum (< 300 μatm) and oxygen supersaturation were also clearly observed below the halocline (Fig. 1). The water in this layer is considered to have advected from the Chukchi Sea and subducted below Canada Basin-origin water owing to its higher density. If this pCO_2 minimum layer surfaced by wind mixing, this region will turn to act as additional CO_2 sink. However, this is unlikely because intensified stratification by sea-ice melt inhibits mixing across the halocline.

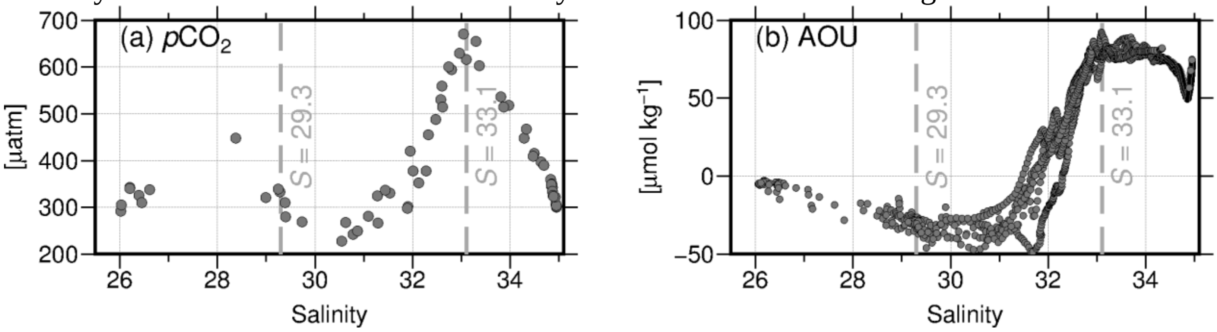

Fig. 1. (a) pCO_2 in discrete bottle samples and (b) apparent oxygen utilization (AOU) from CTD cast data against salinity in entire water column in the Canada Basin. Border between Canada Basin-origin water and Pacific-origin water (S = 29.3) and between Pacific-origin water and Atlantic-origin water (S = 33.1) were indicated as broken lines. pCO_2 was calculated from dissolved inorganic carbon, total alkalinity and dissociation constants of carbonic acid by [1] Lueker et al., (2000). Oxygen solubility was calculated using equation given by [2] Garcia and Gordon (1992).

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S14-P01

The Importance of *Alas* to Horse Herding in Churapcha District, Central Sakha

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In this presentation, I focus on the significance of the alas ecosystem to horse herding in Churapcha District in the central part of Sakha Republic (Yakutia). Specifically, I consider the effects environmental changes may have on the alas ecosystem and horse herding. Alas is a kind of thermokarst, open grassland that has its own freshwater lake. The research was conducted in Khaiakhsyt area in the south-western part of Churapcha District. Typically, horse breeding is practiced in and around the alases scattered in the taiga zone in the central part of Sakha.

The research revealed that horses are managed in herds (for instance 1 stallion, 10 mares, and their foals) and pastured in and around alases remote from a village center, throughout the year. In Churapcha, foals are born in spring, hay is made in the summer, and foals are slaughtered in autumn. Horses are fed hay and oats in the winter. Herders build their cabins in the alases to manage their horses, and they shuttle between their cabins and their homes, which are typically located in the villages.

Moreover, horse herders make hay on alasses, which is an essential food for horses in the winter. Fine weather is crucial for haymaking, and herders have to work intensely in July and August. To secure enough hay for the winter, herders occasionally rent alases from others, in addition to the hay they make on their own alases.

In conclusion, the alas ecosystem in Churapcha is significant to horse herding not only as a grazing land, but also as a hay field. At present, the alases in Churapcha seem to be experiencing minor environmental changes. Horse herding may be adversely affected if the alas ecosystem undergoes major environmental changes. For instance, when heavy rainfall occurs, muddy roads are known to obstruct herders, and hayfields shrink as the lakes expand. High frequency of rainfall would lower efficiency of haymaking and deteriorate in the quality of hay.

Additional
G9-O08

Cultural heritage as an illustration of climate change

S. Barr

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Although the International Arctic Science Committee (IASC) focusses its scientific activities through five Working Groups which cover Atmosphere, Cryosphere, Marine, Social and Human, and Terrestrial themes, we also strongly encourage multi-disciplinary, cross-cutting projects involving two or more of these disciplinary groups. The social sciences have received much greater and well-deserved attention during and after the last IPY 2007-08(9), while it seems to be more difficult to integrate humanities disciplines.

It will be argued here that such disciplines as archaeology, history and material culture studies have much to offer in partnership with natural sciences, not least with respect to climate change, adaptation and mitigation studies. These disciplines can give evidence of previous climatic conditions, human adaptation and mitigation in the face of natural short- and long-term impacts, historical ecology and human impacts on species populations, comparisons of historical local natural conditions with the present time, historical land use, and more.

Examples include how archaeological excavations in north Svalbard in 1980 and 2015/16 have shown the change in permafrost level related to the condition of organic material in 17/18th century whalers' graves, how studies of historical photographs can date the retreat or forward movement of glacier faces, how cultural heritage sites can serve as markers for shoreline erosion, and what studies of historical rubbish dumps can tell us about the flora and fauna of the time.

Archaeologists, historians and other humanities scientists already cooperate in many ways with the natural sciences to gain more insight regarding such studies as these examples illustrate. Interaction is less obvious the other way and natural scientists are to be encouraged to consider more integrated scientific projects spanning across both the natural sciences and the humanities.

Fig: Whalers' clothing from 17/18th century graves in Svalbard in 1980 (S. Barr)