ISAR-3

PROGRAM and ABSTRACTS

Third International Symposium on the Arctic Research

Detecting the change in the Arctic system and searching the global influence

January 14 – 17, 2013

"Miraikan" the National Museum of Emerging Science and Innovation
Tokyo, Japan

Program and Abstracts

Third International Symposium on the Arctic Research (ISAR-3)

- Detecting the change in the Arctic system and searching the global influence –

January 14-17, 2013

Miraikan (7th Floor)

National Museum of Emerging Science and Innovation

Tokyo, Japan

Organized by

National Committee of IASC, Subcommittee for International Affairs, Committee on Earth and Planetary Sciences, Science Council of Japan

Japan Consortium for Arctic Environmental Research (JCAR)

Co-Organized by

IFES-GCOE, Hokkaido University

International Arctic Research Center (IARC)

Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

National Institute of Polar Research (NIPR)

Supported by

Center for Computational Sciences (CCS), University of Tsukuba

Climate and Cryosphere Project (CliC), World Climate Research Programme (WCRP)

International Arctic Science Committee (IASC)

Research Institute for Humanity and Nature (RIHN)

Symposium Organizing Committee

Chair: Tetsuo OHATA, RIGC,JAMSTEC (Chair of JCAR)

Co-chair: Atsuko SUGIMOTO, Hokkaido University (Chair of the Japan National Committee for IASC)

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Local Organizing Committee

Chair: Yuji KODAMA, JCAR, NIPR

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The Third International Symposium on the Arctic Research: Detecting the change in the Arctic system and searching the global influence

Preface

It is our pleasure to welcome you to the Third International Symposium on Arctic Research (ISAR-3) to be held on January 14 to 17, 2013 at Tokyo. This Symposium is the third one following the past two Symposium held in November, 2008 (ISAR-1) and December, 2010 (ISAR-2).

The Arctic and surrounding region of sub-Arctic is one key area for the study of global change since it is showing the strongest warming under the ongoing global warming. It is affecting the natural system and also has strong influence to the people living in that region. Moreover, the influence is not only limited to this area, but is already showing influence to the mid to low latitude, and projected to have global influence. The scientific discussion about this region will be important for advancement of science, and as basis for the social activities in this region.

In this Symposium, first, we expect papers to discuss on the evidence and cause of changes occurring in the Arctic System, composed of atmosphere, ocean, land system and cryosphere, and its interactiona. Secondly, we expect discussions on the influence to the wider globe, presently occurring through atmosphere.

The Symposium is formed from 7 general sessions and 6 special sessions, so that researchers in many disciplines can report, and can also discuss on narrow timely topics. We hope that discussion made in the Symposium will lead to some new idea and research to be made in the future.

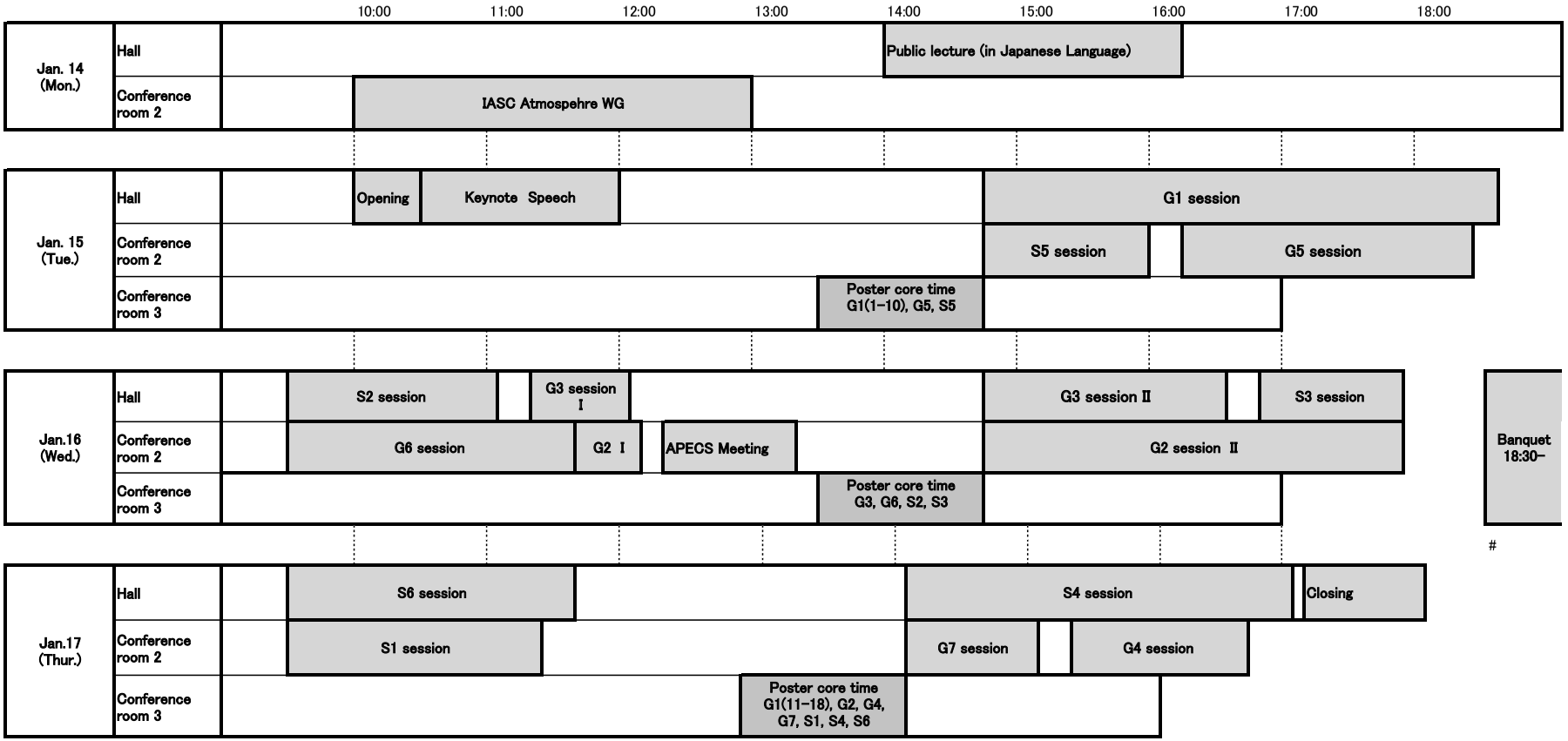
On behalf of the Symposium Organizing Committee of the ISAR-3, I sincerely appreciate the presence of all attendants and hope of the continuous participation to ISAR.

January, 2013.

Tetsuo Ohata

Chair of the ISAR-3 Organizing Committee
Japan Agency for Marine-Earth Science and Technology

ISAR-3 Schedule



Sessions

(G1) Atmospheric science
(G2) Ocean and sea ice
(G3) Hydrology, permafrost and snow cover
(G4) Ice sheets, glaciers and ice cores
(G5) Terrestrial ecosystem
(G6) Marine ecosystem
(G7) Interdisciplinary modeling studies

(S1) Polar (Arctic) amplification in global warming
(S2) Changes in water and carbon cycles of terrestrial ecosystem on permafrost in a warming Arctic
(S3) Changes in the Greenland ice sheet in the context of interactions with the atmosphere and the ocean
(S4) International cooperation on Arctic observation and research
(S5) GRENE Arctic project
(S6) Monitoring of the Arctic environment

Program for the Third International Symposium on the Arctic Research (ISAR-3)
January 14-17, 2013, Miraikan, Tokyo, Japan

January 14, 2013 (Monday)

14:00-16:15 Public lecture (in Japanese language)

January 15, 2013 (Tuesday), MiraiCan Hall

9:15- Registration

10:00-10:30 Opening Session Chair: Yuji Kodama

Welcome Speeches
Tetsuo Ohata (Chair of ISAR-3 Organizing Committee)
Volker Rachold (Executive Secretary, IASC)
TBD (Ministry of Education, Culture, Sports, Science & Technology)
Kazuyuki Shiraishi (Director, NIPR)

10:30 – 12:00 Keynote speech

12:00- Photo, Lunch

13:30-14:45 Poster session G1 (P1-P10), G5, S5 at Conference room 3

Oral session

January 15, 2013 (Tuesday), MiraiCan Hall

14:45-18:40 (G1) Atmospheric science

Chair: Kaoru SATO, John WALSH

16:35-16:50 Coffee break

January 15, 2013 (Tuesday), Conference Room 2

14:45-16:00 (S5) GRENE Arctic project

Chair: Hiroyuki ENOMOTO, Takashi YAMANOUCHI

16:00-16:15 Coffee break

16:15-18:25 (G5) Terrestrial ecosystem

Chair: Rikie SUZUKI, Walter OECHEL

January 16, 2013 (Wednesday), Miraican Hall

9:00- Registration

11:05-11:20 Coffee break

12:15-13:30 Lunch

13:30-14:45 Poster session G3, G6, S2, S3 at Conference room 3

16:30-16:45 Coffee break

16:45-17:55 (S3) Changes in the Greenland ice sheet in the context of interactions with the atmosphere and the ocean

Chair: Teruo AOKI, Shin SUGIYAMA

18:30- Banquet at Hotel Nikko Tokyo, Banquet Room Apollon

January 16, 2013 (Wednesday), Conference Room 2

9:00- Registration

16:10-16:25 Coffee break

18:30- Banquet at Hotel Nikko Tokyo, Banquet Room Apollon

January 17, 2013 (Thursday), Miraican Hall

9:00- Registration

11:40-12:55 Lunch

12:55-14:10 Poster session G1 (P11-P18), G2, G4, G7, S1, S4, S6 at Conference room 3

15:35-15:50 Coffee break

17:10- Closing session

January 17, 2013 (Thursday), Conference Room 2

9:00- Registration

11:25-12:55 Lunch

12:55-14:10 Poster session G1 (P11-P18), G2, G4, G7, S1, S4, S6 at Conference room 3

15:10-15:25 Coffee break

Poster Session

January 15, 2013 (Tuesday)

Core time 13:30-14:45 at Conference room 3

January 16, 2013 (Wednesday)

Core time 13:30-14:45 at Conference room 3

(S3) Changes in the Greenland ice sheet in the context of interactions with the atmosphere and the ocean

January 17, 2013 (Thursday)

Core time 12:55-14:10 at Conference room 3

January 17, 2013 (Thursday)

17:10- Closing Session

Reports by the conveners of Special Sessions

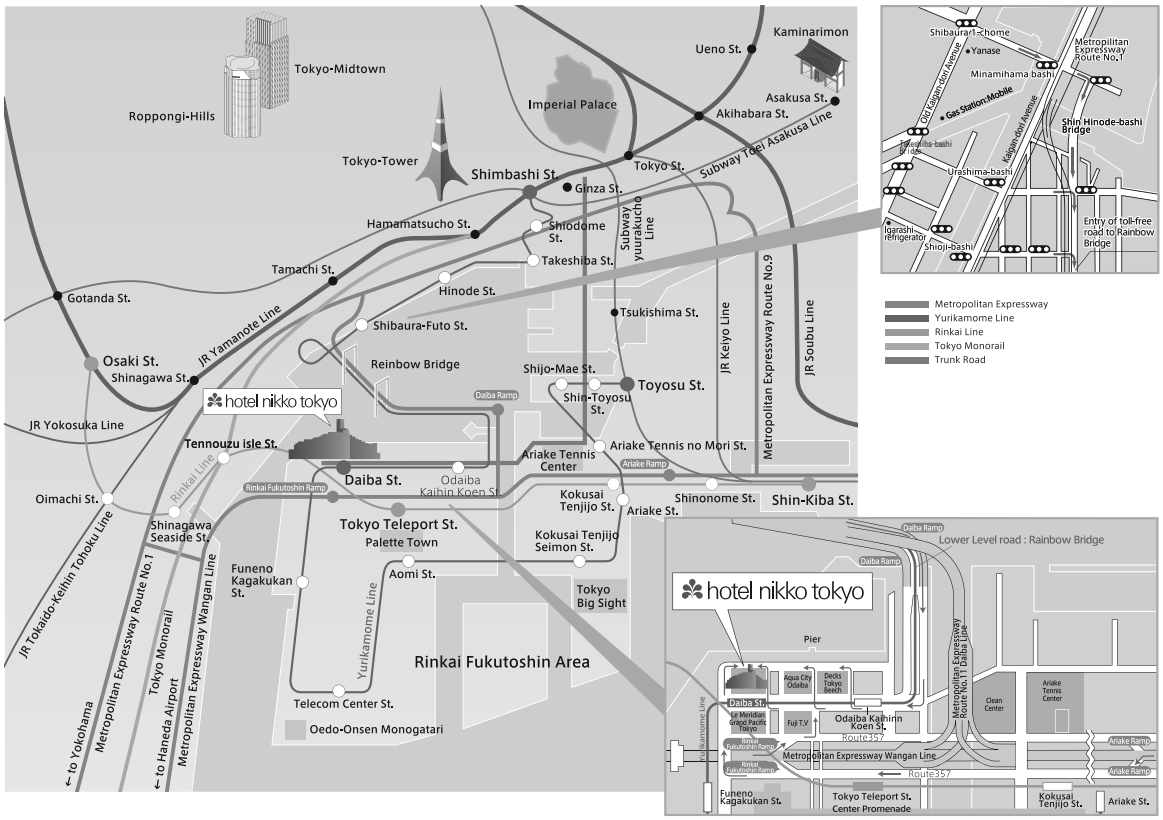
Discussion

Closing speech Atsuko Sugimoto (Co-chair of ISAR-3 Organizing Committee)

Added

Banquet location

Hotel Nikko Tokyo 1st floor "Appolon"



CAR

■**On The Metropolitan Expressway**

【From Central Tokyo】 Approximately 3 minutes from the Daiba Ramp exit on the Metropolitan Expressway No.11(Daiba Line of the upper level of the Rainbow Bridge).
【From HANEDA Airport】 Approximately 3 minutes from the Rinkai Fukutoshin Ramp exit on the Metropolitan Expressway Wangan Line.
【From Kasai】 Approximately 4 minutes from the Ariake Ramp exit on the Metropolitan Expressway Wangan line.

■**On The Trunk Road**

【From Shimbashi/Ginza】 Take kaigan-dori Avenue in Shibaura and turn towards the sea at the Minamihama Bashi, Urashima Bashi or Shioji Bashi intersection. Cross the Rainbow Bridge by the lower level. Approximately 3 minutes from the exit of Rainbow Bridge.
Alternatively, via Kachidoki Bridge, Harumi Bridge, and Kidukuri Bridge. Then, turn right and takes 2 minutes from where you turn.

●Approximate time requirements
【From Ginza/Shimbashi 】15 minutes
【From Tokyo Disney Resort】 20 minutes
【From HANEDA Airport】 15 minutes
【From NARITA Airport】 50 minutes

●Parking
1,000 yen/hour 500 yen additional 30 mins.

TAXI

●Approximate time requirements
【From JR Shimbashi Station】 15 minutes
【From JR Shinagawa Station】 20 minutes
【From JR Tokyo Station / Yaesu Exit】 20 minutes via Tsukuda Ohashi (by way of Toyosu)
【From Roppongi Station】 30 minutes
【From Ginza Station】 20 minutes
【From Tokyo Disney Resort / JR Maihama Station】 20 minutes (of the Metropolitan Expressway)
【From HANEDA Airport】 15 minutes(of the Metropolitan Expressway)

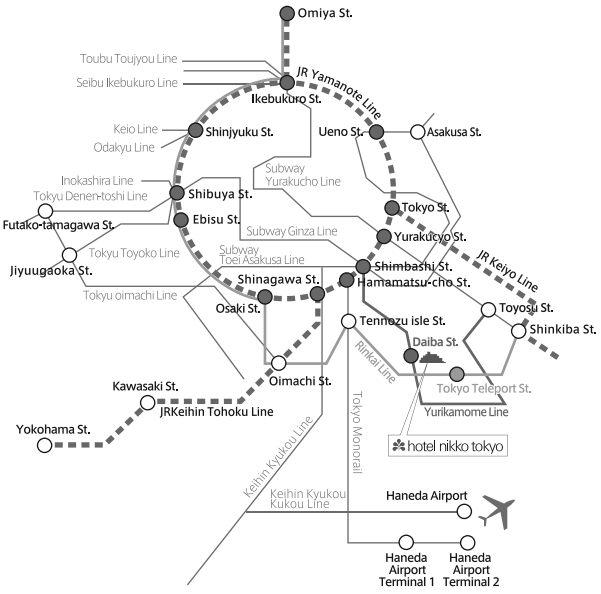
Limousine Bus

■The Limousine Bus Arrives at entrance on the first floor of Hotel Nikko Tokyo.
●Approximate time requirements
【From NARITA Airport】 75 minutes
【From HANEDA Airport】 20 minutes

Train

Directly Connected to Daiba Station.
A 10-minute walk from Tokyo Teleport Station.
A free shuttle bus is also operated from Tokyo Teleport Station.

Yurikamome Line	Shimbashi Station to Daiba Station 15minute.
Yurikamome Line	Toyosu Station to Daiba Station 16minute.
Rinkai Line	Osaki Station to Tokyo Teleport Station 11minute.
Rinkai Line	Shinkiba Station to Tokyo Teleport Station 7minute.



1-9-1 Daiba, Minato-ku, Tokyo 135-8625
TEL.03-5500-5500 URL. http://www.hnt.co.jp

hotel nikko tokyo

Banquet location (In Japanese)

Hotel Nikko Tokyo 1st floor "Appolon"

タクシーをご利用の場合

JR新橋駅から	約15分
JR田町駅から(レインボーブリッジ経由)	約12分
JR品川駅から	約20分
JR東京駅から	約20分
新木場駅から	約10分
六本木駅から	約30分
銀座駅から	約20分
東京ディズニーリゾート(JR舞浜駅) から（高速道路利用）	約20分
羽田空港から（高速道路利用）	約15分

By Taxi

From JR Shimbashi St.	15 min.
From JR Tamachi St.	12 min.
From JR Shinagawa St.	20 min.
From JR Tokyo St.	20 min.
From Shin-kiba St.	10min.
From Roppongi St.	30 min.
From Ginza St.	20 min.
From Tokyo Disney Resort / JR Maihama St. (of the Metropolitan Expressway)	20 min.
From Haneda Airport (of the Metropolitan Expressway)	15 min.

リムジンバスをご利用の場合

成田国際空港から「臨海副都心行き」乗車	約 75 分
羽田空港から「臨海副都心行き」乗車	約 20 分

By Airport Limousine Bus

From Narita International Airport	75min.
From Haneda Airport	20min.

お台場レインボーバスをご利用の場合

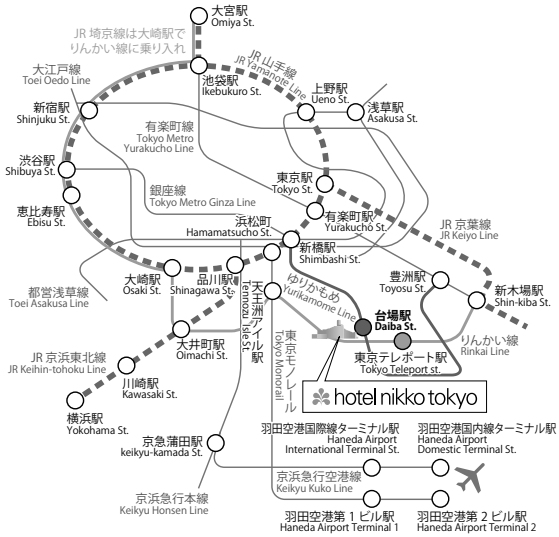
品川駅東口～ホテル日航東京	約 30 分

＊所要時間は交通状況により変わることがございます。

By Odaiba Rainbow Bus

Shinagawa St. East Exit - Hotel Nikko Tokyo	30min.

*The travel time will vary depending on traffic.



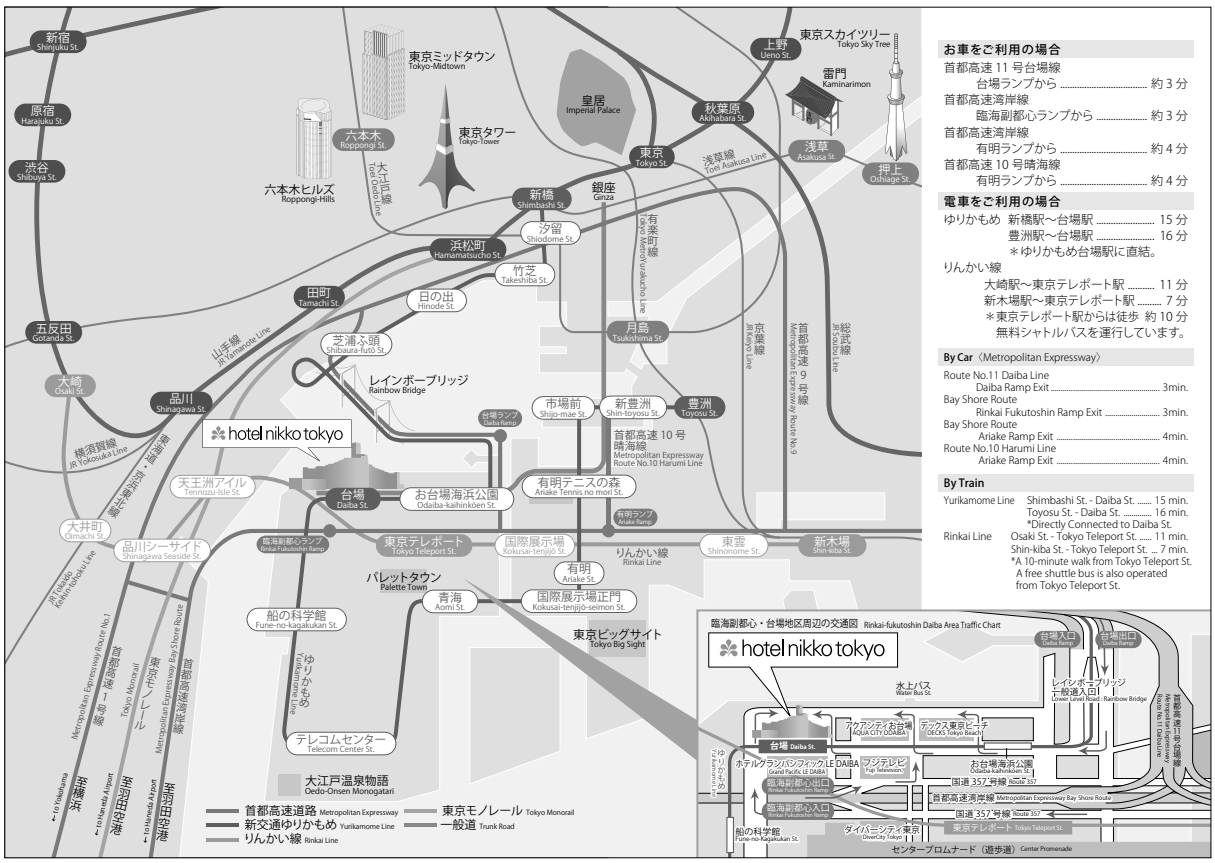
しあわせのリンク＆スマイル

ホテル日航東京

〒135-8625 東京都港区台場1-9-1 1-9-1, Daiba, Minato-ku, Tokyo 135-8625

Tel.03-5500-5500（代表） **www.hnt.co.jp**

hotel nikko tokyo



お車をご利用の場合

首都高速 11 号台場線 台場ランプから	約 3 分
首都高速湾岸線 臨海副都心ランプから	約 3 分
首都高速湾岸線 有明ランプから	約 4 分
首都高速 10 号晴海線 有明ランプから	約 4 分

電車をご利用の場合

ゆりかもめ 新橋駅～台場駅	15 分
豊洲駅～台場駅	16 分
＊ゆりかもめ台場駅に直結。	
りんかい線 大崎駅～東京テレポート駅	11 分
新木場駅～東京テレポート駅	7 分
＊東京テレポート駅からは徒歩 約 10 分 無料シャトルバスを運行しています。	

By Car〈Metropolitan Expressway〉

Route No.11 Daiba Line Daiba Ramp Exit	3min.
Bay Shore Route Rinkai Fukutoshin Ramp Exit	3min.
Bay Shore Route Ariake Ramp Exit	4min.
Route No.10 Harumi Line Ariake Ramp Exit	4min.

By Train

Yurikamome Line	Shimbashi St. - Daiba St. ..... 15 min. Toyosu St. - Daiba St. ..... 16 min. *Directly Connected to Daiba St.
Rinkai Line	Osaki St. - Tokyo Teleport St. ..... 11 min. Shin-kiba St. - Tokyo Teleport St. ... 7 min. *A 10-minute walk from Tokyo Teleport St. A free shuttle bus is also operated from Tokyo Teleport St.

Public Lecture

(In Japanese)

公開講演会

参加無料

今、北極がアツい！

2013年 1月14日（月・祝）

14:00～16:15（13:00 開場）

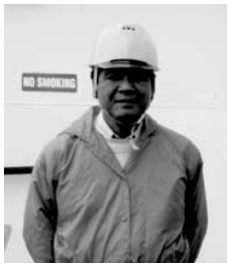
先着順で 300 名まで

～北極各地の写真も展示しています～

大畑　哲夫（北極環境研究コンソーシアム代表・海洋研究開発機構プログラムディレクター）

「変わりつつある北極域－これからどうなるのか？」

地球温暖化が進む中、北極域の気温上昇は地球上で最も大きい。このため、2012年7月にはグリーンランド氷床が内陸部まで融解し、9月には北極海の海氷面積が衛星観測史上（1970年代以降）最小を記録した。温暖化の影響が非常に顕著になっている。このような北極域の最近の変化、今後の行方と地球への影響について紹介する。



山口　　一（東京大学大学院新領域創成科学研究科教授）

「北極海を航路として使う」

北極海を通るとヨーロッパ～日本、アメリカ東海岸～日本間の距離が従来の航路に比べて３～４割も短くなる。北極の急激な気候変動と海氷減少により、この北極航路の商業的な利用の可能性が大きくなってきた。北極海の安全かつ効率的な航路利用について、何が必要かを考える。

中山　由美（朝日新聞報道局記者）

「グリーンランドの氷をとかす謎に迫る」

純白の氷の世界という北極のイメージは見事に裏切られた。グリーンランドは昨夏、雨が降り続き、氷河の表面は薄汚れてとけだし、激流が走っていた。まさに衛星観測史上最大の融解が起きていた、さなかだったのだ。汚れの正体は？氷の融解を加速させるものは？――その謎に迫る研究者たちと歩いた現場を報告する。

お台場 日本科学未来館 7F みらいCANホール

東京都江東区青海 2-3-6

・新交通ゆりかもめ「船の科学館駅」下車、徒歩約 5 分

・新交通ゆりかもめ「テレコムセンター駅」下車、徒歩約 4 分

・東京臨海高速鉄道りんかい線「東京テレポート駅」下車、徒歩約 15 分

・臨界副都心を無料で巡回しているバス「日本科学未来館」下車（約20分間隔で運行）

主催：日本学術会議地球惑星科学委員会国際対応分科会、北極環境研究ｺﾝｿｰｼｱﾑ

共催：国立極地研究所、海洋研究開発機構、北海道大学ｸﾞﾛｰﾊﾞﾙCOE ﾌﾟﾛｸﾞﾗﾑ「総合ﾌｨｰﾙﾄﾞ環境科学の教育拠点形成」、国際北極圏研究ｾﾝﾀｰ

後援：朝日新聞社、筑波大学計算科学研究ｾﾝﾀｰ、気候と雪氷計画(CliC)、国際北極科学委員会(IASC)、総合地球環境学研究所

第 3回国際北極研究シンポジウム公開講演会

お問い合わせ先：　国立極地研究所 北極観測センター内 北極環境研究コンソーシアム事務局（井上）

e-mail：koukai0114@nipr.ac.jp、電話：042-512-0925　http://www.jcar.org/isar-3/lecture.html

プログラム

13：00 開場

14：00-14：10　開会及び趣旨説明

司会進行：**杉本 敦子**

（日本学術会議連携会員　北海道大学大学院地球環境科学研究院教授）

14：10-14：45

「変わりつつある北極域―これからどうなるのか？」

大畑 哲夫（北極環境研究コンソーシアム代表・海洋研究開発機構プログラムディレクター）

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14：45-14：55 休憩

14：55-15：30

「北極海を航路として使う」

山口 一（東京大学大学院新領域創成科学研究科教授）

北極海を通るとヨーロッパ~日本、アメリカ東海岸~日本間の距離が従来の航路に比べて３～４割も短くなる。北極の急激な気候変動と海氷減少により、この北極航路の商業的な利用の可能性が大きくなってきた。北極海の安全かつ効率的な航路利用について、何が必要かを考える。

15：30-16：05

「グリーンランドの氷をとかす謎に迫る」

中山 由美（朝日新聞報道局記者）

純白の氷の世界という北極のイメージは見事に裏切られた。グリーンランドは昨夏、雨が降り続き、氷河の表面は薄汚れてとけだし、激流が走っていた。まさに衛星観測史上最大の融解が起きていた、さなかだったのだ。汚れの正体は？氷の融解を加速させるものは？　－－その謎に迫る研究者たちと歩いた現場を報告する。

16：05-16：15　閉会

趣旨説明

最近、北極では顕著な環境変動が起こっている。例えば、海氷の減少やそれらに伴う気象や生態の変化、グリーンランド氷床や陸上の氷河の融解、永久凍土の変化、河川流量の増加などがある。それらに伴う海洋や陸上の生態系の変化や人間活動への影響も報告されつつある。しかしながら、これらの変化はそこに暮らすものにとって悪い影響ばかりをもたらしているのではなく、例えば、北極航路などは、さまざまに経済活動に新しい可能性を生むかもしれない。これらの変動について、著名な科学者にわかりやすく解説してもらうとともに、この夏グリーンランドの氷床調査に同行した新聞記者が見た、最新の現地の様子を伝えていただく。皆様の北極の環境変動への興味・関心が少しでも増大することを期待している。

北極環境研究コンソーシアム事務局　兒玉裕二

講演者紹介

大畑 哲夫

名古屋大学助手、滋賀県立大学助教授、北海道大学教授などを歴任し、現在は海洋研究開発機構・地球環境変動領域・北半球寒冷圏研究プログラムのプログラムディレクター。専門は雪氷・気象・気候学。日本の北極研究の強化と研究者間の協力を推進・調整する組織「北極環境研究コンソーシアム」の代表。

山口 一

東京大学で船舶海洋工学および極域環境学に関する研究・教育に従事。現在は同大学大学院新領域創成科学研究科教授。文部科学省南極輸送問題調査会議委員、日本船舶海洋工学会海洋環境研究会会長なども務める。1993 年から 2005 年まで国際北極海航路プロジェクトに深く関与し、1995 年北極海航路実船航海試験では国際調査団団長を務めた。

中山 由美

朝日新聞報道局記者。2003 年 11 月から 2005 年 3 月、第 45 次南極観測隊で越冬。女性初の南極観測隊同行記者。第 51 次隊（09～10 年）で隕石探査。2012 年にはグリーンランド氷床調査も取材。南北両極の現場から地球環境を見つめる。2012 年、福島原発事故に関する連載記事に対して科学ジャーナリスト賞受賞。

Abstract

KN–1

INTENSIFIED WARMING OF THE ARCTIC: CAUSES AND IMPACTS ON MIDDLE LATITUDES

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Over the past century, the Arctic has warmed at about twice the rate of the rest of the globe. The amplified Arctic warming of recent decades has resulted in part from reduced sea ice and snow cover, as shown by the seasonality of the polar amplification, which is strongest during the autumn season of greatest sea ice loss. However, there is also theoretical and observational evidence that a key contributor to amplified polar warming is the increased poleward transport of heat and moisture into the Arctic. Variations of poleward fluxes of sensible heat as well as water vapor, a strong greenhouse gas, are consistent with the recent polar-amplified warming. Oceanic heat transport also appears to have played a role in the past decade.

There is emerging evidence that the warming Arctic can influence mid-latitude weather and climate. The warmer and moister atmosphere of an ice-diminished Arctic during autumn has been associated with enhanced autumn snow cover in Asia., which in turn has been linked to wintertime anomalies of anatmospheric circulation pattern that impact Eurasian winter climate. In a feedback of sea ice loss onto the atmospheric circulation of autumn and early winter, reduced sea ice has been shown to have contributed to an increase in the lower atmosphere temperatures, increased tropospheric pressures, and reduced zonal (westerly) winds aloft in recent years. An intriguing possibility is a linkage between these reduced westerlies and the anomalously negative phase of the Arctic Oscillation during the early period of several recent winters. The extreme negative Arctic Oscillation brought exceptional cold and snow to Europe and the eastern United States. Other recent studies support the notion that reduced Arctic sea ice cover in autumn affects the frequency of wintertime blocking events, leading to persistence or slower propagation of extreme temperatures in middle as well as high latitudes. While internal variability cannot be dismissed as the explanation of these anomalies in recent winters, the physical consistency of sea ice loss and early-winter reductions of westerly winds suggests that the warming Arctic may already be influencing middle latitudes.

KN–2

ARCTIC WARMING AND ITS CONSEQUENCES FOR PERMAFROST

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The northern permafrost region contains approximately 50% of the estimated global below-ground organic carbon (C) pool and more than twice as much as is contained in the current atmospheric carbon pool.
The sheer size of this carbon pool, together with the large amplitude of predicted arctic climate change implies that there is a high potential for global-scale feedbacks from arctic climate change if these carbon reservoirs are destabilized. In addition to the carbon available for microorganisms to produce methane and carbon dioxide in the active layer of permafrost landscapes, carbon and free methane gas stored for hundreds or thousands of years in permafrost are increasingly liberated by talik formation under thaw lakes and by coastal erosion. The role of methane emission due to the destabilization of gas hydrates within or under the permafrost along with the Arctic warming is still almost unknown and can only be roughly estimated.
Significant gaps exist in our current state of knowledge that prevent us from producing accurate assessments of the vulnerability of the arctic permafrost to climate change, or of the implications of future climate change for global greenhouse gas (GHG) emissions.
The European PAGE21 project “Permafrost and its global effects in the 21st century” directly addresses these questions through a close interaction between monitoring activities, process studies and modeling on the pertinent temporal and spatial scales. PAGE21 is directly linked to the Japanese-EU cooperative GRENE-TEA project, the Canadian ADAPT project and the Nordic Centre of Excellence DEFROST project.
In this presentation, we present an overview of the current state of knowledge on permafrost and its evolution in regard to warming air temperatures in the Arctic as well as the strategy behind the PAGE21 project and the coordination of field activities with international partners.

KN–3

CATASTROPHIC REDUCTION OF SEA-ICE IN THE ARCTIC OCEAN - ITS IMPACT ON THE MARINE ECOSYSTEMS IN THE POLAR REGION-

Naomi Harada[1], Katsunori Kimoto[1], Jonaotaro Onodera[1], Eiji Watanabe[1], Makio Honda[1], MIchio J. Kishi[1] Sanae Chiba[1], Takashi Kikuchi[1], Yuichiro Tanaka[2], Manami Satoh[3], Kazuko Saruwatari[3], Fumihiro Itoh[3], Yoshihiro Shiraiwa[3], Kohei Matsuno[4], Atsushi Yamaguchi[4]

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The sea-ice in the Arctic Ocean has dramatically reduced during the past decade. The drastic sea-ice reduction would cause a complicated and difficulty to understand the changes in marine ecosystem surrounding the Arctic Ocean, because “disadvantage” phenomena such as ocean acidification and “advantage” phenomena such as improving light condition for marine organisms, respectively, are simultaneously progressing. Therefore, aims of this project are 1) to understand temporal changes in primary production, 2) to understand the physiological response of marine phyto- and zooplanktons having carbonate tests on warming or freshening associated with sea-ice melting, 3) to develop a new model for marine ecosystems in the Arctic Ocean, to reproduce the primary production by using the model and to understand the response of marine ecosystems on the environmental changes caused by rapid sea-ice reduction.

In this presentation, we will show an overview of this project and a seasonal change in biogenic components flux obtained at the Northwind abyssal plain by a year round time series sediment trap system. We will also consider the mechanism of change in biogenic fluxes associated with the seasonal sea-ice extent. The seasonal change in major planktons (diatoms and mesozooplankton), physiological response of coccolithophorid on environmental changes caused by sea-ice melting by culture experiments, the quantitative analysis of dissolution of pteropods tests and model result for low trophic level ecosystem in the Arctic Ocean will be presented as a part of this project in the Sessions of ISAR-3.

G1–O1

ATMOSPHERIC REMOTE SENSING IN THE ARCTIC BY INCOHERENT SCATTER TECHNIQUE USING THE EISCAT AND EISCAT 3D RADARS

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EISCAT Scientific Association runs incoherent scatter radars in the Arctic of Northern Scandinavia. The present EISCAT facilities include the UHF and VHF radars, as well as the Heating Facility and dynasonde in Tromso Norway, EISCAT Svalbard radar with 2 antenna dishes and a dynasonde in Longyearbyen Svalbard, UHF receivers in Sodankyla Finland and Kiruna Sweden and an EISCAT_3D demonstrator receiver in Kiruna. Moreover, the EISCAT users have installed significant new instrumentation to be used together with EISCAT, such as the Japanese Lidar observatory and Norwegian MORRO radar in Tromso, EASI interferometry receiver in Svalbard operated in a Norwegian-British-Swedish collaboration, and the Finnish KAIRA wide-band astronomy and EISCAT_3D demonstrator receiver in Kilpisjarvi. We review the recent science highlights based on all of the EISCAT facilities. The incoherent scatter method importantly addresses the interactions between geospace and the atmosphere, as well as between the atmospheric layers themselves. The EISCAT radars offer a unique opportunity to study the atmospheric energy budget and solar system influences, such as the effects of solar wind, meteors, dust, energetic particles and cosmic rays in the atmosphere. New continuous measurements with the proposed EISCAT 3D radar will support studies of upward energy flow from the stratosphere, to the mesosphere, and thermosphere, lower atmospheric tidal variability and interactions with the mean atmospheric circulation, gravity waves, planetary waves, and ionospheric variations, gravity wave excitation mechanisms, the implications of significant observed gravity wave geographical and temporal variability, and the impacts of stratospheric warming events on the ionosphere. We expect novel quantitative results on atmospheric coupling processes also from above to below, such as is the transport-chemistry effect of odd nitrogen created by high-energy particle precipitation into the Arctic atmosphere, demonstrated here using the EISCAT Svalbard radar data from 2007-2008.

G1–O2

Polar ionosphere and thermosphere cooling over the past 30 years

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The upper atmosphere is strongly affected by variations in the solar EUV radiation, geomagnetic activity, and energy and mass exchange with the near Earth space. Trends over longer terms are predicted to be rather caused by anthropogenic increases of greenhouse gases and the global increase of the atmospheric temperature near the Earth's surface. The thermosphere is expected to on average cool down [e.g., Roble and Dickinson, 1989]. From European Incoherent Scatter (EISCAT) radar data gathered in the polar ionosphere above Tromsø we have derived the first significant temperature trends over 30 years (1981-2011). The results are a cooling of 10-15 K/decade near the *F*-region peak (around 220-380 km altitude). Height profiles of the observed trends are close to those produced by recent atmospheric general circulation model. Our results are a first quantitative confirmation of the simulations and so far rather qualitative expectations.

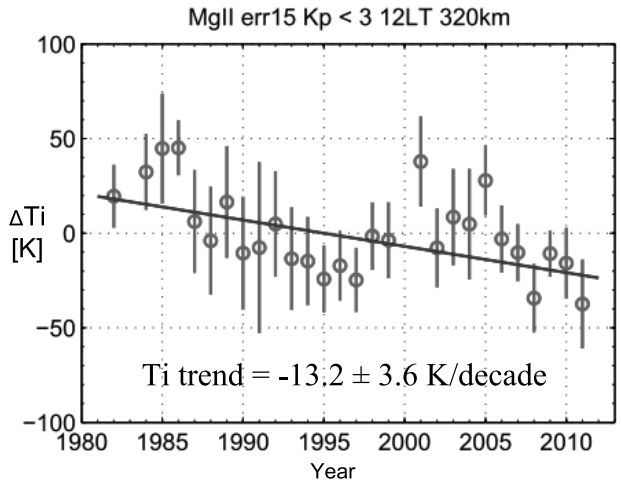

Figure: Yearly averaged ion temperature (residual variations after removing solar influenced variation pattern) at an altitude of 320 km measured with the EISCAT Tromsø UHF radar over 30 years and fitted trend (blue line).

Roble, R. G. and R. E. Dickinson, How will changes in carbon dioxide and methane modify the mean structure of the mesosphere and lower thermosphere?, Geophys. Res. Lett., vol 16, pp1441–1444, 1989.

CHARACTERISTICS OF THE MESOSPHERIC GRAVITY WAVES DERIVED FROM OH AIRGLOW IMAGES AT TROMSØ, NORWAY

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An important aspect of the wind dynamics in the mesosphere is to know characteristics of the atmospheric gravity waves, such as propagation direction, horizontal wavelength, phase speed, and wave amplitude, because it is widely known that the atmospheric gravity waves transport momentum from the lower atmosphere to the upper atmosphere. Statistical analysis of the OH airglow images measured with all-sky cooled-CCD imagers suggest seasonal and geographical dependencies, in particular, of the wave propagation direction.

A new all-sky imager was installed at the Tromsø EISCAT (European Incoherent Scatter) radar site in Norway (69.6°N, 19.2°E) in January 2009. The imager has six optical filters (557.7 nm, 630.0 nm, near-infrared OH band, 589.3 nm, 572.5 nm, and 732.0 nm), and this study focuses on the OH airglow images to study the mesospheric gravity waves in winter (from October to March). A typical emission layer of the OH band may be located around 85 km height. Statistical analysis has been made of data for 48 nights with clear sky and no auroral emissions, selecting gravity waves with horizontal wavelength of 20-100 km. The statistics suggest that predominantly propagation directions are north-to-northeastward, southeastward, and southwest-to-westward. Of particular interest in this statistical result is dependence of the propagation direction on the horizontal wavelength. Gravity waves propagating north-to-northeastward and southwest-to-westward are more clearly appeared with decreasing the horizontal wavelength; by contrast, those of southeastward-propagating component becomes more noticeable with increasing the horizontal wavelength. Winds from a collocated MF radar below 85 km height show gaps of the direction in northeast and southwest, mainly flowing east-to-southeastward. (for reference, winds from NCEP below ~50 km have smaller wind speeds than the MF-radar winds). This result suggests that the wind-filtering effect plays an important role to decide the propagation direction of the gravity waves with relatively shorter horizontal wavelengths. The horizontal phase speed of the gravity wave with relatively longer horizontal wavelengths tends to be larger than the MF radar winds. In this case horizontal propagation directions of the gravity waves can be identical to the background-wind direction. This may be the case for gravity waves with longer wavelengths.

G1–O4

UPPER ATMOSPHERIC OBSERVATION AT RESOLUTE CANADA

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Long-term changes in the upper atmosphere in the polar region may be a reflection of changes in the lower atmosphere. However, such a link is not easy to establish, because the upper atmosphere is also affected by solar cycle. Stratosphere warming events also generates large inter-annual variations. Furthermore, it is hard to find long data set of upper atmosphere observation in the polar region. In this study we examine the changes in the mesosphere over 10-year period and their possible link to solar and other middle and lower atmosphere changes. The data set is mesosphere observation from a Fabry-Perot interferometer at Resolute from 2003 to 2012. The instrument has operating during every winter seasons.

G1–O5

Studies of vertical coupling processes in the Arctic region using a GCM

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It is considered that the Arctic is one of the most sensitive regions to climate change where the temperature rise due to the increase of greenhouse gas is most distinct. On the other hand, the increase of greenhouse gas does not only warm the troposphere, but also cool the middle and upper atmosphere. The cooling trend of the middle and upper atmosphere increases the appearance frequency of polar stratospheric clouds and slows down the recovery of the Antarctic ozone hole. In addition, it could be partly responsible for the tropospheric climate change through the interaction with some dynamical and chemical processes. It suggests that the effect of coupling processes between the Arctic troposphere and the middle and upper atmosphere should be examined in detail as a possible mechanism of the Arctic climate change.

In order to examine the change of vertical coupling processes due to the CO_2 increase and its impact on the Arctic warming, our research group plans to perform several kinds of model experiments (e.g., CO_2 control run, CO_2 doubling, and runs with variable model tops) as a part of the GRENE Project using the Kyushu GCM covering the height region from the ground up to 500 km. The Fortran codes of the Kyushu GCM were already installed on the supercomputer of National Institute of Polar Research (NIPR), and preliminary runs in which the JCDAS reanalysis data below 30 km was nudged into the GCM have been performed. Hereafter, we intend to perform several kinds of experiments mentioned above, and advance the collaborative research with many researchers in the research community using the obtained model datasets. In our presentation, we will introduce the status of model experiments and their preliminary results concerning the vertical coupling processes in the Arctic region.

G1−O6

INTERHEMISPHERIC DIFFERENCES ON THE WINTER POLE- EQUATOR CONNECTION IN THE UPPER STRATOSPHERE/LOWER MESOSPHERE

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A dynamical connection between the equatorial semiannual oscillation (SAO) around the stratopause and the polar night jet (PNJ) in the austral winter is investigated using a gravity wave-resolving general circulation model data and a reanalysis (MERRA) data. The contributions of gravity waves and planetary waves to the connection are separately examined. The stratopause defined as vertical temperature maximum is discrete around a latitude of 60°S, which is influenced by the upwelling above and equatorward of PNJ core. The upwelling is maintained by a combination of a poleward flow driven by planetary wave forcing around the stratospheric SAO level, a poleward flow driven by the gravity wave drag above the PNJ, and a relatively equatorward flow above the SAO easterly in the mesosphere, through the mass continuity. The variability of the upwelling significantly affects the easterly shear above the PNJ core due to the adiabatic heating/cooling through the thermal wind balance. A variation of the upper part of PNJ leads to an adjustment of PNJ height along the seasonal evolution. Since interseasonal and interannual variations of the SAO modulate the subtropical momentum deposition in the mesosphere, the variation in the upwelling is dominated by the SAO. In contrast, it seems that PNJ core height variation has no significant effect on the SAO variation. It is concluded that PNJ core tends to be phase-locked to SAO when the easterly phase of stratospheric SAO is strong in the austral winter. On the other hand, It may be difficult to apply the mechanism of the winter pole-equator coupling for the Northern Hemisphere. The PNJ often breaks in the boreal winter due to the sudden stratospheric warming, leading to transient changes in the residual circulation.

G1–O7

Analysis of vertical profiles of CO_2, CH_4, N_2O, SF_6 in the arctic atmosphere

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Airmass in the arctic region is a complex mixture of emissions from boreal land regions in the northern hemisphere, fluxes across the air-sea/ice, and stratosphere- troposphere exchange within the polar vortex. To elucidate interactions between these processes, we use continuous measurements of three species, namely, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and sulphur hexafluoride (SF_6), during the five Hiaper Pole-to-Pole Observations (HiPPO) campaigns and an atmospheric general circulation model (AGCM)-based chemistry transport model (ACTM). The ACTM simulations at T42 (~2.8x2.8 degrees) and T106 (~1.125x1.125 degrees) and 67-sigma model layers have been completed. We will analyse the model results in comparisons with HiPPO measurements soon after the QA/QC of data from all the five campaigns is completed (within 2012). Detailed results will be presented during the symposium.

G1–O8

SIMULTANEOUS OCCURRENCE OF POLAR STRATOSPHERIC CLOUDS AND UPPER-TROPOSPHERIC CLOUDS CAUSED BY BLOCKING ANTICYCLONES

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This study statistically examines the simultaneous appearance of polar stratospheric clouds (PSCs) and upper tropospheric clouds (UCs) using satellite lidar observations for five austral winters of 2007-2011. The time series of PSC occurrence in the height range of 15-25 km are significantly correlated with those of UC in 9-11 km. The UCs observed simultaneously with PSCs reported in previous case studies are possibly located around and slightly above the tropopause (~7-8 km) rather than in the troposphere. It is shown that the simultaneous occurrence of PSCs and UCs is frequently associated with blocking highs having large horizontal scales (several thousand kilometers) and tall structure (up to a height of ~15 km). The longitudinal variation of blocking high frequency accords well with that of the simultaneous occurrence frequency of PSCs and UCs. This coincidence is clearer when the analysis is limited to the latitudinal regions inside the stratospheric polar vortex. This fact suggests that the blocking highs provide a preferable condition for the simultaneous occurrence of PSCs and UCs. Moreover, PSC compositions are investigated as a function of relative-longitude of the anticyclones including blocking highs. It is seen that relatively high proportions of STS (super-cooled ternary solutions), Ice, and Mix2 (mixture of nitric acid trihydrate and STS) types are distributed to windward of, around, and to leeward of the anticyclones in the westerly background flows, respectively.

G1–O9

PROJECTED CHANGES IN ARCTIC SUMMER STORM-TRACK ACTIVITY BY CMIP3 CLIMATE MODELS

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Model reproducibility and future projection of summer-time storm-track activity in the Arctic region and associated climate components are investigated on the basis of Coupled Model Intercomparison Project Phase 3 (CMIP3) climate models. Most of the models underestimate storm-track activity over the Arctic Ocean measured locally as the variance of subweekly SLP fluctuations, and its large inter-model diversity is related to that of the lower-tropospheric westerlies in the Arctic region and the storm-track activity over the entire extra-tropics. As a multi-model mean, the CMIP3 models project the enhancement of storm-track activity over the Arctic Ocean off the eastern Siberian and Alaskan coasts, the region called the Arctic Ocean Cyclone Maximum (AOCM), in association with the strengthening of the westerlies projected in the warmed climate. This intensifying storm-track activity is likely due to enhancing ocean-land contrast in surface air temperature (SAT) across the Siberian coast, which reflects greater surface warming over the Siberian continent with increasing surface sensible heat flux and slower warming over the Arctic Ocean with reduction in sea ice cover. The projections of these variables nevertheless exhibit large inter-model variability, although their model biases are correlated significantly in the same manner as among their multi-model means.

INTERANNUAL VARIABILITY OF THE EAST ASIAN WINTER MONSOON

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Interannual variability of the East Asian winter monsoon has been investigated on the basis of observational data over the recent 50 years. Although the winter monsoon activities themselves are confined within the lower troposphere, their variability in mid-winter tends to be associated with upper-tropospheric geopotential height anomalies similar to the Eurasian (EU) pattern and the Western Pacific (WP) pattern. In the “EU-like” pattern, a wavy signature similar to the EU pattern can be found over the Eurasian continent. Interestingly, source regions of the wavy signature may be found over the North American continent, implying co-occurrence of temperature anomalies over the Far East and the North America. In the “WP-like” pattern, a meridional dipole pattern similar to the WP pattern can be found over the Far East region.

The variability of the atmospheric circulations may relate to modulations of the planetary wave formations associated with a seasonal march from late autumn to midwinter. In the climatological seasonal march, geopotential height in the upper troposphere generally lowers since temperature in the lower troposphere also decreases toward midwinter. Decreasing tendencies are especially strong in the mid-latitudes. They are, however, very weak in high latitudes, especially over the eastern Siberia and Alaska, and even a positive tendency can be found over the Bering Straight. Such an asymmetry in the height tendencies corresponds to evolutions or formations of the planetary waves: weak (strong) decreasing signals mean anticyclonic (cyclonic) tendencies, which tend to form ridges (troughs) of the planetary waves. In the seasonal marches in the WP-like patterns, anticyclonic tendencies over the eastern Siberia and Alaska region are strengthened (weakened) in cold (warm) Januaries over the Far East. Even for the EU-like patterns, we can verify similar patterns of the seasonal march.

G1–O11

ARCTIC OSCILLATION AND EAST ASIAN CLIMATE CHANGE

Seong-Joong Kim[1], Baek-Min Kim[1], Jee-Hoon Jeong[2], Sung-Ho Woo[3], Taehyoun Shim[1], Heysun Choi[1]

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As the leading mode of climate variability in the northern hemisphere winter, the Arctic Oscillation (AO) is the north-south oscillation of the atmospheric mass and largely influences the mod latitude climate. When the AO is in positive phase, the Siberia and East Asia tend to be warmer than normal years and vice versa. Therefore, efforts on skillful prediction of the AO phase are important in forecasting the surface temperature over the Arctic and mid latitudes, especially during winter. Until middle of 1990s, the AO was in increasing trend and this led to the marked arming over the rim of the Arctic regions. In the 2000s, however, the AO shows more frequently negative phases with the extremely large negative AO amplitude in 2009/2010 winter. From the data analysis, we found several links between AO and East Asian climate variabilities, which can be useful for seasonal prediction. Firstly, more frequent occurrences of strong negative AO event, especially in recent decade, lead to more frequent and longer lasting extreme cold surges over East Asia. Second, the AO phase in spring time influences the Asian summer monsoon through a teleconnection by the North Pacific. Third, the amplitude of the AO appears to be modulated by the amount and coverage of snow over Siberia and Tibetan Plateau. Finally, the recent frequent occurrences of negative AO in late winter can be, in part, caused by unprecedented Arctic sea-ice loss in early winter and this lagged connection between sea-ice and AO is established by stratosphere-troposphere dynamic coupling: Enhanced upward propagation of the Rossby wave generated by sea-ice melting, especially over Barents/Kara Sea, in early winter is one of the key factors for the weakening of stratospheric polar vortex, which, in turn, induces a negative AO anomaly at the surface.

Impact of Arctic sea-ice retreat on the recent change in cloud-base height during autumn

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[2]*Research Institute for Global Change, Japan Agency for Marine-Earth Science and Technology, Yokosuka, Japan*
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Cloud-base observations over the ice-free Chukchi and Beaufort Seas in autumn were conducted using a shipboard ceilometer and radiosondes during the 1999-2010 cruises of the Japanese R/V Mirai. To understand the recent change in cloud base height over the Arctic Ocean, these cloud-base height data were compared with the observation data under ice-covered situation during SHEBA (the Surface Heat Budget of the Arctic Ocean project in 1998). Our ice-free results showed a 30 % decrease (increase) in the frequency of low clouds with a ceiling below (above) 500 m. Temperature profiles revealed that the boundary layer was well developed over the ice-free ocean in the 2000s, whereas a stable layer dominated during the ice-covered period in 1998. The change in surface boundary conditions likely resulted in the difference in cloud-base height, although it had little impact on air temperatures in the mid- and upper troposphere. Data from the 2010 R/V Mirai cruise were investigated in detail in terms of air-sea temperature difference. This suggests that stratus cloud over the sea ice has been replaced as stratocumulus clouds with low cloud fraction due to the decrease in static stability induced by the sea-ice retreat. The relationship between cloud-base height and air-sea temperature difference (SST-Ts) was analyzed in detail using special section data during 2010 cruise data. Stratus clouds near the sea surface were predominant under a warm advection situation, whereas stratocumulus clouds with a cloud-free layer were significant under a cold advection situation. The threshold temperature difference between sea surface and air temperatures for distinguishing the dominant cloud types was 3 K. Anomalous upward turbulent heat fluxes associated with the sea-ice retreat have likely contributed to warming of the lower troposphere.

References

Sato, K., J. Inoue, Y.-M. Kodama, and J. E. Overland, 2012: Impact of Arctic sea-ice retreat on the recent change in cloud-base height during autumn. Geophys. Res. Lett., 39, L10503, 6pp doi:10.1029/2012GL051850.

G1–O13

PAN EURASIAN EXPERIMENT (PEEX) – TOWARDS A NEW MULTINATIONAL ENVIRONMENT AND CLIMATE RESEARCH EFFORT IN EURASIA

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ABSTRACT Boreal forests are the major source of greenhouse gases, biogenic volatile organic compounds (BVOCs) and natural aerosols, the critical atmospheric components related to climate change processes. Major fraction of boreal forests of the world is situated in Siberian region. Representative measurements of carbon dioxide (CO_2) and methane (CH_4) concentrations, BVOC emissions and aerosols production from Siberian are of special importance when estimating global budgets of climate change relevant factors. The scope of a new concept of the Pan Eurasian Experiment (PEEX) is to set up a process for planning of a large-scale, long-term, coordinated observations and modeling experiment in the Pan Eurasian region, especially to cover ground base, airborne and satellite observations together with global and regional models to find out different forcing and feedback mechanisms in the changing climate. University of Helsinki together with Finnish Meteorological institute are organizing the Pan-Eurasian Experiment and to gather all the European and Russian key players in the field of climate and Earth system science to plan the future research activities in the Pan-Eurasian region. The approach starts with the series of workshops in October 2012 and writing the overall Science Plan for Pan-Eurasian experiment. This series of workshops is linked to several national and international research actions and projects. In the European scale PEEX is part of the JPI Climate Fast Track Activity 1.3. “Changing cryosphere in the climate system – from observations to climate modeling”. PEEX research topics are closely related the NordForsk’s Top Research Initiative CRAICC – Cryosphere – atmosphere interaction in the changing Arctic climate. PEEX is also a central part of the ongoing the Finnish Cultural Foundation – Earth System modeling Working Group activity (2012-2013). PEEX scientific aims and future actions to develop Pan Eurasian research infrastructure can be linked to several EC and ESA funded activities aiming to develop next generation research infrastructures and data products: EU-FP7-ACTRIS-I3-project (Aerosols, Clouds, and Trace gases Research InfraStructure Network-project 2011-2015); ICOS a research infrastructure to decipher the greenhouse gas balance of Europe and adjacent regions; EU-FP-7 e-infra ENVRI “Common Operations of Environmental Research Infrastructures” project. New Siberian research infrastructure and data products should be developed in line with the ACTRIS, ICOS and ENVRI approaches. Furthermore, The Pan-Eurasian Experiment will be supported iLEAPS (Integrated Land Ecosystem – Atmosphere Processes Study) bringing the PEEX under umbrella of the International Geosphere-Biosphere Programme (IGBP). The permafrost regions and boreal forests of the Pan Eurasian area can be identified as a hot spot of climate change research in a global scale. PEEX experiment can be considered as a crucial part of the strategic aims of several international and national roadmaps for climate change research and the development of next- generation research infrastructures.

G1–O14

ENHANCED POLEWARD ATMOSPHERIC MOISTURE TRANSPORT AMPLIFIES NORTHERN HIGH-LATITUDE WETTING TREND

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Observations and greenhouse-gas-emissions-forced climate change projections have indicated a wetting trend in northern high latitudes and Arctic, evidenced by increasing Eurasian Arctic river discharges. The increase in river discharge has accelerated in the latest decade, and an unprecedented, record-high discharge occurred in 2007 along with an extreme Arctic summer sea-ice-cover loss. Studies have ascribed this increasing discharge to various factors attributable to local global-warming effects, including intensifying precipitation minus evaporation, thawing permafrost, increasing greenness, and reduced plant transpiration. However, no agreement has been reached and causal physical processes remain unclear. Here we show that enhancement of poleward atmospheric moisture transport (AMT) decisively contributes to increased Eurasian Arctic river discharges. Net AMT into the Eurasian Arctic river basins captures 98% of the gauged climatological river discharges. The trend of 2.6% net AMT increase per decade accounts well for the 1.8% per decade increase in gauged discharges, and also suggests an increase in underlying soil moisture. A radical shift of the atmospheric circulation pattern induced an unusually large AMT and warm surface in 2006-07 over Eurasia, resulting in the record high discharge. The result from this study has significant implications for better understanding Arctic climate system changes and its interplay with global climate system.

S5–O1

GRENE-ARCTIC CLIMATE CHANGE RESEARCH PROJECT: STRATEGY AND IMPLEMENTATION

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GRENE-Arctic project is a new initiative of Arctic study by more than 30 Japanese universities and institutes as the flame work of GRENE (Green Network of Excellence) of MEXT (Ministry of Education, Culture, Sports, Science and Technology, Japan). The new Arctic Climate Change Research Project “Rapid Change of the Arctic Climate System and its Global Influences” has started in 2011 with strategic research targets:

- Understanding the mechanism of warming amplification in the Arctic
- Understanding the Arctic system for global climate and future change
- Evaluation of the effects of Arctic change on weather in Japan, marine ecosystems and fisheries
- Prediction of sea Ice distribution and Arctic sea routes

This project aims to realize the strategic research targets by executing following studies:

・Improvement of coupled general circulation models based on validations of the Arctic climate reproducibility and on mechanism analyses of the Arctic climate change and variability
・The role of Arctic cryophere in the global change
・Change in terrestrial ecosystem of pan-Arctic and its effect on climate
・Studies on greenhouse gas cycles in the Arctic and their responses to climate change
・Atmospheric studies on Arctic change and its global impacts
・Ecosystem studies of the Arctic ocean declining Sea ice
・Projection of Arctic Sea ice responding to availability of Arctic sea route

- Changes in the Arctic ocean and mechanisms on catastrophic reduction of Arctic sea ice cover
- Coordinated observational and modeling studies on the basic structure and variability of the Arctic sea ice-ocean system
- Sea ice prediction and construction of ice navigation support system for the Arctic sea route.

S5–O2

ARCTIC CHALLENGE – OUR RESEARCH STRATEGY FOR ARCTIC CLIMATE CHANGE

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The changes in the Arctic are highly substantial and rapid, and different parts of the Arctic climate system are involved. The Arctic sea ice extent is retreating at an alarming rate, reaching its new record low in September 2012. The ocean and surface temperatures are rising. The recent temperature rise in the Arctic is about twice as much as the global average. Concurrent with these changes the Greenland ice sheet is thinning, and permafrost is thawing, which inevitably bring other changes in the Arctic hydrological cycle and ecosystems.

The Arctic is said to be the precursor of our changing planet. There is no doubt that the ice-albedo feedback can accelerate warming of the ocean and melting of sea ice. But beyond that, the Arctic change likely results from a complex combination of different factors. The roles of solar activities, ozone depletion, aerosols, water vapor, clouds, carbon and land processes and other factors involved in the Arctic change await better explanation and clarification.

In this presentation we will provide an overview on part of the GRENE Arctic Climate Project, a joint perspective from Modeling, Land Process, Atmosphere, Cryosphere, and Carbon Cycle Groups, and discuss our integrated strategy for investigating underlying mechanisms and relative contributions from different factors relevant to Arctic change and global impacts. In particular three steps, identification, assessment and synthesis, are set. The key in the identification step is to fully appreciate Arctic climate as complex and woven in the global climate system. For the synthesis step we address the question of how much of contributions are from different feedback processes and mechanisms to the recent (post 1970s) Arctic warming, before extending the question to the early 20C Arctic warming and to future prediction. The critical step is the assessment of temporal, for instance seasonal, dependence among different feedbacks and processes from both observational and modeling views. By this, we look into the picture of how multiple feedback processes act as an interacting process – a view perhaps necessary to explain the rapidness of the Arctic change.

S5−O3

How vegetation change contribute to polar amplification in warm climate?

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In projections of future global change induced by CO2 emission using general circulation models (GCMs), globally averaged surface air temperature increase is ranged between at the end of 21st century range from 2K to 4.5K, even higher in the high latitudes, known as the 'polar amplification'. We investigated the contribution of vegetation change to global warming and polar amplification in elevated atmospheric CO2 condition and orbit-induced condition using an atmosphere-ocean-vegetation coupled GCM. Paleo-evidences indicate that mid-Holocene (6ka) and the last inter glacial (125ka) were warmer and more humid than present-day, caused by a different shortwave radiation pattern which corresponds to earth's orbit at that time. For example, annual averaged temperature over northern hemisphere continent is about 2K warmer in 6ka than that of today. By comparing the role of CO2 and orbital elements, we suggest difference mechanisms of vegetation feedback to the atmosphere in these two kinds of warming

experiments.

COMPARISON OF XCO_2 SIMULATED BY NIES TRANSPORT MODEL AND OBSERVED BY GOSAT IN POLAR REGIONS

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The Polar Regions are large carbon reservoirs in the world. However, carbon cycle in the Polar Regions remains poorly investigated due to the insufficient observations. The Greenhouse gases Observing SATellite (GOSAT) was launched on 23 January 2009 to monitor the global distributions of greenhouse gases (CO_2 and CH_4) from space. The main aim of GOSAT is to fill gaps in the ground-based observation network. However, the GOSAT retrieval algorithms are under continuing development and require reliable data for evaluation.

In this work, we compared column-averaged dry air mole fractions of atmospheric carbon dioxide (XCO_2) simulated by the National Institute for Environmental Studies (NIES) offline three-dimensional chemical transport model (TM) and observed by GOSAT in Polar Regions. The GOSAT data were retrieved using the photon path length probability density function (PPDF) method developed by Oshchepkov et al., 2008. We performed multi-annual simulations of CO_2 using NIES transport model (version NIES-08.1i), driven by JRA-25/JCDAS reanalysis data (Belikov et al., 2011). In the study NIES TM was implemented with a 2.5˚ × 2.5˚ horizontal resolution and 32 vertical levels in a hybrid sigma-isentropic (σ−θ)) coordinate system consisting of terrain-following and isentropic levels switched smoothly near the tropopause.

The CO_2 simulation was started with the initial distribution derived from GLOBALVIEW-CO2 observations using prescribed fluxes. The following source components of CO_2 were considered in the three different scenarios: 1) Fossil fuel emissions are derived from the EDGAR-1998 distribution and scaled using the growth rate obtained from the Carbon Dioxide Information Analysis Center (CDIAC). The climatological inversion flux represents all non-fossil source/sink distributions over land and ocean, derived by inverse modelling with 12 TransCom3 models and from observational data obtained from GLOBALVIEW-CO2 at 87 sites during 1999–2001. This combination was used in the Comprehensive Observation Network for Trace gases by AIrLiner (CONTRAIL) Transport Model Intercomparison (TMI) (Niwa et al., 2011). 2) Monthly mean CO_2 fluxes for 64 regions from June 2009 to May 2010 are estimated by inverse model of atmospheric transport based on Fixed Lag Kalman Smoother using monthly averaged Globalview-CO2 observations (Takagi et al., 2011). 3) The 3-hourly inverse model-adjusted fluxes obtained by optimizing the surface fluxes of CO_2 using the LMDZ model for the period 2000-2010 on a 3.75x2.5 deg lat/lon grid (Chevallier et al., 2010).

Before comparison with GOSAT data the simulated XCO_2 was evaluated against daily ground-based high-resolution Fourier Transform Spectrometer (FTS) observations measured at twelve sites of the Total Carbon Column Observing Network (TCCON).

S5–O5

FORECAST OF SUMMER SEA-ICE EXTENT IN THE ARCTIC BASED ON WINTER ICE MOTION

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With recent attention to the decrease of the Arctic ice area in the context of global warming, a greater understanding of sea-ice processes is required. Interannual variability with sorter timescales is more noticeable than the long-term reduction. This study examines one of the factors controlling the variability, the relationship between interannual difference in winter ice motion and ice area in the following summer.

Daily ice velocity products with resolutions of 37.5 and 75 km are prepared using the satellite passive microwave sensors Advanced Microwave Scanning Radiometer for EOS (AMSR-E) and Special Sensor Microwave Imager (SSM/I). The ice motion becomes more active in the last several decades. Derived daily ice motion reveals the dynamic modification of the winter ice cover. The winter ice divergence/convergence is strongly related to the summer ice cover; the correlation coefficient between the winter ice convergence and summer ice area ranges between 0.5 and 0.9 in many areas. This relation indicates that the winter ice redistribution controls the spring ice thickness and the summer ice cover. Based on this relation, we propose a method to predict the summer ice area in the Arctic. This medium-term forecast (looking several months ahead) is useful for human activity in the Arctic, for example to determine whether or not the shipping route through the Arctic will be navigable.

CROSS-DISCIPLINARY RESEARCH COLLABORATION FOR EARLY DETECTION OF BIOLOGICAL FEEDBACKS

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To predict global climate change and its influence on ecosystems and human societies, reliable understanding of land surface - atmosphere interactions is essential. We will report current status and issues of international cross-disciplinary research collaborations focusing on early detection of biological feedbacks to climatic change. One of our urgent tasks is to develop monitoring systems for the spatial distribution and temporal variation of fluxes of energy, water, carbon and various biogenic trace gases at scales ranging from point to continental. Relevant programs and the potential of collaboration will be introduced based on Asian regional activities in international projects such as iLEAPS*, FLUXNET**, and ILTER network***.

Positive biological feedbacks include higher temperatures bringing higher emissions of GHGs (CO_2 and CH_4) and irreversible changes that may occur in vulnerable ecosystems such as permafrost and peatlands. Negative feedbacks include higher temperatures expanding the growth area of plants in arctic regions and the rising atmospheric CO_2 concentration enhancing the growth rate of plants by a fertilization effect. To detect such biological feedbacks in regional and continental scales, cross-disciplinary research collaboration helps scientists develop integrated long-term observation networks. In mid-latitudes, JapanFlux (a sub-network in FLUXNET) and JaLTER (Japan national network in ILTER) have started working together by sharing sites, data, and observational skills toward maintaining long-term comprehensive observation networks. The long-term ground observations of phenology are also expanding using spectral radiometers and camera images for verification of satellite remote sensing.

Cross-disciplinary research collaboration at integrated observations helps us develop comprehensive datasets, which accelerate the development and testing of various process-based ecosystem models. Long-term ground-truth datasets with appropriate spatial resolution will have high value for direct comparison with airborne and satellite remote sensing. The research communities growing at integrated observation platforms will also contribute to educating the next generation of scientists by bridging different disciplines.

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*iLEAPS: integrated Land Ecosystem - Atmosphere Process Study; the land-atmosphere core project of the International Geosphere-Biosphere Programme (IGBP).

**FLUXNET: The worldwide network of monitoring sites for energy, water vapor, and CO_2 fluxes over terrestrial ecosystems;. an iLEAPS recognized project.

***LTER network: International Long Term Ecological Research; an endorsed network of the Global Land Project (GLP), a joint core Project of IGBP and the International Human Dimensions Programme (IHDP).

G5–O2

LONG TERM VARIABILITY OF CARBON IN PERMAFROST-DOMINATED ECOSYSTEMS

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This report is compiled on the results of multi-year investigations conducted within the frameworks of international scientific programs in cooperation with scientists from Japan and European Union on the study of carbon and water cycles in permafrost region, as well as execution of thematic plans of the IBPC SB RAS.

For the first time in the conditions of Eastern Siberia an attempt has been made to ground the photosynthetic productivity of plants in terms of physiology, and quantitative parameters of the productive process were obtained. Original data on sink-source system of plants are stated at the levels of whole plant organism and community. A number of specific results have been got: 1) conclusion was made about high depositing role of the root system of high latitude plants; 2) micrometeorological estimates of carbon balance were done; 3) quantitative dependence of CO_2 concentration on the season period, weather condition and forest fire intensity was shown; 4) carbon parameters of forest and tundra ecosystems were investigated; 5) attention was drawn to short vegetative period of plant development – this feature contributes to enrichment of the atmosphere of high latitudes by carbon dioxide.

The growth of plant species in Eastern Siberia during growing season is provided by high rates of photosynthesis and transpiration at relatively low dark expenses on respiration and maintenance. High inter annual variability of photosynthesis and dark respiration testifies to high adaptability of plants to the specific conditions of cryolithozone.

The productive process of plant species in Eastern Siberia is limited both by endogenous (stomatal conductance) and exogenous (provision with moisture and nutrients, nitrogen specifically) factors.

Permafrost forest and tundra ecosystems at present are estimated by carbon budget as areas of significant carbon sink. However, under predicted climate warming, their functions as carbon absorbers will essentially depend on the result of coordination of antagonistic processes: 1) increasing of carbon accumulation owing to prolonged vegetative period and elevated summer air temperatures; 2) frequency raise of forest fires that result in increased carbon dioxide emission into the atmosphere.

G5–O3

ESTIMATING LARGE SCALE, REGIONAL, NET CO_2 AND CH_4 FLUXES USING NESTED TOWER, AIRCRAFT FLUX, REMOTE SENSING, AND MODELING APPROACHES

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Estimating current and predicting future greenhouse gas fluxes from the Arctic is of great importance but is also exceedingly difficult. In addition to remote locations, logistic limitations, and difficult environmental conditions, especially during non-summer periods, landscape heterogeneity make measuring, quantifying, and modeling greenhouse gas fluxes challenging. Here we investigate some of the implications of landscape heterogeneity on GHG fluxes in the Arctic, and consider how these can be measured and scaled to better inform current and future generations of land surface models dealing with arctic regions. Landscape heterogeneity and microtopography affect processes that control CO_2 and CH_4 fluxes in a non-linear fashion. It is therefore currently not possible to describe, “average conditions” or “average responses” to a change in temperature or moisture for a region of the Arctic that adequately describes current or predicts future fluxes. A combination of measurements from plot to aircraft scales and nested models can be used to evaluate current understanding and develop new algorithms for the next generation of LSM for Arctic areas.

G5-O4

Cancelled

G5–O5

Impact of Climate Change on ecosystem functioning and GHG emission in Arctic tundra across multiple scales

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Arctic tundra ecosystem present a large level of heterogeneity, in terms of species composition, micro-topography, and greenhouse gas (GHG) emission. In particular, GHG emission (CH4 and CO2) may double even in the meter scale, making very challenging to scale up these fluxes to the regional and global scale. On the other hand, another challenge may arise from understating if these large scale investigations allow us to understand the response of arctic ecosystems to climate change. In this presentation I will introduce some of these important issues and describe the results from several years of research in the Arctic tundra in Alaska, and the challenges that I am planning to address with my future research.

G5–O6

REMOTE SENSING OF DECIDUOUS SHRUBS AND PHYTOMASS IN ALASKAN ARCTIC TUNDRA

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The relationships among spectral indices, phytomass, and plant functional types were determined through field observations of moist acidic tundra (MAT), moist non-acidic tundra (MNT), and heath tundra (HTT) in the Toolik Lake Long Term Ecological Research (LTER) site and sedge-shrub tundra (SST) in the Arctic National Wildlife Refuge (ANWR), Alaska, USA. For MAT, MNT, and HTT, among aboveground phytomass, aboveground vascular phytomass, and vascular plant green phytomass, the last showed the best fit to an exponential function of the normalized difference vegetation index (NDVI). Overall, the vascular plant green phytomass was more strongly correlated to exponential functions of NDVI and two-band enhanced vegetation index (EVI2) (The coefficients of determination (R^2) of 0.59 and 0.57, respectively) than to the other spectral indices. On the other hand, for deciduous shrub green phytomass, the strongest correlation was with the product of an exponential function of EVI2 and a spectral index (B+G–R)/(B+G+R) (DSI, R^2 of 0.66). Here, B, G, and R denote the blue, green, and red bands, respectively. Results offer empirical evidence that a new spectral index DSI provides the distributions of deciduous-shrub and leaf carbon and nitrogen turnovers, which influences on the interactions between the tundra ecosystems and the atmosphere.

G5–O7

The climatic effect to North Eurasia ecosystems. Analysis of 30-years satellite data

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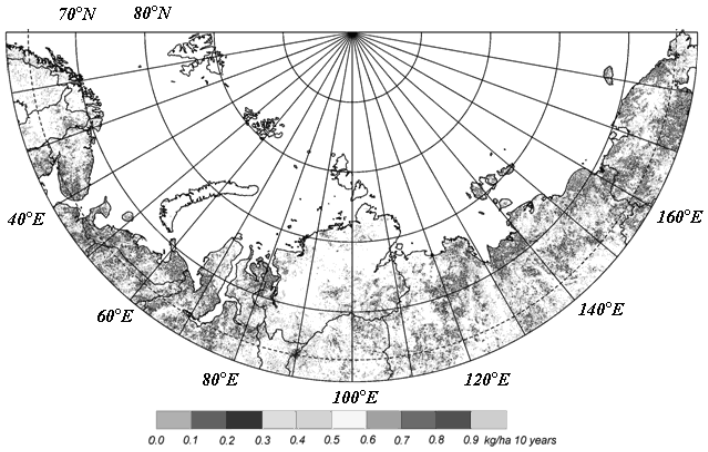
The temporal series of satellite images NOAA-AVHRR (1982-2006 years period, 15 days periodicity), SPOT-Vegetation (1998-2004 years, 10 days periodicity), Terra-MODIS (2000-2009 years, 16 days periodicity), Landsat (1973-2010 years, episodically) were used for selection of statistically significant trends of natural positive and negative dynamics of vegetation production. The selected plots of North-Europe Russia were investigated by geobotanical and aerovisual methods then. The increasing of vegetation community's biomass was mainly related with growing amount and biomass of shrubs in areas with constant permafrost soils. On basis of comparable analyses of time-series satellite data was developed technology for quantitative estimation of features of vegetation in model area (carbon accumulation, projective chlorophyll content, biomass, productivity). Estimation of seasonal changes of parameters of native vegetation for years of first decade of 2000 demonstrate more stable level of variations for area then early supposed. The trend of increasing of aboveground green biomass in this regions is near 7-30 kgC*ha per year $^{-1}$. The investigation was supported by program of scientific research of UrD RAS «Reaction of cryolithozone ecosystems of European North and west Siberia to climatic fluctuation» (*12-C-4-1018*).



The model of intensity of projective chlorophyll dynamic changes in vegetation for North Eurasia for 2000-2011. The MODIS satellite data.

Ground-truth for satellite observation by performing daily field studies in an open-canopy black spruce forest in Alaska and a closed-canopy evergreen coniferous forest in Japan

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Evergreen coniferous forests are widely found across cool-temperate and boreal regions, and accurate *in site* and satellite observations of the spatio-temporal dynamics of such forests are required to evaluate the carbon, water, and energy balances under global climate changes. Recent studies identify that daily digital photographs are useful to evaluate relationships among phenology, gross primarily productivity (GPP) and meteorological parameters, and to obtain ground-truth of satellite observations. In this study, we examined the characteristics of relationship between seasonal patterns of red, green and blue digital numbers extracted from daily canopy surface images, eddy-covariance-based GPP and satellite-observed vegetation indices by performing field studies in an open-canopy black spruce forest in Alaska and a closed-canopy cedar forest in Japan. Although the ratio of green digital number to total digital numbers, green excess index (GEI) and one of image characteristic index; hue (in HSV colour model) showed the bell-shaped seasonal patterns as well as GPP at both sites, canopy surface images at an open-canopy black spruce forest and a closed-canopy cedar forest mainly detected the seasonal changes of forest floor vegetation and tree canopy, respectively. In contrast, the different seasonal patterns of the ratios of red and blue digital numbers to total digital numbers and satellite-observed vegetation indices were shown between two sites. They might be caused by different characteristics of forest structure and leaf colour change on canopy surface. These facts suggest that characteristics of forest structure such as a degree of canopy openness and seasonal changes on forest floor should be considered to continuously observe phenology in evergreen coniferous forests by using near-surface and/or satellite remote sensing techniques.

S2–O1

Acceleration of the arctic water cycle: evidence from the Lena Basin, Siberia

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Trends and feedbacks in arctic hydroclimatology are explored from station observations and a land surface model. Our analysis of the Lena river basin in Siberia shows canonical acceleration of the hydrologic cycle and amplification of warming, despite several apparent paradoxes. Data analysis shows that though most of warming in the Lena basin is occurring when the ground is covered by snow, increases in frozen precipitation are contributing to permafrost thawing by increasing insulation. Hydrologic baseflow is increasing due to a deepening active layer. A deeper active layer holds mode soil moisture and is leading to increasing evapotranspiration (shown in the model), increased hydrologic baseflow (modeled and observed), and increased summer cloudiness (observed). Earlier onset of snowcover in autumn traps the modest summer warming, further deepening the active layer. These observed and modeled feedbacks point to an increasingly wet Arctic.

RECENT VEGETATION FIRE INCIDENCE IN RUSSIA

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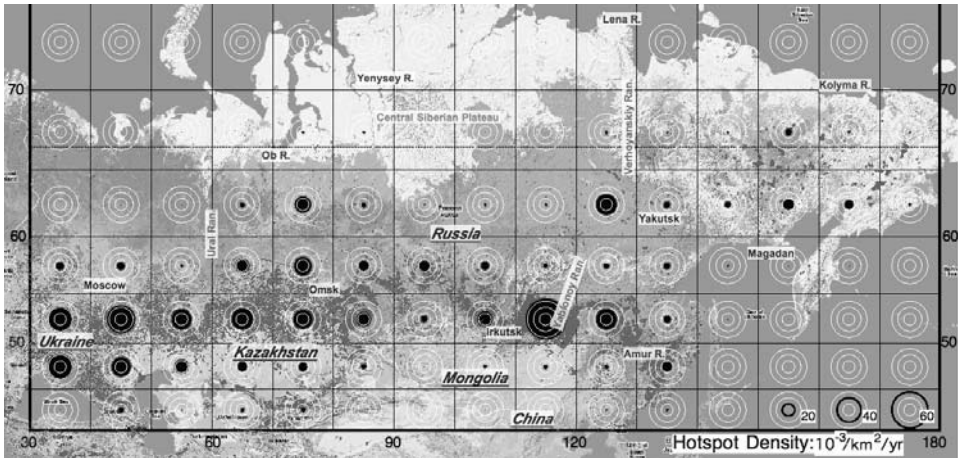
Vegetation change due to fire incidence, deforestation, cultivation and so on in Russia may have great effect on recent rapid climate change because the Russian Federation is the largest country in the world (total area: 17,075,400 km^2) and contains about 6,200,000 km^2 of boreal forest. Remote sensing is the most effective tool for large countries like Russia because it is very hard to obtain exact and detailed forest fire data. Accumulated MODIS hotspot data from 2002 to 2012 may allow us to assess recent changes in the vegetation fire incidence in Russia. Fire intensity and severity, burnt area, fire return interval, and emission of greenhouse gas such as CO_2 were estimated by using various satellite data. This paper discusses recent changes in the incidence of vegetation fires across the entire area of Russia based on analysis results of MODIS hotspot data. Firstly, Russia and its vicinity (covered area: 30-75°N, 30-180°E) were divided into 135 regions with equal intervals of 5° latitude and 10° longitude. By introducing an annual mean hotspot density measure (AMHD, number of hotspots/km^2/yr), Russian regional and seasonal fires were determined. In addition to this analysis, a detailed analysis was carried out for the Yakutsk region of Sakha using long-term weather data from 1830 to the present, recent daily weather data, hotspot data in 2002, and other data. The background to the intense fire activity near Sakha was determined by showing drought conditions and the daily changes of air temperatures.



S2–O3

VEGETATION GROWTH AND METHANE EMISSION AT TAIGA–TUNDRA BOUNDARY ECOSYSTEM IN EASTERN SIBERIA

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Recent warming is affecting the terrestrial system in Arctic region. Terrestrial system is expected to be greatly affected by warming not only through temperature rise but also degradation of permafrost system. Moisture condition caused by the change in permafrost may bring about a change in vegetation and greenhouse gas emission, then, as a result feedbacks to the global climate system. GRENE Arctic Climate Change Research Project funded by the Ministry of Education, Culture, Sports, Science and Technology, Japan, started in 2011. One of the research projects, “Change in the terrestrial ecosystem of the pan-Arctic and effects on climate”, is for terrestrial ecosystem of Arctic (GRENE-TEA).

Taiga-tundra boundary is an ecotone which is sensitive to environmental change, therefore, strong impact of warming on terrestrial system is expected. To know the response of the system, observations on vegetation (growth, photosynthesis, C and N contents and their isotope ratio, and nutrient status for larch trees) and methane dynamics with permafrost hydrological processes were conducted at taiga-tundra boundary ecosystem near Chokurdakh (70N, 148E) in eastern Siberia, Yakutka, Russia. Distribution of larch trees (dominant species) was depending on the moisture condition which reflected the topography, while, larch tree growth seemed to be controlled by radiation. Nitrogen availability may also affect the growth of larch trees. Methane emission also depended on the surface vegetation.

THAW LAKE EVOLUTION AND LONG TERM CARBON EMISSION FROM PERMAFROST.

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Thaw (thermokarst) lakes have attracted attention as major sources of CH_4. This source may increase as a result of climate change in the future, resulting in a positive feedback in the climate system. This interesting link between gemorphology and the carbon cycle is reviewed in this paper.

The evidence on thermokarst lake expansion is mixed, and shows stability, net contraction or expansion in various regions of the Arctic permafrost realm. The evidence may also differ with lake size: net expansion for smaller lakes and ponds, while the area of larger lakes contracts due to drainage of larger lakes. Next, evolution of lakes may differ in relation to physographic setting.

The assumption of the existence of a thaw lake cycle, that consists of a repeating cycle of lake formation by permafrost thaw, drainage of lakes and re-establishment of ice-rich permafrost, is crucial in the interpretation of lake area changes. The thaw lake cycle implies that expansion or contraction of thaw lake area may not necessarily relate to climate change. However, the existance of a thaw lake cycle is disputed.

Examples from eastern Siberia and Alaska also suggest a more complicated evolution. In the northeast Siberian lowlands, rapid lake expansion starts from existing lakes and appears restricted largely to areas with remnants of ice-rich Pleistocene permafrost. Localized pond formation appears the dominant mode of permafrost thaw. Lake expansion replaces dry terrestrial environments with CH_4 emitting lake environments.Terrestrialization mainly occurs by partial drainage after contact with rivers, resulting in integration of the lakes into the river floodplain. Talik development is probably insufficient for subsurface drainage of lakes. More complete lake drainage is likely to result only from river downcutting. Integration into the river floodplain may result in continued CH_4 emission but also carbon sequestration in sediments, complete drainage may result in a net greenhouse gas sink created by peat accumulation.

In more southerly located areas in eastern Siberia, subsurface drainage and changes in lake level by changes in precipitation and evaporation are more important. Evidence for a thaw lake cycle is absent (Pestryakova et al, 2012); most lakes originate from the Late Glacial and Early Holocene, although at present there is ample evidence of present-day lake formation and expansion.

Modeling of the evolution of thermokarst in ice-rich permafrost is still in its infancy. Hence, prediction of future lake area evolution is highly uncertain. Given the complexities of lake evolution, paleo-environmental research on lake sediment may prove to be crucial to understand past and future lake evolution and the resulting greenhouse gas emissions, and to improve existing models.

Pestryakova, L.A., Herzschuh, U., Wetterich, S., Ulrich, M 2012: Present-day variability and Holocene dynamics of permafrost-affected lakes in central Yakutia (Eastern Siberia) inferred from diatom records. Quaternary Science Reviews 51, 56-70.

S2–O5

UPSCALING OF METHANE FLUXES FROM ARCTIC WETLANDS USING PEATLAND-VU MODEL AND FOOTPRINT MODELING

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Arctic wetlands are considered to be a major natural methane (CH_4) source to the atmosphere. However, it is quite difficult to properly quantify CH_4 emissions from these areas on large scales due to high heterogeneity of vegetation cover and hydrological conditions.

We address this issue by using the process-based PEATLAND-VU model to estimate CH_4 emissions from different vegetation types and upscale them to eddy covariance scale by using Kormann & Meixner, 2001 analytical footprint model as well as high-resolution vegetation map. We then test our results against eddy covariance measurements of CH_4 collected at the Kytalyk Resource Reserve site in Russia.

Hitherto, CH_4 process models are rarely validated on ecosystem scale. Our upscaling of model results to eddy covariance scale shows that using this approach it is possible to reconstruct temporal dynamics of eddy covariance observations albeit with some mismatch. We are currently working on refinement of our method to produce more accurate comparison.

S2−O6

CH_4 AND N_2O DYNAMICS OF A *LARIX GMELINII* FOREST IN CONTINUOUS PERMAFROST REGION OF CENTRAL SIBERIA

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Methane (CH_4) and nitrous oxide (N_2O) are major greenhouse gases, and generally, forest soils are sink of CH_4 and source of N_2O. However, the climate of central Siberia is more continental than that of the other boreal forest regions because of lower temperature and smaller precipitation. To characterize of the gases dynamics in central Siberia, we measured CH_4 and N_2O fluxes from a forest soil in relation to floor vegetation types with soil temperature and moisture, the gases concentration in the soil air and river water. From the soil surface, both CH_4 uptake and emission were observed at the site. N_2O also were emitted and taken up into the soil. CH_4 flux increased with soil moisture, on the other hand, N_2O flux decreased with soil moisture. Therefore, N_2O uptake was occurred due to denitrification process. From the river water, both CH_4 and N_2O were emitted. Thus, in this region, it is considered that the forest soil acts as both source and sink of CH_4 and N_2O, however, the river acts as a source of both gases.

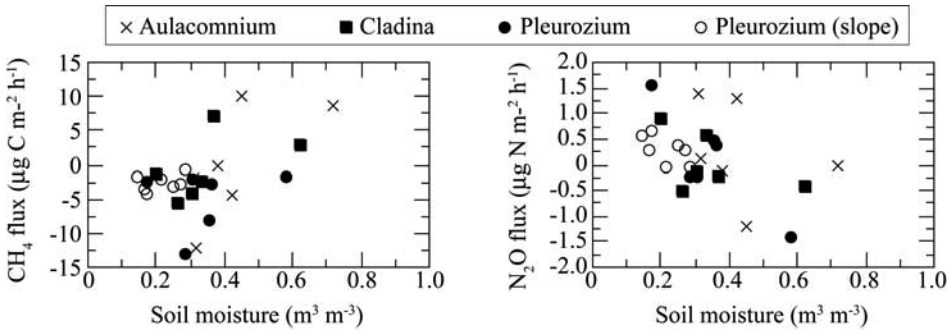

Figure Relationship between the CH_4 and N_2O flux and soil moisture.

G3–O1

GROUND THERMAL REGIME AND ACTIVE LAYER THICKNESS MONITORING AND MODELLING IN THE NORDIC AREA

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Since 2001 numerous shallow boreholes were equipped to monitor ground temperatures in the Nordic area, especially in Norway, Svalbard and Iceland. The total number of monitored boreholes is 42, of which 4 are located in Iceland, 20 in southern Norway, 16 in northern Norway and 12 in Svalbard. Most of these boreholes in northern Norway and Svalbard were established during the IPY campaign 2007-2009. They are set up to characterize the ground thermal regime in different environmental settings along altitudinal and continental transects, and to validate spatially distributed, equilibrium and transient permafrost models. Also as an important and integrative part of the IPY activities the Norwegian permafrost database, NORPERM was established. Most of the Norwegian permafrost data are today archived in the database, which is located at the Norwegian Geological Survey (NGU).

Permafrost data were used to calibrate a transient heat flow model for altogether 29 of our sites all over the study area. The model was forced with meteorological data over various time periods, ranging from the beginning of the instrumental data record at the end of the 18th century to down-scaled projections of climate scenarios for the future (2100). The results illustrate the potential evolution of permafrost conditions and the response to climate perturbations in sub-arctic mountains and high-arctic environments. Also the data were used to validate numerical spatial permafrost models for Norway.

Here we present the updated permafrost thermal state as observed in the borehole network, along with modeled ground temperature and active layer thickness (ALT) development since the end of the Little Ice Age and their potential future evolution. Also new spatial permafrost maps based on equilibrium and transient thermal modeling for the Nordic area will be presented.

G3–O2

PERMAFROST AND ACTIVELAYER MONITORING NETWORK IN ALASKAN COMMUNITIES

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The presence or absence of frozen ground has a strong effect on hydrology. Frozen soil acting as an impermeable layer affects water availability to root systems of plants and the recharge of groundwater reservoirs. The frost tube (active layer monitoring) program has been a great success in Alaskan communities because it is relatively easy to implement, is cost-efficient, and is a highly dynamic student activity. We have installed over 200 communities for a small one-channel data logger connected to an ground temperature sensor next to the frost tube. From the ground surface temperature data, freezing °C*days (freezing index) and thawing degree-days (thawing index) as well as mean annual temperature can be calculated. This program reveals much of the thermal structure of ground in Alaska, especially in many of the remote communities on the southern boundary of permafrost (i.e., the northern end of the seasonal frost region). Though there are many interesting aspects to this program, here we discuss (1) the distribution of the maximum freezing and thawing layer thickness, and (2) freezing and thawing °C*days ground surface distribution in Alaska.

THERMAL STATES OF MONGOLIAN PERMAFROST AND DEPLYOYING PERMAFROST OBSERVATORIES OVER THE ARCTIC

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Permafrost has been degrading over large areas of the world, although the warming rates show large spatial variations. Hence, it is important to organize and sustain to monitor the long-term thermal state of permafrost in various natural settings. We have been improving permafrost network over Mongolia, establishing new boreholes and recovering boreholes abandoned in the past. Currently available datasets showed that warming rate ranges between 0.01 and 0.03°C/a, and is more pronounced in the northern provinces with continuous permafrost. Permafrost partly disappeared at the southern boundary of the discontinuous permafrost in recent 30 years. Beside these country-scaled dynamics, strong influences of local geographic variations on permafrost temperatures could be observed. Cold permafrost occurs beneath topographic depressions, within ice-rich soils, and under forested slopes. Further applications of these borehole data are to develop high resolution permafrost map and to model future distribution of permafrost.

The permafrost dynamics over Mongolia would be the epitome of those in globe, since they involve the features of continuous, discontinuous, sporadic and mountain permafrost even in a small areas. Under the umbrella of GRENE and international collaborations, we are deploying permafrost observatories in Siberia and Canada where the spatial density of permafrost network is currently sparse.

PERMAFROST MAP IN RUSSIA USING COMMUNITY-BASED PERMAFROST AND ACTIVE LAYER MONITORING NETWORK

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In 2008, an approach to mapping permafrost based on thermal conditions was introduced during the Ninth International Conference on Permafrost (Jorgensen et al., 2008). This approach maps permafrost distribution using the annual mean air temperature model (PRISM) and surficial geology (the GIS platform). A thermal offset or gap occurs between air and ground surface temperatures mainly because of snow cover or other thermal effects. Use of the annual mean ground temperature model instead of air temperature will produce better results. Our community-based permafrost and active layer monitoring network measures ground temperature year-round at hundreds of locations. These data are useful for calibration or verification of the new model. The original objective of this network was to establish long-term permafrost monitoring sites near communities and schools so that students and teachers could be involved in installation of the monitoring equipment and data gathering. Permafrost condition is an important indicator of climate change, since permafrost is directly influenced by climate. Permafrost affects local ecosystems and hydrological regimes, and is a factor in natural disasters related to ground stability. Once we develop a station, data are available to the public for science, engineering, and education purposes. An important project related to the permafrost monitoring stations is the mapping/modeling of permafrost. Our community-based monitoring system will contribute to the production of a more-accurate permafrost map. With improved mapping/modeling in mind, we plan to finish the Alaska permafrost map, then develop the same method in Russia as in Alaska by establishing monitoring stations in Sakha Republic and other parts of Russia. To begin with, however, we will focus on establishing this network over the next several years.

G3–O5 Cancelled

PARAMETRIZATION OF RUNOFF FORMATION MECHANISMS IN MOUNTAINOUS PERMAFROST CONDITIONS OF RUSSIA AND CANADA (THE KOLYMA WATER BALANCE STATION AND WOLF CREEK RESEARCH WATERSHED)

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The parameterization of process-based hydrological models reflects natural conditions of runoff formation processes and should be developed and tested on the basis of detailed and long-term measurements at research watersheds. Very limited number of such catchments exists in the permafrost zone.

The aim of the study was the development of parameterization schemes describing mountainous territories of Russian Northern East and Canadian part of the Yukon River basin for the purposes of hydrological modelling.

The study included the following steps: i) comparative analysis of flow formation processes in two research watersheds of Russia and Canada at slope and catchment scales ii) deriving soil and vegetation parameters by additional sources of information and modelling experiments at slope scale iii) transferring the parameters from slope to catchment scale and performing runoff simulations iiii) analysis of the results and conclusion about workability and limitations of developed parameterization scheme.

Two research watersheds, the Kontaktovy Creek and the Wolf Creek basins (21.2 and 195 km^2 respectively) were studied. Although both of them are covered by permafrost and relate to the zone of mountainous taiga and tundra, they have significant differences in runoff formation mechanisms.

The Kontaktovy Creek basin is characterized by continuous permafrost while in the Wolf Creek basin permafrost occupies only northern slopes and headwaters. It leads to predominance of surface and shallow subsurface flow formed in active layer at the Kontaktovy Creek watershed, while the underground flow dominates in the Wolf Creek basin. At both watersheds different slopes show specific thermal and water regime due to difference in solar radiation income and dominant landscapes.

Observable land cover properties were derived from literature review and used as the model parameters to simulate soil thaw/freeze depths, soil moisture and temperature, snow accumulation and melting.

Soil and vegetation parameters were initially refined at slope scale on the base of multiple modelling experiments and then transferred to the watershed scale without change. Good agreement between observed and simulated runoff confirmed the effectiveness of the parameterization.

The Hydrograph model applied to both watersheds at slope and catchments scales is a process-based hydrological model. It adequately describes land hydrological cycle based on standard daily input information. Sufficient algorithm of water and heat dynamics in the soil enables to use this model in various condition of permafrost.

We propose that gained parameterization scheme and the Hydrograph model can be applied to ungauged and poorly gauged basins at the Yukon River in Canada and the Upper Kolyma River in Russia.

G3–O6

TEMPORAL SEQUENCING OF ANNUAL SPRING RUNOFF IN FOUR MAJOR ARCTIC-DRAINING RIVERS

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Warming in the Arctic has significance as an indicator of global climate change and through feedbacks to the global climate system. The influx of freshwater to the Arctic Ocean has the potential to influence global climate through modification of the intensity of the thermohaline circulation. This emphasizes the importance of understanding climate-discharge linkages in Arctic-draining rivers, which are the dominant source of freshwater input to the Arctic Ocean. To date, no research has evaluated trends in the magnitude and sequential timing of the spring freshets – the dominant hydrologic event occurring on these nival river systems – or of the atmospheric circulation patterns that control them. To address these shortcomings, historic daily discharge data from selected hydrometric stations within the four largest Arctic-draining watersheds (Mackenzie, Ob, Lena, Yenisei) have been analyzed to extract data about the timing, magnitude and characteristic shapes of the spring freshet hydrographs. Discussion of results focus on: the temporal sequencing of spring discharge at stations draining directly to the Arctic Ocean along the Mackenzie, Ob, Lena, and Yenisei rivers; the discharge linkages with controlling patterns of temperature and precipitation; and the major atmospheric teleconnection patterns associated with extreme high and low flow years.

ICE MOVEMENT IN THE LENA RIVER AND THE TYPOLOGY OF SPRING FLOOD: AN INTERPRETATION OF LOCAL SOURCES INTEGRATED WITH SATELLITE IMAGERY USING A MULTIDISCIPLINARY APPROACH

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Spring flooding of northern rivers in both Arctic and sub-arctic regions is a regular seasonal event. As snow and ice thaw, floating freshwater ice appears in the rivers and flooding occurs, which is critical for the regional ecosystem and for water circulation. Theoretically, climate change should have some effect on this phenomenon, but due to regional variations and the complex interplay of elements, scientific data on how the climate is altering the freshwater ice process is still unclear. At the same time, since the spring river ice process and flooding have definite effects on human societies, these are now becoming issues of focus and urgency for social scientists and disaster management policymakers. From the human-dimension perspective, river ice is an important regional infrastructure because it is used for major winter transportation and local subsistence activities. Understanding the process of river ice breaking and consequent flooding is important for interdisciplinary area studies because they are closely related to local societal-technological aspects and the regional environment. This paper explores the concrete process of spring flooding through a case study of the Lena River in eastern Siberia. Recently, the frequency of disastrous spring flooding has increased in this region. Although a decisive explanation is not yet available, the local government is urgently demanding adequate policies and measures. In what conditions does the process of spring flooding develop in the Lena River? We will describe concrete processes such as ice movement and velocity, the locus of the flooding outbreak, and the disastrous results. The method of analysis is an interpretative approach using multi-disciplinary data from satellite imagery, literature sources, and fieldwork. At the same time as Landsat or large scale resolution images of flooding from a bird's-eye view provides the general outlook, the information of ice monitoring and flood reporting from local newspapers will be visualized using GIS software (Google Earth), and ALOS satellite or high resolution imagery of a particular flooding event is interpreted based on anthropological field data. Through these means, we identify several types of flooding and examine their implications for human societies.

G3–O8

WATER BALANCE OF ARCTIC WETLANDS WITH DIFFERING ICE WEDGE POLYGON TYPE

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Ice wedge polygons are common in landscapes underlain by permafrost. Still, their role on watershed-scale hydrology is constrained. We combined field measurements with mass and heat transfer modeling to assess the effect of ice wedge polygon type on landscape-scale hydrologic fluxes and stores. The physically-based model WaSiM was applied to airborne LiDAR and schematic DEMs, and forced by climate data from an Arctic wetland, Barrow, Alaska. Simulations and field measurements were concentrated to four sites, i.e. landscape types: high-centered, low-centered, and two transition polygon sites (the latter having both low-centers and troughs). Model simulations suggest that low-centered polygons, through elevated rims, reduce runoff while increasing evapotranspiration and water storage. The high-centered polygon landscape favors runoff, while storage and evapotranspiration drastically decrease. Continuous field measurements in neighboring, individual ice wedge polygons presents drastically different seasonal variability in water tables between study sites, despite the same landscape-scale end-of-winter snowpack water storage. It is evident from the field and modeling analyses that microtopography plays an important role on low-gradient Arctic wetland watershed-scale hydrology. Further, the fine microtopographical variability results in hydrologic characteristics that can present important geomorphological feedbacks. A shift in ice wedge polygon type could potentially dominate the initial effects of altered climate on Arctic wetland hydrology.

VEGETATION WATER USE COMPARISON IN A SUB-ARCTIC, BOREAL FOREST ENVIRONMENT USING HYDROGRAPH ANALYSIS

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The sub-Arctic environment is in the zone of discontinuous permafrost. The extreme energy influx from winter to summer has a strong influence on water storage and release processes at the watershed scale. For example, the seven months of snow accumulation are followed by a short 2-4 week period of snow ablation in which approximately 1/3 of the annual precipitation is released into the watershed. In permafrost soils, the soils begin to thaw immediately at the conclusion of snow melt, increasing the storage capacity of the soils. The storage capacity of the soils reaches a maximum in late summer then rapidly decreases during the freeze-back period in October. In permafrost-free soils dominated by deciduous vegetation, the trees appear to have a major role in taking up and transpiring liquid precipitation to back to the atmosphere. Conversely, in permafrost soils dominated by coniferous vegetation, the trees appear to have a minor role in the cycling of liquid water during precipitation events.

The overarching goal of our research is to quantify the relative roles of vegetation water use and soil storage dynamics associated with permafrost presence/absence in determining the magnitude and timing of water pathways in the sub-Arctic boreal forest. As part of this goal, we quantified the Horton Index - a metric that describes vegetation water use relative to available soil water - in two small sub-basins of the Caribou-Poker Creeks Research Watershed, located near Fairbanks, Alaska. The C2 (5.2 km^2) and C3 (5.7km^2) sub-basins are underlain by approximately 2 and 53% permafrost, and are dominated by deciduous (*Betula neoalaskana* and *Populus tremuloides*) and coniferous vegetation (*Picea mariana*), respectively. Catchment scale calculations of the Horton Index are made using stream flow analysis and during snow-free precipitation events over a 13-year period. In each sub-basin, the Horton Index varies with time with the greatest variation occurring in the spring and fall shoulder seasons. During the middle of the summer growing season, the Horton Index reaches its maximum value (indicating the highest fraction of available soil water is taken up by plants) with generally larger values in the low-permafrost, deciduous dominated sub-basin. Results from this study will be used to compare results from a storage-based hydrologic model that is being developed to better understand the relationships between vegetation, permafrost, water and climate in the boreal forest ecosystem.

G3–O10

ICE COVER OF EURASIAN LAKES AND INLAND SEAS FROM SATELLITE AND IN SITU OBSERVATIONS

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Because of its response to regional and global variations in the climate system, arctic and sub-arctic lakes and internal seas are not only an integrator of climate processes, but also strong indicator of existing or potential change. It is important to well understand what are temporal and spatial scales of variability of natural parameters, what are teleconnections, feedbacks and mechanisms responsible for the changes, what are natural and anthropogenic causes of recent and historical changes in the hydrophysical and meteorological parameters. Changes in natural parameters are important for human activity (navigation, transport, fisheries, tourism etc) and affect large population living around.

We present studies of ice and snow cover of continental water bodies using the synergy of more than 15 years-long simultaneous active (radar altimeter) and passive (radiometer) observations from radar altimetric satellites (TOPEX/Poseidon, Jason-1, ENVISAT and Geosat Follow-On) complemented by SSM/I passive microwave data. Five largest Eurasian continental water bodies - Caspian and Aral seas, Baikal, Ladoga and Onega lakes are selected as examples. An ice discrimination approach based on a combined use of the data is presented, as well as validation of this approach using *in situ* and independent satellite data in the visible range. We then analyse the long-term evolution of ice conditions for these lakes and inland seas using historical data and recent satellite observations. We also present our results of the field studies on the lakes Ladoga and Baikal.

We address another interesting phenomenon - formation of giant rings on Baikal Lake ice. These rings (diameter 5-7 km, thickness of dark layer - 1 - 1.8 km) have almost perfect circular shape. The rings have been observed since the early 1970ies by satellite imagery in various regions of the lake. We present several existing hypotheses of the origin of these rings and discuss strengths and weaknesses of each hypothesis. We present observation of the formation, development and disappearance of these rings using various satellite data. We discuss the conditions needed to create and maintain these rings, the timing of and duration of their existence, as well as horizontal and vertical structure of ice and snow cover and of temperature and conductivity before and during the appearance of rings.

This research has been done in the framework of the Russian-French cooperation GDRI "CAR-WET-SIB", French CNES TOSCA AO, CNRS-Russia PICS BALALAIKA, Russian FZP 1.5 and FP7 "MONARCH-A" projects.

S3−O1

A unified view of the Greenland flow distortion and its impact on barrier flow, tip jets and coastal oceanography

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Abstract: A new diagnostic is developed that allows for a more complete view of the atmospheric flow distortion that arises from the high topography of Greenland. This flow distortion results in the frequent occurrence of high speed surface wind events, known as tip jets and barrier winds along the southeast coast of Greenland. Unlike previous diagnostics, it is able to partition the occurrence frequency of easterly and westerly tip jets that form in the vicinity of Cape Farewell, the windiest location on the ocean's surface. In addition, the diagnostic clearly identifies the 2 locations along the southeast coast of Greenland where barrier flow is enhanced and confirms previous work that indicated that these locations are collocated with regions of steep coastal topography. It also results in the identification of new regions, the northeast and southeast coasts of Greenland as well as the southeast of Iceland, where tip jets and barrier flow exist. Along the northeast coast, these high speed wind events are proposed to be associated with the formation of the North East Water Polynya as well as contributing to the southward advection of sea ice. Along the southwest coast, the high speed wind events, which result in a reversal of the wind direction, may contribute to the enhanced oceanic eddy activity in the region that plays an important role in the oceanography of the Labrador Sea.

S3−O2

BIOGENIC IMPURITIES DARKENING THE GREENLAND ICESHEET

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Studies have revealed that a part of the bare ice surface of the Greenland Icesheet appeared to be dark coloration compared with those in the surrounding surface. The area, dark region, is likely to melt greater because the dark-colored surface can absorb more solar radiation compared with the white clean ice. The possible causes of the darkening are impurities on the ice, such as mineral dust, black carbon, and organic matter. In particular, organic compornent derived from snow algae, cyanobacteria, and bacteria, may have significant effet of darkening since they usually contain substantial amounts of dark-colored humic substances. However, it is still unknown that where the impurities came from and how they appear and distribute on the surface. To understand dynamics of impurities and formation process of organic matter on the glacier, we investigated characteristics of impurities on Qaanaaq Ice cap located in the north-westen part of the Greenland in melting season of 2012.

Substantial amounts of impurities were found on both snow and ice surfaces. Microscopy revealed that the impurites consisted of mineral dust, snow algae, and other organic matter. In the ice area, they formed granular aggregates: cryoconite granules. The amount of impurities (dry weight) was greatest on the bare ice surface at the middele part of the ice cap, while that was smallest at the lowest site close to the terminus. In the snow area, red snow algae were blooming and visibly recognized. The red algal blooms were comfirmed from the snow line to the top of the ice cap, indicating that the algae appeared on the entire surface of the ice cap. Results suggest that organic matter deribed from snow algae plays a substantial role to darken the surface of the glacier.

S3−O3

ICE MASS LOSS IN NORTHWESTERN GREENLAND

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Greenland is losing ice mass under the changing climate conditions. Not only at the Greenland ice sheet which is currently drawing widespread attention, ice is rapidly decreasing at glaciers and ice caps that are physically separated from the ice sheet. Overview of the changes have been monitored by satellite observations, but further investigations including field measurements are required to capture the details and mechanisms of the changes.

To better understand the recent ice volume change and its drivers in Greenland, we have initiated a research project as a part of GRENE Arctic Climate Change Research Project. The goal of the project is to quantify the mass change of an ice sheet drainage basin and peripheral glaciers and ice caps in northwestern Greenland. Field and satellite data will be collected to accurately evaluate ongoing changes, and the data will be utilized to improve future prediction by numerical modeling. Our field base is Qaanaaq, a small village in the northwestern coast of Greenland. In the summer 2012, we performed field observations on an ice cap and reconnaissance of calving glaciers in the region. In this contribution, we present the overview of the research project and initial results of satellite data analyses and field activities in 2012.

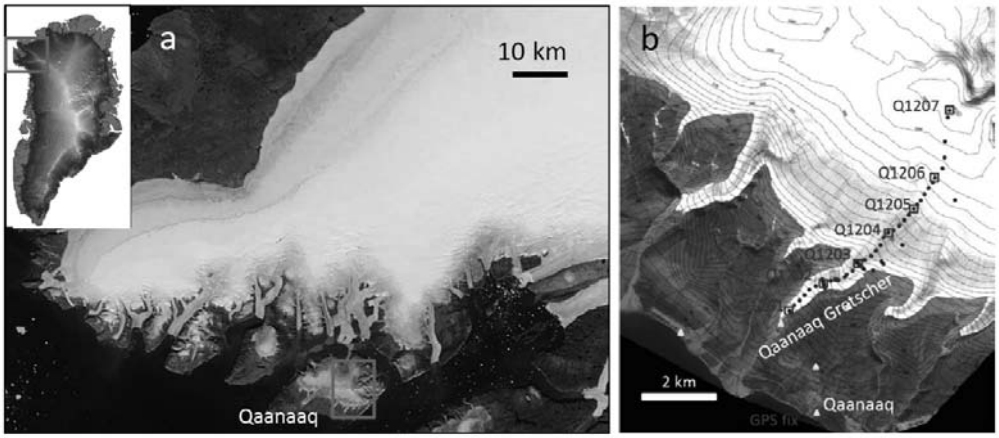

Figure 1. (a) Satellite image of the study area, northwestern Greenland. (b) The ice cap studied in the 2012 field campaign. Locations of survey stakes, GPS and ice radar measurement sites are indicated.

S3–O4

SENSITIVITY OF RESPONSE OF GREENLAND ICE SHEET TO GLOBAL WARMING ON SURFACE MASS BALANCE PARAMETERIZATION AND REFERENCE CLIMATE STATES

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We present a series of numerical experiments of Greenland ice sheet under global warming condition using Ice sheet model for Integrated Earth system Studies (I_CIES). In this study, influence on the simulation from the difference in the method to compute the surface mass balance is focused. Typically, ice sheet simulation is driven by a *reference-anomaly* method, in which the surface temperature and/or the accumulation are decomposed into the reference terms (e.g., observation), the anomaly (e.g., climate scenario from climate models). Then the surface melting is computed using parameterization such as positive degree-day (PDD) method with the temperature. These decomposed terms have own uncertainties, which may influence the ice-sheet simulation. In this study, impact of these properties to the present-day control case, as well as the response under uniform warming condition are discussed, which is thought be a useful and basic information of the property/sensitivity of the Greenland ice sheet.

G6-O1

Cancelled

G6–O2

Satellite remote sensing of primary productivity in the Bering and Chukchi Seas using an absorption-based approach

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Ocean colour remote sensing has been utilized for studies on primary productivity in the Arctic Ocean. However, phytoplankton chlorophyll *a* is not accurately predicted in the estimation model, because of the interference of coloured dissolved organic matter (CDOM) and non-algal particles (NAP). To enhance estimation accuracy, a phytoplankton absorption-based primary productivity model (ABPM) was applied to the Bering and Chukchi Seas.

The phytoplankton absorption coefficient was correctly retrieved from sea surface remote sensing reflectance (R_{rs}) and reduced the effect of CDOM and NAP in primary productivity (PP_{eu}) estimation. PP_{eu} retrieved from *in situ* R_{rs} using the ABPM satisfied a factor of 2 of measured values. PP_{eu} estimated from MODIS R_{rs} data were within the range of historical values. These estimated PP_{eu} was less than half of the chlorophyll *a* based model, and the difference between the two models reflected the influence of CDOM and NAP absorptions. Inter-annual variation in August and September for the period 2002–2010 showed an increase in primary productivity. The increase in 2007 was especially large, by a factor of 1.51–2.71, compared with 2006. The significant temporal increase in productivity detected here differs from earlier studies that detected little, if any, change in the region.

Keywords: Arctic Ocean, Chukchi Sea, Bering Sea, primary productivity, absorption coefficient, coloured dissolved organic matter (CDOM), ocean colour remote sensing

G6–O3

Macromolecular production of phytoplankton in the Northern Bering Sea, 2007

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Macromolecular production of phytoplankton was investigated in the northern Bering Sea in 2007, and the relationships between the production and environmental factors (nutrients, salinity, light, temperature, Chlorophyll-a) were examined. The productivity experiments for photosynthetic carbon allocations were conducted at three light depths (100%, 30%, and 1%) for nine different stations, using ^{13}C isotope tracer technique. The photosynthetic carbon allocations into different macromolecular classes (proteins, lipids, polysaccharides, and low-molecular-weight metabolites (LMWM)) of primary producers were determined based on the productivity experiments. The overall average allocations were 37.9% (S.D. = ± 18.8%), 26.6% (S.D. = ± 17.4%), 9.1% (S.D. = ± 7.8%), and 26.5% (S.D. = ± 20.7%), respectively, for LMWM, lipids, polysaccharides, and proteins. LMWM and polysaccharides had similar vertical patterns whereas lipids and proteins had reverse vertical patterns at all the stations. In our study, low incorporation into proteins and relatively high incorporation into lipids at 100% light depth would suggest that the phytoplankton had nitrogen limitation in the northern Bering Sea. In contrast, high incorporation into proteins and relatively low incorporation into lipids at 1% light depth suggest that phytoplankton had no nitrogen limitation during our study period. Based on a general pattern of macromolecular production in the northern Bering Sea, phytoplankton was a physiologically transitional phase from a unlimited status during our cruise period, 2007.

G6–O4

ISOLATION OF NEW STRAINS OF COCCOLITHOPHORE, *EMILIANIA HUXLEYI* FROM ARCTIC SEA AND THEIR CHARACTERIZATION

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The cosmopolitan coccolithophore *Emiliania huxleyi* widely is known as the most abundant bloom-forming coccolithophore. It becomes more prominent since the late 1970s in Eastern Bering Sea (Harada et al. 2012) as one of examples of changing ecosystem caused by global warming. In this study, we isolated Coccolithophore *Emiliania huxleyi* from Arctic sea and Bering Sea in order to characterize their growth to study on the effect of climatic change on phytoplankton community.

First, we collected seawater sample during the MR10-05 cruise of the R/V *MIRAI* and cultivated them after mixing with sterilized seawater enriched with the microelements of Erd–Schreiber's medium. After incubation for 5 months at 4°C, coccolithophores were found at 5 sampling sites from arctic sea to Bering Sea and isolated to establish clones. All these strains were identified to be *E. huxleyi*. We incubated *E. huxleyi* strains at 25, 20, 17, 10 and 4°C. All the 5 strains showed similar response to temperature. Interestingly, they could not survive at 25°C and it is very different from *E. huxleyi* strains isolated from warm region. Growth rates of subarctic strains at 4°C were not strongly diminished but maintained to a greater extent, namely ca. 1/3 of the maximum rate. The Arctic strains showed clear cold-tolerance. The optimum growth temperature of most of the *E. huxleyi* strains were around 20°C, irrespective of place where it was isolated. The mechanism how to keep cold tolerance is interesting to be elucidated. As arctic *E. huxleyi* strains can keep its growth even at higher temperature, raising of oceanic temperature by the global warming will not give serious damage on coccolithophore and associated with ecosystems in Arctic sea.

This work was supported by Grant-in-Aid for Scientific Research(S) Catastrophic reduction of sea-ice in the Arctic Ocean – its impact on the marine ecosystems in the polar region–.

Harada et al. (2012) Global Biogeochemical Cycles 26, GB2036.

G6–O5

FAUNAL TURNOVER AND SHELL DENSITY CHANGE IN THE ARCTIC SEA: RESPONSES UNDER OCEAN ACIDIFICATION

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It is deeply concerning about biological and geochemical influences of ocean acidification due to carbon emission by human activity. The reaction of atmospheric CO2 with seawater reduces pH and carbonate ions that are necessary for phyto- and zooplankton which produce CaCO3 skeletons. In the Arctic Ocean, it is considered that sea ice melting by global warming may change saturation states of calcium carbonate and production rates of marine calcifires (e.g. Coccolithophores, Planktic foraminifers, Pteropods, and Ostracods), therefore composition of Arctic ecosystem would be drastically changed in near future. Here we reported the results of sediment trap experiment to understand biogeochemical responses and effects of ocean acidification in the western Arctic Sea. We deployed two sediment traps in the Northwind Abyssal Plain (Stn. NAP10t, 75° N, 162° W, water depth: 1.975m) in the Arctic Sea from October 2010 to September 2011. The sediment trap had been deployed about 180 m (shallow) and 1,300 m (deep) water depths, respectively. In this study, we analyzed total mass flux (TMF) and assemblages of carbonate-shelled zooplankton. As the results, remarkable seasonal changes of TMF and carbonate-shelled zooplankton community had identified. It seems that carbonate-shelled zooplankton in the Arctic Ocean is close related with sea ice distributions. Furthermore, we developed a novel method to know shell density of carbonate-shelled zooplankton quantitatively by using micro-focus X-ray Computing Tomography technique. According to this, severe dissolution of aragonitic shells had been occurred at the shallow water depth. It suggests that freshwater that has lower Ω for aragonite affects shell density of marine calcifier.

G6–O6

YEAR-LONG MONITORING OF UNDER-ICE PHYTOPLANKTON ASSEMBLAGES IN THE ARCTIC BY ICE-TETHERED PROFILERS

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In September 2012 an Ice-Tethered Profiler (ITP) completed the first-ever year-long daily assessment of phytoplankton abundance in the water column under ice-covered Arctic Ocean waters. This new ability to observe seasonal trends in under-ice phytoplankton populations with such high temporal and spatial resolution provides critical data for understanding how climate-driven changes in the Arctic Ocean will affect these organisms, which are the foundation for primary production and biogeochemistry in these ocean ecosystems. A special bio-optical sensor suite was developed for this research, which represents the first sensor system for ITP platforms designed specifically to measure biological processes. This sensor suite uses optical approaches to measure properties related to phytoplankton biomass (chlorophyll fluorescence), the presence of other particles (optical scattering), and the concentration of colored dissolved organic material (UV excitation of fluorescence). Of particular interest in these data is the timing and duration of the increase in phytoplankton biomass in the spring, and the rapidity with which phytoplankton abundance decreases in the fall at the end of the growing season. Three more bio-optically equipped ITPs were added to the Arctic Observing Network in summer 2012, in the Canada Basin and in the Eurasian Basin, providing a substantial improvement in our ability to monitor under-ice phytoplankton in the Arctic, year-round on daily timescales. Preliminary data from these additional sites will be presented.

G6–O7

SINKING FLUXES OF DIATOM AND SILICEOUS FLAGELLATES IN THE NORTHWIND ABYSSAL PLAIN

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In order to understand time-series sinking fluxes of siliceous microplankton (diatoms, silicoflagellates, chrysophyte cyst, endoskeletal dinoflagellate *Actiniscus*, and ebridian) in seasonal sea-ice environment, sediment trap experiment was conducted at Station NAPt in the Northwind Abyssal Plain (75N 162W, 1975 m water depth) from 4 Oct. 2010 throughout 28 Sep. 2011. Two time-series sediment traps with 26 collecting cups were deployed at 180 m and 1300 m water depths. Total mass fluxes at both depths were relatively high in Nov.-Dec. 2010 and July-Aug. 2011. Chemical component analysis of sinking particles showed high dominance of lithogenic materials rather than biogenic components throughout the studied period. However, the relative increases of biogenic opal were observed in Nov.-Dec. 2010 and Apr.-Aug. 2011. Just after the initial decrease of summer sea-ice concentration at Station NAPt in late June, the sinking flux of silicoflagellate *Distephanus speculum* (= *Dictyocha speculum*) reached up to 2.3 $\times 10^4$ skeletons m^{-2} d^{-1}. The sinking diatom fluxes, which are mainly composed of *Fragilariopsis* spp., increased after the silicoflagellate flux peak. The highest diatom flux in summer was 5.5 $\times 10^6$ skeletons m^{-2} d^{-1}. During the high diatom flux period in July-August, abundant gelatinous materials such as house of *Appendicularia* were also contained in >1mm size fraction. The high total mass flux in summer is essentially explained by increased primary production under the sea-surface environment with seasonal sea-ice reduction and increased insolation. On the other hand, the high biogenic flux in Nov.-Dec. 2010 does not reflect the high primary production at Station NAPt due to limited light condition during polar night. The sinking flux of ebridian *Ebria tripartita*, which is mainly observed in the shelf of Chukchi Sea, increased in Nov. 2010. The large portion of high total mass flux in Oct.-Dec. 2010 is probably explained by lateral particle input into the Northwind Abyssal Plain from the Chukchi Sea shelf by the northward flow of North Pacific waters.

G2–O1

MONITORING THIN SEA ICE THICKNESS WITH MODIS

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Sea Ice is an important component of the climatic system. It affects the global energy budget as well as the oceanic circulation. Sea Ice is also an indicator variable of climate change. The thin sea ice is most vulnerable to summer sea melt, and thus allows for more heat transfer. Therefore, this type of sea ice deserves some particular attention.

Currently, earth observation methods are accurate and well validated for estimating sea ice concentration of multi-year ice and consolidated first-year ice. However, they are less reliable and accurate for the youngest stages of sea ice development. Alternative algorithms, making use of different sensors for observing young, seasonal sea ice are therefore valuable. We will here present an on-going project where the goal is an algorithm for fully automatic estimation of thin sea ice thickness, well suited for evaluating time series of data, using optical satellite data from the MODIS sensor.

The model is closely based on Yu & Rothrock (1996) [1] in that the heat balance on the ice surface is described as a sum of the contributing heat fluxes. Each of the component heat fluxes are then expressed using various empirical models. Several of the heat fluxes are dependent on the ice thickness, in particular the conductive heat flux, which describes the heat transfer from the water to the ice surface. This flux is assumed to be inversely proportional to the ice thickness. We further assume thermal equilibrium, resulting in an equation which may be solved with respect to ice thickness. This is done independently for every pixel in the data.

Night and daytime images have different properties with respect to cloud masking and accuracy of the estimate. These aspects will also be discussed.

As input we use data from the MODIS sensor on board the Aqua and Terra satellites, using the thermal bands to estimate the surface temperature. The algorithm also makes use of some atmospheric variables (e.g. air temperature, wind speed, air pressure), which are acquired from re-analyzed ERA data.

Since this algorithm aims to estimate the thickness of young, thin ice, we also use passive microwave data from AMSR-E and AMSR2 to separate (thick) first- and multiyear ice from potential (thin) new ice and water.

We also plan to include SAR data into the processing, in order to account for partially ice-covered MODIS pixels.

In this presentation we will describe the approach, and present and discuss some preliminary results, including estimates of extent and thickness of thin sea ice from time series of both night and daytime images.

[1] Yu, Y. and Rothrock, D. A., 1996. Thin ice thickness from satellite imagery. *Journal of Geophysical Research,* 101 (C10), 25753.

G2-O2

Cancelled

G2–O3

SEA-ICE MELT ONSET ASSOCIATED WITH ICE DEFORMATION EVENTS DURING EARLY SUMMER

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In the central Arctic Ocean, autonomous observations of ocean mixed layer and ice documented the transition from cold spring to early summer. Our ice-motion measurements using GPS drifters captured three events of lead opening and ice ridge formation in May and June. We clarify how these ice deformation events are linked with the onset of sea ice melt. In early June, the buoy array detected a shear deformation coincident with a temperature peak at 7 m below the ice bottom. At this time, an autonomous profiler shows there was a gentle decrease of temperature with depth and nearly homogeneous salinity profiles, with persistently stable mixed layer. We use a one-dimensional numerical simulation incorporating the Local Turbulence Closure (LTC) scheme to investigate the mechanisms controlling basal melt onset. According to the simulation, a combination of the extremely slow ice motion and incoming solar energy input at the open lead, followed by a transient low pressure system, produced a thin, low density surface layer by advection of warm lead water under the ice. This enhanced stratification near the surface facilitates storage of solar radiation within the thin layer, instead of exchange with deeper layers, leading to early onset of basal ice melt preceding the upper surface melt.

G2−O4

HOW DOES ARCTIC SUMMER WIND MODULATE OCEAN HEAT BUDGET IN SEA ICE REDUCTION ZONE?

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It is expected that the Arctic summer wind has a significant impact on sea ice distribution and ocean heat budget via various kinds of processes. Basin-wide anti-cyclonic wind circulation promotes sea ice export from the Arctic Ocean to the Greenland Sea. This pattern can eventually cause a new record minimum of sea ice extent as observed in 2007. On the other hand, synoptic cyclones produce mechanical sea ice divergence and Ekman upwelling. Both enhanced absorption of shortwave radiation in newly formed open water area and vertical heat flux from a subsurface temperature maximum layer would work on thermal reduction of sea ice. Our previous modeling experiments demonstrated that an eddy-induced transport of warm shelf water preferably occurs under summertime westerly wind in the western Arctic. The westerly shelf wind has a linkage with low sea level pressure in the basin area. This finding indicates that lateral heat transport in the ocean surface layer is also activated by cyclonic wind pattern. However, the relative contribution of each process to ocean heat budget in sea ice reduction zone has not been estimated. We performed numerical experiments on seasonal to decadal timescales using a newly configured pan-Arctic ice-ocean model and then addressed these issues.

G2–O5

ARCTIC ICE-OCEAN MODELING STRATEGY: HOW TO VERIFY MODELS OF CLIMATE CHANGE WITH EXISTING DATA

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Although the main stream of modeling for the Arctic climate change is to develop sophisticated models with high resolution and realistic conditions, an alternative way is to use idealized models with an aim at exploring key mechanisms in a projection of the sea ice cover trend. The former strategy requires extensive data collections for verification of the models, while the latter strategy provides potential of utilizing the existing data. An attempt was made on the sea ice cover and ocean interior showing decadal-to-interannual variability caused by atmospheric forcing.

For the recent 50 years, valuable geochemical data in the ocean interior were analyzed, along with the sea ice and atmospheric data, and used to verify a coupled ice-ocean model with idealized configuration in the Arctic Basin, which is fundamentally driven by buoyancy flux in addition to atmospheric circulation and cooling. The dominant atmospheric mode shifted from the Northern Annular Mode (NAM) to the Arctic Dipole Mode (ADM) around 1990. The sea ice cover variability was explained by these two modes sequentially: i.e., the decadal ice cover variability was well correlated with the NAM until 1990, and then, the several-year cycle variability with the ADM. The low sea ice cover matched with the peaks of the NAM over the East Siberian-Laptev Sea, and then, 2 years later showed the low anomaly in the Barents-Kara Sea and the high one in the Beaufort-Chukchi Sea. As presented with the coupled ice-ocean model and the geochemical fields, the positive NAM induced the oceanic variability with the Transpolar Drift Flow shifting toward Canadian side in 3 or 4 years. After 1980, the positive phase of the ADM with a low anomaly over Siberia and a high anomaly over Greenland induced low (high) ice cover in the Pacific (Atlantic) sector in 1 year. The ADM produced the ocean general circulation and made the Pacific water spread toward the Atlantic side in 2 years.

On the top of these fundamental mechanisms, the models with high resolution and realistic conditions should be verified against data collected by dedicated observations so that various important mechanisms may be reproduced in the models: e.g., sea ice ridging, ice band formation, inertial oscillation, double diffusion, step-like stratification, wind-wave in polynya, shelf wave and others.

G2–O6

RECONSTRUCTION OF WATER CIRCULATION IN THE PACIFIC SECTOR OF THE ARCTIC OCEAN

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Circulation in the Pacific sector of the Arctic Ocean was reconstructed for 1900-2006 and for cyclonic (1989-1997) and anticyclonic (1997-2006) climate states through the use of modeling with 4Dvar data assimilation. The comparison of these climatological states with reconstructed circulation for 2008 (July-October) reveals significant changes in water motion between climate states. These differences were caused by changes in model forcing—namely, wind forcing and sea ice conditions. Reconstructed circulation for 2008 was additionally validated with respect to available velocity observations, which were not assimilated

ARCTIC OCEAN LIQUID FRESHWATER STORAGE TREND 1992-2011

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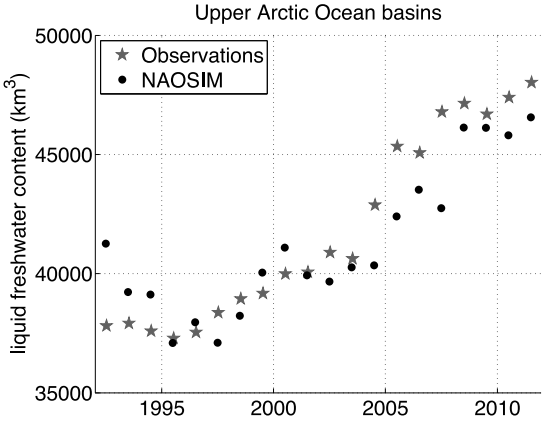
The upper Arctic Ocean has experienced significant freshening from the 1990s to late 2000s. A very strong Beaufort Gyre and a freshened Transpolar Drift raise the question how much longer the Arctic Ocean can accumulate freshwater. Since 2006, autonomous CTD profilers have allowed to estimate upper ocean properties in the Arctic through all seasons. In combination with observations from other platforms, these data show a continuous increase in liquid freshwater into the second decade of the 21st century: the trend from 1992 to 2011 was about $600 \pm 300\ km^3 yr^{-1}$.

Excellent agreement between these observational estimates and results from the North Atlantic Arctic Ocean Sea Ice Model (NAOSIM) allows to view this in the context of physical processes in the model: Ekman pumping from the ocean surface stress in the simulation strongly covaries with the vertical movement of the top of the lower halocline, represented by the 34 isohaline. Whereas downward Ekman Pumping shows no noticeable trend in the Eurasian Basin, it shows an increase in the Amerasian Basin from the mid-1990s to 2008.

On a longer timescale, the model shows that a freshwater minimum in the mid-1990s was preceded by a maximum near the end of the 1960s. The level in 2011 is similar to the one around 1980, and it remains to be seen if liquid freshwater levels will supersede that of the end 1960s. Furthermore, our results raise the question where and when this additional freshwater will be released from the Arctic Ocean to the regions of deep-water formation in the North Atlantic in future years.



G2–O8

TEMPORAL VARIATION OF OCEAN CURRENT STRUCTURE CAUSED BY SEA ICE MOTION

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The reduction rate of Arctic sea ice extent and volume exceed the rate of surface temperature warming. This suggests that the changes in the horizontal and vertical ocean heat fluxes are the key components to understand the rapid reduction of sea ice. Shimada et al. (2006) showed the recent warming of upper ocean in the Canada Basin associated with substantial activation of sea ice motion. However, only the ocean warming below the surface mixed layer cannot cause the warming in the surface mixed layer interacting with sea ice. Increase in vertical heat flux associated with turbulent mixing would be a key process to understand the rapid reduction. At the first step of our studies, we examine current structure and its variation caused by inertial motion of sea ice using an ice-mounted mooring and continuous CTD profiling data during the Araon 2012 cruise.

Clear structures of oscillatory horizontal currents were detected under the inertial oscillation of sea ice (Fig.1). The observed vertical shear of horizontal currents accompanied large temporal variation. This suggests that the actual vertical mixing results in quite different effect on vertical ocean heat flux from that without inertial motion of sea ice. Detailed joint analysis using current and density stratification will be made.

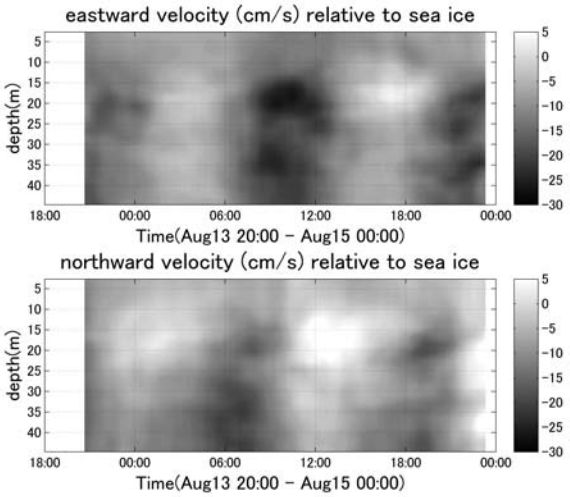

Fig.1: Time series of horizontal currents relative to sea ice obtained by ADCP.

G2–O9

ESTIMATION OF VOLUME TRANSPORT AND HEAT FLUX THROUGH BARROW CANYON

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The Pacific water through Barrow Canyon is critical for determining heat, fresh water and nutrient flux. In particular, heat flux due to the Pacific water through Barrow Canyon is directly linked to heat content in subsurface layer around the Northwind Ridge area, where drastic decrease of sea ice has been evident. First of all, we attempt to build the method to estimate volume transport. The data from moored ADCP and CTD (2001 October to 2007 September) at Barrow Canyon was examined. The variability of volume transport (or barotropic transport) is well correlated with NCEP 45^{o} (northeastward) wind component observed 27 hours before around Pt. Hope. 60^{o} Wind component at Barrow Canyon was secondary. The multiple linear regression model using 45^{o} wind component (Pt. Hope, 27-hour before) and 60^{o} wind component (Barrow Canyon, 13-hour before) was made (R^2=0.575). The empirical orthogonal function (EOF) analysis shows that vertical structure of the first EOF of velocity is typical baroclinic 1st mode explaining about 70% of total variance. The variability of 1st EOF of velocity has weak correlation with 45^{o} wind component (Pt. Hope, 30-hour before, R^2=0.346). Hence, near real-time forecasting of volume transport and baroclinic component using wind data can be made by the regression model proposed here. The offset of the regression model is 0.77 (Sv), which is almost same as mean transport of the Bering Strait, i.e., most of the Bering Strait inflow flows down Barrow Canyon, even under the variable wind filed. In the next, we also developed the regression model for vertical profile of temperature to estimate heat flux using CTD data described above and satellite sea surface temperature data. Data analysis shows temperature at Barrow Canyon has positive correlation with SST near Cape Lisburne 5 days before (R^2=0.49). Estimated heat flux through Barrow Canyon using all estimated parameters described above is well comparable to in-situ measured heat flux.

SHIFTS IN SEA ICE CONDITIONS OF SIBERIAN SHELF SEAS IMPACT THE HALOCLINE OF THE ARCTIC OCEAN

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The signature of the upper halocline of the Arctic Ocean is formed in Siberian Seas largely by a combination of mineralization of organic matter and release of decay products to the sea ice brine enriched bottom water. In 2008 exceptionally high nutrient concentrations and low pH were observed in the bottom waters of the East Siberian Sea. These waters typically had between 5% and 10% of sea ice brine contribution as computed from salinity and oxygen-18 values. In the northern East Siberian Sea the silicate maximum was found over a wider salinity range than traditionally found in the Canada Basin, in agreement with observations east of the Chukchi Plateau during one expedition in 2004 [*Nishino et al*., 2009]. As all waters containing high nutrient concentrations at the shelf break had a deficit in nitrate, indicating a low oxygen environment during mineralization as well as a brine contribution of about 6% it is suggested that the shelves are a source for these waters. The variable salinity distribution, together with signs of a double peak in nutrient conditions, suggest at least two different areas for the formation of this nutrient rich halocline within the East Siberian Sea. These areas must have some different physical and biochemical environments in order to sustain the observed conditions, for instance a different surface water salinity. One plausible explanation is that brine is produced along a large north-south gradient within the shelf sea by sea ice formation, where the salinity of the outer region is much less impacted by river runoff. This would require that a much larger area of the East Siberian Sea has been sea ice free in the summers over the last 5-10 years. The satellite record shows substantial changes in the amount of open water in September during the last 30 years from around 60% sea ice coverage in the 1980s to a low of about 20% in the early 1990s, back to about 50% in the late 1990s and then a dramatic decrease with less than 10% since 2003. More open water also favor primary production through improved light conditions, adding to the organic matter at the sediment surface.

Observational data will be presented together with satellite records of sea ice coverage and plausible scenarios for halocline water formation will be discussed.

Nishino, S, K. Shimada, M. Itoh, and S. Chiba (2009), Vertical Double Silicate Maxima in the Sea-Ice Reduction Region of the Western Arctic Ocean: Implications for an Enhanced Biological Pump due to Sea-Ice Reduction *J. Oceanogr,* 65, 871 to 883.

G2–O11

SHOALING OF THE NUTRICLINE WITH AN INCREASE IN NEAR-FREEZING TEMPERATURE WATER IN THE MAKAROV BASIN

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The water mass changes in the Makarov Basin and adjacent areas associated with the recent loss of Arctic sea ice had not been studied in detail. We combined data obtained from multiple cruises in these regions and used chemical tracers to investigate the spatial and temporal changes in water masses. Our data show that a previously present temperature maximum water has disappeared from the Makarov Basin and Chukchi Abyssal Plain due to enhanced cooling and convection in the East Siberian Sea. In addition, a large volume of water has formed by cooling and convection and is flowing into the Makarov Basin, producing a temperature minimum with relatively high nutrients and resulting in a shoaling of the nutricline. This temperature minimum water likely originated from the eastern part of the East Siberian Sea, where significant open water areas appeared after 2005 in the freeze-up season. The water mass boundary between this temperature minimum water and the Pacific-origin temperature minimum water shifted westward from the Chukchi Plateau in the early 2000s to the Mendeleyev Ridge in the late 2000s, probably owing to a westward flow of the enhanced Beaufort Gyre associated with recent sea ice loss in the Canada Basin. Although the shoaling of the nutricline in the Makarov Basin could increase phytoplankton production, such production could decrease in the southern Makarov Basin because a large amount of sea ice meltwater covers that region and might decrease the nutrient supply from the subsurface layer.

SPATIAL AND TEMPORAL VARIABILITY OF AIR-SEA CO_2 EXCHANGE OF ALONGSHORE WATERS NEAR BARROW, ALASKA

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Alongshore waters near Barrow, Alaska feature unique characteristics being at the intersection of four aquatic locations: Chukchi Sea, Beaufort Sea, north and south Elson Lagoon. Partial pressure of CO_2 (pCO_2) measured at the alongshore waters in summer, 2007 and 2008 showed that the average pCO_2 was the lowest in the Chukchi Sea side and that of the south Elson Lagoon side was the highest. The difference in pCO_2 between locations appeared due to differences in water temperature that controls the solubility of seawater for CO_2. The temporal variations in pCO_2 within each location were highly controlled biologically as inferred from the relation between pCO_2 and apparent oxygen utility (AOU). No significant difference in pCO_2 corrected to 3 °C between locations and the low AOU in the south Elson Lagoon side suggested that a potential of carbon source from the region due to coastal erosions and terrestrial runoff was offset by biological carbon uptake. The average CO_2 flux estimated from pCO_2 over all locations showed a sink of CO_2. Our data and others (e.g., Oechel et al., 2000) suggested that the coastal ecosystem including the wet sedge tundra that dominates the terrestrial coastal margin and the coastal water near Barrow was a sink for CO_2 during the summer growing season. CO_2 flux measured by the eddy covariance technique also showed a sink of CO_2 overall, but the presence of ice sheets inhibited a gas transfer.

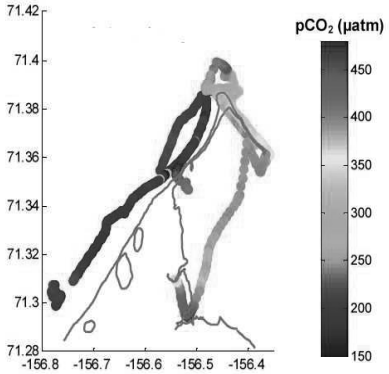

Fig. 1 Boat cruise measurements for pCO_2 in 2007.

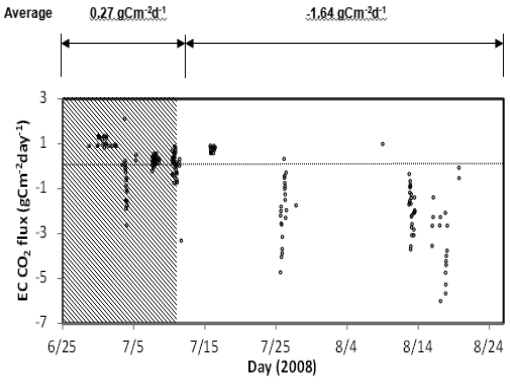

Fig. 2 CO_2 flux measured by the EC technique for the Beaufort Sea. The gray area indicates the period with ice sheets.

G2–O13

FATE OF TERRESTRIAL COLORED DISSOLVED ORGANIC MATTER (CDOM) IN THE ARCTIC OCEAN: EXPORTED OR REMOVED?

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Colored dissolved organic matter (CDOM) was measured with hydrographic parameters (salinity, $\delta^{18}O$ and inorganic nutrients) annually across Fram Strait in 2009 to 2011.
East Greenland Current (EGC) surface waters showed a pronounced CDOM absorption maximum between 30 and 120 m depth associated with both river and sea ice brine-enriched water, characteristic of polar mixed layer water and upper halocline water. Lowest CDOM was found in the Atlantic inflow within the West Spitsbergen Current (WSC).
Although applied elsewhere in the Arctic, we show that the salinity–CDOM relationship is not suitable for evaluating the mixing behavior of CDOM (conservative vs. nonconservative) in Fram Strait. The strong correlation between meteoric water and optical properties of CDOM are indicative of the terrigenous origin of CDOM in the EGC and marine origin in WSC.
Based on CDOM absorption in Polar Water and comparison with an Arctic river discharge weighted mean, we estimate that a 68% integrated loss of CDOM absorption across 250-600 nm has occurred, with a preferential removal of absorption at longer wavelengths reflecting the loss of high molecular weight material.
Budget calculations of CDOM exports through Fram Strait using modeled volume transports indicate that the net southward export of CDOM in Fram Strait equals about 50% of the total riverine CDOM inputs to the Arctic Ocean, thus physical export can be a major sink of CDOM.
These constrasting results indicate that both removal and loss within the Arctic Ocean and export are major sinks for CDOM, this suggest that several of the possible sinks need to be better quantified. This means improving our knowledge of export with sea ice, seasonality and transport on the East Greenland Shelf, photo-oxidation of CDOM, and the transports through the Canadian Arctic Archipelago need to be quantified.
We surmise that the changes in the characteristics of CDOM exported in Fram Strait in recent years are a result of changes in freshwater pathways in the Arctic Ocean, especially the residence time will affect the integrated effect on the fate of CDOM. This will also leave a fingerprint on the carbon export from the Arctic Ocean to the North Atlantic.

INTRODUCTION TO S6: MONITORING OF ENVIRONMENT IN THE ARCTIC

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An awareness of the need and the importance of monitoring in environment science is new, although even today not fully acknowledged. Consequently, monitoring activities must struggle to acquire legitimacy and financial support. However some monitoring activities lack professional expertise in long-term accurate observations. It is essential to clearly formulate the objectives, to identify the appropriate methods and to examine from time to time if the monitoring observations are fulfilling their original goals.

In principle there are two types of monitoring. The first type was intended from the start as monitoring of the environment, the second type was initially not intended for long-term monitoring but later was found to be useful for this purpose. The former is legitimate monitoring work, with a clear object and method, aiming at a long-term observation. Two examples of this category are “Sea ice conditions in Greenland seas” by the Danish Government, going back to 1895, and “Sea ice analysis” by NSIDC, starting in the late 1970s. The second type of monitoring makes use of past data that were obtained before it was known that such observations could later be used for monitoring the environment. A good example of this type of monitoring is air temperature. Measuring air temperature began in mid-17th century and presently occupies the most important position in environment monitoring, but its value for monitoring climate change has only been appreciated since the middle of the 20th century. A great deal of work is necessary to edit and homogenize the past data in order to bring it up to a comparable level with contemporary observations.

Monitoring differs from other observations, mainly owing to its importance in long-term constancy of the measuring scales. The time frame of at least several decades, if possible more than a century is aimed at. The monitoring should ideally start before the advent of the incident to be monitored. The length, method and spatial density depend on an individual object to be monitored. In the Arctic, the objectives range from the exosphere and thermosphere down to the ocean bottom. For example one can consider certain cases in the cryosphere observations, glaciers, ice sheet, sea ice, seasonal snow cover and permafrost. The gravest problems for monitoring these cryospheric sub-systems are the insufficient sampling for glaciers and the short observation period for sea ice, snow cover and permafrost observations, which have data inhomogeneity problems. Fortunately there are at least several decades of observations. It is important to continue these observations long into the future. For the success it is of utmost importance to establish, maintain and apply the traceability of scales in all monitoring works at the earliest stage possible in the Arctic. The following presentations will report concrete examples of the monitoring in the Arctic. The session should deliberate how a successful campaign can be formulated and carried out.

THE RAPIDLY CHANGING ARCTIC SEA ICE EXTENT FROM SPACE BASED AMSR-E AND AMSR2 OBSERVATIONS

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The extent of the Arctic sea ice is a key parameter for detecting climate change of amplification of warming signals in the region. Since the late 1970's significant negative trend in sea ice extent has been observed using passive microwave (PM) data and has often been discussed as related to the global warming issue. Objective, accurate, and successive monitoring is necessary for the analysis of the Arctic sea ice trend in extent. PM radiometers onboard U.S polar orbiting satellites, such as the SMMR and SSM/I series, are frequently used for that purpose for the period from the 1970's to the present. In May 2002, Japanese Aerospace Exploration Agency (JAXA) launched the Advanced Microwave Scanning Radiometer for EOS (AMSR-E) which has a finer spatial resolution and wider swath than the US PM sensors. The Advanced Microwave Scanning Radiomete-2 (AMSR2) onboard Japanese GCOM-W1 satellite, the successor of AMSR-E, was also launched on 18 May 2012 to continue the time series and has been providing useful data from 3 July 2012. The AMSR series has become the baseline for sea ice studies because of higher resolution and more accurate sea ice concentration and ice extent products. JAXA launched a web-based monitor of the Arctic sea ice extent in the spring 2007 and has been provided near realtime information about the Arctic sea ice extent to the public (http://www.ijis.iarc.uaf.edu/en/home/seaice_extent.htm). JAXA also provides the historical Arctic BT, ice concentration and sea ice extent data from SMMR, SSM/I, and Windsat radiometers which are all adjusted to be consistent with those of AMSR-E. In particular, the normalization parameters for BT data were derived from data acquired during the overlapped observation period and the sea ice concentration was retrieved using only the Bootstrap algorithm. The sea ice monitor currently has functions to show not only sea ice concentration image but also some PMR raw images (RGB composite of BT 36GHz and 18GHz, Polarization ratio image of 89GHz) and MODIS reflectances. The latter browse images enable us to assess daily sea ice conditions (and also, rough estimation of multi-year ice fraction, ice motion, sky condition etc.). Results of analysis of the web-based monitor of the Arctic sea ice extent shows an unprecedented shrinkage in the Arctic perennial ice cover, as observed during summer 2012 (Fig. 1), and a trend that indicates an acceleration in the decline of the Arctic sea ice cover.

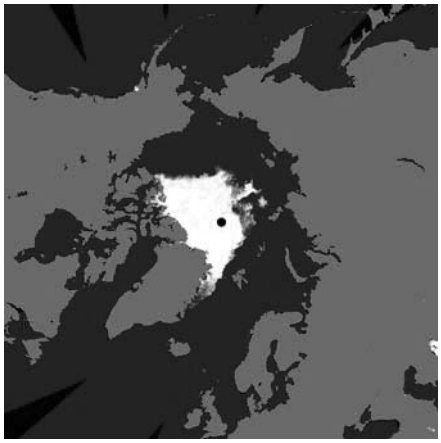

Fig. 1 Arctic sea ice concentration captured by AMSR2 on Sep.16 2012.

S6−O3

ESTIMATION OF ARCTIC SEA-ICE THICKNESS FROM SATELLITE PASSIVE MICROWAVE RADIOMETERS

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To investigate daily large-scale sea-ice thickness distribution in the Arctic and its interannual change, a new algorithm from satellite-based observations was developed by comparing AMSR-E satellite passive microwave data with sea-ice thickness data from shipborne Electro-Magnetic induction ice profiler (EM) and moored Upward Looking Sonar (ULS) of the Beaufort Gyre Observing System in the Canada Basin.

In-situ sea-ice thickness was measured by an EM-31 along with a portable passive microwave radiometer system which has the horizontally and vertically polarized 6, 18, 36 GHz in Joint Ocean Ice Study during summer and autumn 2009 to 2012. As a result, polarization ratio of 6 GHz and gradient ratio between 6 GHz and 36 GHz indicated good sensitivities for thicknesses of second-year and multi-year ice. The penetration depth of 6 GHz is the deepest among the other frequencies. Therefore 6 GHz is more sensitive for information of thicker ice properties than the others.

A sea-ice estimation algorithm was developed using those ratios. This algorithm was applied for AMSR-E and compared with ULS ice draft data during 2003 to 2011. Although AMSR-E sea-ice thickness showed significant under- and overestimation through a year, the error fluctuated cyclically with season. On the other hand, the estimated thickness showed a good agreement with ULS ice draft in March and October. The error assumed to be generated by the seasonal changes of surface salinity, density, temperature, snow cover, and water content (melting). We modified the algorithm to minimize error empirically using a simple approximation of date function.

S6–O4

Monitoring warming in the Eurasian Basin of the Arctic Ocean

Igor V. Polyakov

IARC/UAF

Over the past decade, atmospheric thermodynamic forcing played the increasingly important role in shaping changes of the Arctic multiyear ice. However, analysis of satellite ice motion suggests that the role of ice export through straits connecting the Arctic Ocean with sub-polar basins may be elusive. Available observations suggest a thermodynamic coupling between the heat of the ocean interior and the sea ice. In the Canadian Basin, the impact of Pacific water warmth has been recently documented. While vertical AW heat fluxes are negligible in the Canadian Basin, turbulent mixing may be strong enough in the western Nansen Basin to produce a sizeable effect of AW heat on sea ice. In the eastern Eurasian Basin, double diffusion provides an important alternative to weak turbulent mixing for upward AW heat transport. The relative roles of dynamic and thermodynamic factors in recent changes of the Arctic MYI cover remains to be determined. Quantifying these roles via building a reliable observational monitoring system is a high priority if we are to develop reliable forecasts of the future state of Arctic ice coverage.

S6−O5

OCEAN WARMING, FRESHENING AND CIRCULATION IN THE PACIFIC SECTOR OF THE ARCTIC OCEAN, “POSITIVE FEEDBACK MECHANISMS TO DRIVE THE CATASTROPHIC REDUCTION OF SEA ICE”

Koji Shimada[1], Kohei Mizobata[1], Eri Yoshizawa[1], Daisuke Hirano[1], Tae Wan Kim[2], Ho Kyung Ha[2], Ho Jin Lee[3], Hyun Jung Lee[2], Kyung Ho Chung[2], Sung Ho Kang[2]

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The Arctic Ocean is not homogenized ocean, but is classified into three types. It means the recent catastrophic reduction of sea ice associated with oceanic changes should be examined taking the regional oceanic properties into consideration.

The first type is the Nansen and Amundsen Basins in the Atlantic sector of the Arctic Ocean. In this region, the surface stress by sea ice motions and winds establishes upwelling favorite condition (i.e. just like as sub-polar gyre), then the warm and saline Atlantic Water affects the fate of sea ice. The second type is the Canada Basin in the Pacific sector of the Arctic Ocean where the clockwise upper ocean circulation (i.e., just like as sub-tropical gyre) and Pacific water dominate the upper ocean. In this region, major heat source to affect the sea ice is not the Atlantic Water but is the Pacific Summer Water. The last type is Makarov Basin where the curl of surface stresses is near zero (i.e. Kuroshio extension) .

Here we focus the warming of the Pacific sector of the Arctic Ocean associated with the catastrophic reduction of sea ice. We also introduce the histories of long-term monitoring in this region since 1990s and recent international challenge for comprehensive understandings of Arctic changes in the missing area, "Makarov Basin", by Korean icebreaker ARAON.

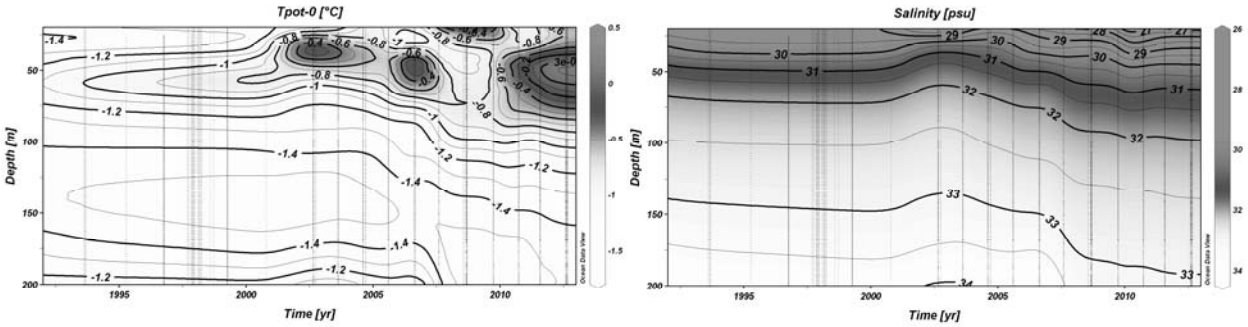

Figure: 20 years time series of potential temperature and salinity in the Pacific Sector of the Arctic Ocean (75-78N,145-165W).

S6–O6

THE OPTIMISM PROJECT (OBSERVING PROCESSES IMPACTING THE SEA ICE MASS BALANCE FROM IN SITU MEASUREMENTS): CURRENT STATUS AND FUTURE PLANS.

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Arctic sea ice declines both in extent and volume, at a rate outpacing the most pessimistic climate model predictions. Observations are key not only to assess ongoing changes, but also to improve our understanding and parameterization of physical processes that govern heat exchanges between the ocean, sea-ice, and atmosphere, in order to improve the predictive capabilities of climate models. In situ observations are also critical for the calibration and validation of satellite observations which provide a synoptic view of the Arctic. While sea ice extent is routinely monitored from space, remote sensing of ice thickness is still in its early stage with dedicated missions recently launched (e.g., CryoSat-2) for which in situ data are important to relate raw measurements to geophysical parameters.

The OPTIMISM project, supported by the French National Research Agency (ANR) and the French Polar Institute (IPEV), brings together scientists and engineers from 5 laboratories in France covering the fields of ocean and atmospheric sciences, hydrodynamics, and radar altimetry. A main objective of the project is to develop an autonomous, reasonable cost, system providing real-time measurements not only of ice thickness and heat content, but also of heat fluxes at the ocean-ice-atmosphere interfaces, which are needed to assess the sea-ice mass balance. These challenging technological developments build upon the “Ice-T” (Ice-Thickness) buoy developed at LOCEAN, intended to both thin and thick ice conditions. In particular, a short meteorological mast, dubbed “BEAR” (Budget of Energy for Arctic Region) has been developed to monitor radiative and turbulent heat fluxes, and validated during several field works.

We will present technological developments carried out as part of this project as well as recent or ongoing field experiments. Field works are focused on the study of processes in a coastal polynya of the Svalbard Archipelago where dense water forms, on the one hand, and in the ice pack in the Central Arctic on the other hand. The latter are in particular carried out in collaboration with US and Japanese teams involved in the North Pole Environmental Observatory.

S6–O7

DYNAMICS OF THE GROUND TEMPERATURE REGIME IN EAST SIBERIA

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In view of recent climate warming observed over the globe, much attention in Earth sciences is given to climate effects on ecosystem response, including permafrost as an ecosystem component.

The ground thermal state and seasonal thaw depth respond most rapidly to environmental changes and anthropogenic disturbances and can serve as permafrost stability assessment criteria.

Development, adaptation and reanalysis of prediction models require reliable baseline data which can only be obtained through establishment of a permafrost monitoring network.

In 2007, the Melnikov Permafrost Institute, with support from the TSP international project, initiated a program to establish a permafrost monitoring network in north-eastern Asia. Long-term (>20 years in length) records of ground temperatures within the depth of zero annual amplitude are available for Yakutsk, Tiksi, Anadyr and Chulman. During the last five years, more than 20 new sites were installed in eight regions of East Siberia, including southern Yakutia, Verkhoyansk Mountains, northern Krasnoyarsk District, north-western Yakutia, and Magadan Province. Ground temperature measurements were resumed in 2007 in several existing boreholes where observations started in the 1980s had been discontinued.

The nature and dynamics of permafrost response to climate change varies between regions and depends on atmospheric circulation patterns, surface heat balance, and soil/rock type. All regions of East Siberia have experienced an increasing trend of 0.3 to 0.6°C/decade in mean annual air temperature during the last 30 years.

Analysis of the ground thermal monitoring data over this period has shown the following:

In Central Yakutia, ground temperatures at the depth of zero annual amplitude exhibit strong interannual variability due to colder (summer) or warmer (winter) periods in some years. However, data obtained by Varlamov et al. indicate no significant warming trend in ground temperatures over this period.

In mountainous regions of southern Yakutia, ground temperatures have increased at most sites, by 0.4 to 1.9ºC depending on local site conditions. Warming is greatest for the subalpine areas and smallest on the slopes and in the valleys.

In Magadan Province, ground temperature warming varies from 0.40ºC on the flat water divide to 0.24ºC in the subalpine zone.

In Chukotka (the Anadyr Lowland), climate warming has resulted in an increase in active layer depth, as well as in ground temperatures at rates of 0.022 to 0.060ºC/yr.

In northern Krasnoyrsk District (Igarka) where permafrost is sporadic with temperatures of – 0.4 to –0.2ºC, its thermal state is stable.

S4–O1

Cancelled

AN OVERVIEW AND PERSPECTIVE ON CHINESE ARCTIC RESEARCH

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China is not an Arctic country, but its understanding on Arctic linkage has been greatly pushed forward by recent episodes of abnormal climate change in the Arctic. The unusual snow disaster happened in south China at the end of January 2008, for example, has been associated with the unprecedented sea ice retreat in the Arctic Ocean in September 2007. The accelerated melting of Greenland ice sheet has been counted into the cause of more frequent costal disasters, while the open of Arctic passages has drawn great concerns and interests with its implication on international trade and social developments of China.

China initiated its Arctic research program since early 1990s and organized its 1st National Arctic Research Expedition (CHINARE) cruise into the Arctic Ocean onboard R/V Xuelong on 1999. So far, China has dispatched 5 Arctic research expeditions onboard R/V Xuelong and established one Arctic research station at Ny Alesund on Svalbard. The brief history and scientific achievements of the Chinese research expeditions on the Arctic Ocean will be reviewed in this presentation. New research program and capacity building plan on Arctic environments monitoring and investigation will be introduced.

The Arctic is a region where natural change and social developments are closely coupled and both have global significance. Studies on Arctic passages, laws, economics, governance, and geopolitics have been carried out in China intensively in recent years. International cooperation, especially those on Arctic social science between China and Arctic countries, will be strengthened in the future to make comprehensive understandings on Arctic environmental, social, economic and cultural issues. A China-Nordic Arctic Research Center is under exploration to be established between the Polar Network of Strategy Research of China and relevant Nordic research institutions and networks.

S4–O2

NEW KOREAN BI-POLAR OCEAN PROGRAM (K-PORT, KOREA-POLAR OCEAN IN RAPID TRANSITION)

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The bi-polar oceans (the Arctic and the Antarctic) are globally linked, not only through exchange of water and atmosphere but also by the fluxes and dispersal of flora and fauna between the two polar regions. Both regions are experiencing profound changes under the present warming and are predicted to be even more highly impacted under future global change. To understand how climate variability and change will affect these bi-polar ocean systems, it is essential to understand the role of biogeochemical, geological, and physical structure and transport processes between the Arctic and the Antarctic as well as the mechanisms that link the physical characteristics and biogeochemical systems of these ocean areas. The new Korean bi-polar ocean program using the Korea's first icebreaker RV *Araon* (K-PORT, Korea-Polar Ocean in Rapid Transition) has now been developed to detect the changes of structure and processes in the water column and subsurface in the Arctic (Chukchi and Beaufort Seas) and the Antarctic (Ross Sea) regions.

S4−O3

THE PRESENT CONDITION OF ARCTIC ENVIRONMENTAL RESEARCH IN JAPAN AND THE ROLE OF JCAR

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The Arctic environmental research in Japan has been changing quickly in these one to two years, in accordance with the fast change in the Arctic. New GRENE (Green Network of Excellence) Arctic Program started in 2011 and new consortium JCAR (Japan Consortium for Arctic Environmental Research) began, along with the existing research at various Institutes. It can be said that research component and coordination function started at the same time. Overall condition of the Arctic environmental research in Japan and the role of JCAR, will be presented from the Chair of the Steering Committee of JCAR and Executive Director of the JCAR Office.

S4–O4

INTRODUCTION OF ASIAN FORUM OF POLAR SCIENCE (AFOPS)

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Asian Forum of Polar Science (AFoPS) is an international cooperations of polar science in the Asian countries. Malaysia, India, Korea, China, Japan are member and AFoPS has also observer countries.

Objectives of AFoPS are ecognizing the importance of international cooperation and aiming to serve the common interests in polar sciences, member countries work together to provide a foundation for cooperative research activities, to present Asian achievements toward international polar communities, to encourage Asian countries' involvements in polar research.

AFOPS's major activities are,

1) Provide a forum to seek a common view on polar affairs among member countries.
2) Develop and support cooperative programs on polar research.
3) Convene joint symposia and workshops for polar sciences
4) Support Asian countries to develop their national polar programs.
5) Produce joint publications on polar sciences

AFoPS countries have research stations in the Arctic or visiting Arctic stations. AFoPS is willing to contribute Arctic science and effective international collaborations.

NEXT-GENERATION ECOSYSTEM EXPERIMENT (NGEE ARCTIC): OPPORTUNITIES FOR INTERNATIONAL COLLABORATION AND PARTNERSHIP

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The Next-Generation Ecosystem Experiments (NGEE) project will use observations and models to quantify the response of physical, ecological, and biogeochemical processes to climatic change across molecular to landscape scales. Our approach addresses the question ***"How does permafrost thaw and degradation, and the associated changes in landscape evolution, hydrology, soil biogeochemistry and plant community dynamics, affect feedbacks to the climate system?***" Field and lab research will focus on interactions that drive ecosystem-climate feedbacks through greenhouse gas fluxes and changes in surface energy balance. These feedbacks will arise due to gradual thawing of permafrost and thickening of the seasonal active layer. Feedbacks will also occur as a result of the threshold-dominated processes of permafrost degradation and thermokarst formation and through the many processes that are influenced as a result of these landscape-scale dynamics. Our approach will consider how components of complex systems are linked and the interplay in space and time that determines system behavior. Fundamental knowledge gained in these investigations will be used to improve representation of ecosystem dynamics, subsurface biogeochemistry, and land-atmosphere processes in regional and global models, and will reduce uncertainty and improve prediction of climate change in high-latitude ecosystems.

The research scope of NGEE Phase 1 is designed to address our overarching science question through a series of integrated field observations, lab experiments, and modeling activities. Permafrost degradation and its impact on water, nitrogen, carbon, and energy-related processes will be investigated across a hierarchy of scales, including the pore/core, plot, and landscape scales. Field research will be conducted in Alaska on the North Slope (Barrow) and Seward Peninsula (Council), U.S.A. Phase 1 modeling efforts will focus on application of existing models to evaluate their predictive capability across a range of spatial scales, from single-column to plot to landscape scales. Model results will be compared with laboratory experiments and field observations at the Barrow and Council sites. We will simulate permafrost degradation in a warming Arctic using the land surface component of a major climate prediction model as well as several high-resolution process-resolving models of subsurface physical and biological dynamics. These integrated experimental and modeling efforts will (1) quantify how permafrost degradation influences surface and subsurface hydrology, (2) resolve biogeochemical mechanisms that control rates of CO_2 and CH_4 flux, (3) characterize the role of nitrogen availability in shrub expansion and plant productivity, (4) identify mechanisms underlying changes in ecosystem net energy budgets due to vegetation dynamics, and (5) quantify prediction capabilities associated with existing models.

Insights gained in Phase 1 will be used to address the challenge of extrapolating process studies to larger grid scales of climate models and to sharpen our scientific hypotheses about physical, chemical, and biological processes that shape the structure and function of Arctic ecosystems. Our goal throughout the NGEE project will be to provide the underpinning science and process understanding required to develop a new generation of high-resolution land surface simulation capabilities for the Arctic.

INTEGRATED LAND ECOSYSTEM – ATMOSPHERE PROCESSES STUDY (ILEAPS)

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The land-atmosphere interface is where humans primarily operate. Humans modify the land surface in many ways that influence the fluxes of energy and trace gases between land and atmosphere. Their emissions change the chemical composition of the atmosphere and anthropogenic aerosols change the radiative balance of the globe directly by scattering sunlight back to space and indirectly by changing the properties of clouds. Feedback loops among all these processes, land, the atmosphere, and biogeochemical cycles of nutrients and trace gases extend the human influence even further.

iLEAPS (Integrated Land Ecosystem – Atmosphere Processes Study, a core project of the ICSU-sponsored IGBP (International Geosphere-Biosphere Programme), is an international cross-disciplinary research program aimed at improved understanding of processes, linkages and feedbacks in the land-atmosphere interface affecting the Earth System. iLEAPS facilitates scientific collaboration as well as synthesis and distribution of results to scientific, political and public audiences. The main activities is iLEAPS include 1) highlighting and advertising important scientific results (newsletters, bulletins, website, synthesis reports and articles); 2) organising science conferences, workshops and trainings around LEAP science; 3) organising and co-sponsoring sessions at conferences; 4) organising the iLEAPS Science Conference that gathers together the latest findings and breakthroughs of the iLEAPS science community all over the world, and most importantly 5) developing LEAP science by starting off new initiatives and projects that focus on land-atmosphere-society interactions and take steps towards global sustainability. One of the foci of iLEAPS research in the next 3-4 years is Arctic research such as the international multidisciplinary initiative Pan-Eurasian Experiment (PEEX).

S4–O7

INTERACT – ACCESS TO THE ARCTIC

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INTERACT is currently a network of 45 terrestrial research stations from all Arctic countries, but is still growing. The network was inaugurated in January 2011 when it received an EU 7th Framework award. INTERACT's main objective is to build capacity for identifying, understanding, predicting and responding to diverse environmental changes throughout the wide environmental and land-use envelopes of the Arctic. Implicit in this objective is the task to build capacity for monitoring, research, education and outreach.

INTERACT is increasing access to the Arctic: 20 INTERACT research stations in Europe and Russia are offering Transnational Access and so far, 3900 person-days of access have been granted from the total of 10,000 offered.

An INTERACT Station Managers' Forum facilitates a dialogue among station managers on subjects such as best practice in station management and standardised monitoring. The Station Managers' Forum has produced a unique "one-stop-shop" for information from 45 research stations in an informative and attractive Station Catalogue that is available in hard copy and on the INTERACT web site (www.eu-interact.org).

INTERACT also includes three joint research activities that are improving monitoring in remote, harsh environments and are making data capture and dissemination more efficient. Already, new equipment for measuring feedbacks from the land surface to the climate system has been installed at several locations, while best practices for sensor networking have been established.

INTERACT networks with most of the high-level Arctic organisations: it includes AMAP and WWF as partners, is endorsed by IASC and CBMP, has signed MoUs with ISAC and the University of the Arctic, is a task within SAON, and contributes to the Cold Region community within GEO/GEOSS. INTERACT welcomes other interactions.

S4–O8

HISTORY AND FUTURE OF THE PACIFIC ARCTIC GROUP (PAG)

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The Pacific Arctic Group was imagined during the Arctic Science Summit Week of 2002 and formed during the International Arctic Science Committee (IASC) Council Meeting in April 2003 as a subunit of IASC with the mission to “Serve as a Pacific Arctic regional partnership to plan, coordinate, and collaborate on science activities of mutual interest”. During the formative years the Group developed a number of science themes that it wished to pursue and adopted a mode of action based on two primary types of activities: 1) enhancement of individual national field programs by inclusion of an international component; and 2) creation of collaborative activities focused on synthesis of data and publication on topics of mutual interest. Descriptions of these activities are available through the PAG website located at http://pag.arcticportal.org. The PAG is now distinct from but affiliated with the IASC, and is evolving to meet the needs of its major members (Canada, China, Japan, Korea, Russia, and United States). During and subsequent to the International Polar Year 2007-2009, the PAG members increased efforts on Arctic marine science and are developing a rich set of data to describe the Pacific sector of the Arctic. Discussions within the group have identified new areas for potential collaboration, such as model-data fusion, distributed biological observatory, and studies at the northward-moving sea ice edge. This presentation will highlight some of the accomplishments from these efforts and discuss the continuing role of the PAG in promoting international coordination of research in the Arctic.

S4–O9

ADDED VALUE THROUGH COOPERATION. THE ROLE OF SVALBARD SCIENCE FORUM AND THE RESEARCH IN SVALBARD DATABASE

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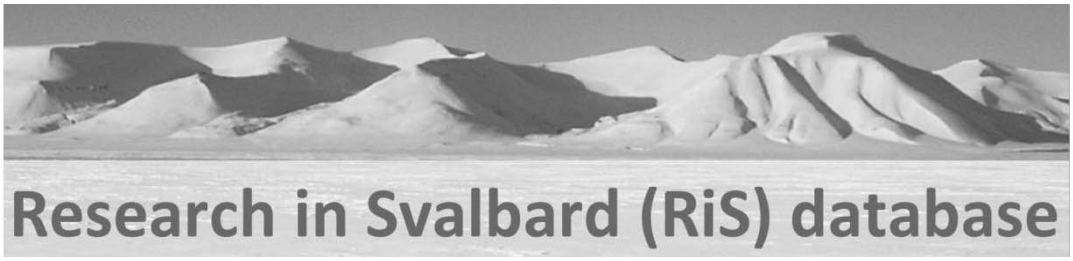
Thirteen nations have permanent research stations in Svalbard and in 2012 900 scientists from 33 different nations conducted research in the archipelago. There are occasions of research groups in Svalbard working separately on similar topics in the same locations without cooperating or even being aware of each other. It is clear that given the number of scientists from various nations and disciplines working in such a relative small region, effective mechanisms for research coordination can create benefits for all. Better coordination of logistics and fieldwork, increased data sharing and the use of new technology are all factors, which can contribute to releasing scientific results more efficiently and can also lead to decreasing the environmental impact of our research.

The Svalbard Science Forum (SSF) is a part of the Research Council of Norway (RCN) and promotes coordination and collaborative efforts in research activities in Svalbard. This includes managing the “Research in Svalbard” (RiS) database which contains information on more than 2000 Svalbard-based projects. RiS is established in cooperation with the Norwegian Polar Institute and is a valuable source for information on previous, current and future research activities in the region.

The SSF also organizes workshops and administers strategic funding schemes. These aim at increasing international and interdisciplinary cooperation in Svalbard. The funding also promotes coordination of activities to reduce the environmental footprint of the research activities. This funding scheme is open for applications from all scientists and students active in Svalbard provided the research is in active cooperation with Norwegian institutions.

A major challenge ahead is to ensure the accessibility and open sharing of data from research projects carried out in Svalbard. The planned SIOS (Svalbard Integrated Arctic Earth Observing Systems) infrastructure and data access network will be a crucial part of achieving this goal.



THE ARCTIC MONITORING AND ASSESSMENT PROGRAMME (AMAP)

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AMAP is an international organization established in 1991 to implement components of the Arctic Environmental Protection Strategy (AEPS). Now a working group of the Arctic Council, AMAP's objective is "providing reliable and sufficient information on the status of, and threats to, the Arctic environment, and providing scientific advice on actions to be taken in order to support Arctic governments in their efforts to take remedial and preventive actions relating to contaminants".

AMAP is responsible for measuring the levels, and assessing the effects of anthropogenic pollutants in all compartments of the Arctic environment, including humans; documenting trends of pollution; documenting sources and pathways of pollutants; examining the impact of pollution on Arctic flora and fauna, especially those used by indigenous people; reporting on the state of the Arctic environment; and giving advice to Ministers on priority actions needed to improve the Arctic condition.

AMAP's priorities include the following contaminant groups and issues:

- Persistent organic contaminants, heavy metals and radioactivity
- Acidification and Arctic haze
- Petroleum hydrocarbon pollution
- Climate change
- Stratospheric ozone depletion
- Effects of pollution on the health of humans living in the Arctic
- Combined effects of pollutants and other stressors on both ecosystems and humans

AMAP has produced a series of high quality scientifically-based assessments of the pollution status of the Arctic. Recent assessments published by AMAP are on mercury (2011), persistent organic pollutants (2009), and snow, water, ice and permafrost dynamics (SWIPA, 2011).

S4–O11

THE SUSTAINING ARCTIC OBSERVING NETWORKS (SAON)

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The need for a well-coordinated and sustained Arctic Observing Network that meets scientific and societal needs has been identified in numerous reports and at a variety of workshops and conferences. In November 2006, at the Arctic Council Ministerial Meeting in Salekhard, Russian Federation, Ministers welcomed the International Polar Year (IPY), 2007 –2008, as a unique opportunity to stimulate cooperation and coordination of Arctic research and increase awareness of the importance of the Arctic region.

Further, the Arctic Council Ministers (AC) requested the Arctic Monitoring and Assessment Programme (AMAP), to cooperate with the other AC working groups, the International Arctic Science Committee (IASC), and other partners in efforts to create a coordinated Arctic Observing Network that meets identified societal needs (Salekhard Declaration).

The Sustaining Arctic Observing Networks (SAON) promotes the vision of well-defined observing networks that enable users to have access to free, open and high quality data that will realize pan-Arctic and global value-added services and provide societal benefits. Its goal is to enhance Arctic-wide observing activities by facilitating partnerships and synergies among existing observing and data networks, and promoting sharing and synthesis of data and information. SAON also is committed to facilitating the inclusion of Arctic indigenous people in observing activities, in particular by promoting community-based monitoring (CBM) efforts. Non-Arctic Council countries and international organization will be invited to have a seat on the SAON Board when they participate in the work of SAON.

SAON has been operational since January 2012, where the first meeting of the SAON Board was held. Currently 17 projects have been initiated, but more are under development.

S4–O12

THE INTERNATIONAL POLAR INITIATIVE

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The Polar Regions of the world are undergoing dramatic transformations impacting their environment, economy, and life of local residents. The magnitude and interdependence of the associated challenges and their interdisciplinary nature call for a coordinated, resourceful and informed response from relevant international and national stakeholders. Inaction will lead to serious consequences for current and future generations around the globe. To effectively address the challenges and efficiently use the available resources, a cooperation framework provisionally entitled “International Polar Initiative” (IPI) is proposed. If endorsed by major organizations, IPI will prepare a common Implementation Plan for the development of observing systems, research, services, related education and outreach, and practical applications of scientific knowledge in the Polar Regions. IPI will be instrumental in helping the nations to optimize the use of existing resources and identify the areas where new investments in polar activities are necessary for environmental protection, sustainable development of the regions, and addressing the existing and emerging societal needs. IPI will adopt a forward-looking approach but will be largely built on consolidation of and cooperation between existing polar programs and infrastructure. It will serve as effective means of preserving the valuable legacy of the recently concluded International Polar Year 2007-2008. Communities behind major polar organizations and programmes are invited to review the concept of IPI and provide input to the initiative development.

S1–O1

Does polar amplification have a maximum in present day climate?

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Polar amplification (PA) is a prominent feature of currently observed and predicted future climate change suggested by both observations and models. Surface albedo feedback (SAF) has been shown to contribute prominently to the currently observed PA along with other mechanisms, e.g. involving atmospheric heat transport. However, significant PA can also be obtained in models without any surface albedo feedbacks, although the PA obtained in these models is typically smaller than the PA in models taking SAF into account. From the conceptual point of view, PA due to SAF should be relatively weak in the two extremes where the whole earth is covered by ice, on one hand, and where all the sea ice is gone, on the other. Therefore it is reasonable to assume that PA reaches a maximum at some point between the icehouse and hothouse climates. A simple conceptual model is used together with observational data to find the point at which PA could be at its maximum, which according to the analysis, appears to be close to the present day climate.

S1–O2

ON PROCESSES AND FEEDBACKS OF RELEVANCE TO ARCTIC AMPLIFICATION AND CLIMATE CHANGE

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The Arctic System has experienced major changes including declining cryosphere, warmer air and ocean temperatures and ecosystem shifts. Understanding and prediction of these changes is critical since this region is a key player of the Earth System and an early indicator of the state of global climate because of both its sensitivity to warming and its role in amplifying climate change. Such changes influence the global surface energy and moisture budget, atmospheric and oceanic circulation and feedbacks.

However, a system-level understanding of critical Arctic processes and feedbacks is still lacking. Moreover, large natural variability and sensitivity of Arctic climate to global change make the attribution of those changes difficult. Yet, such changes could have significant ramifications for global sea level and future climate change, native communities, natural resource exploration, transportation and international diplomacy.

This talk will focus on some oceanic and sea ice processes and ocean-sea ice/atmosphere feedbacks that might significantly contribute to both an amplified warming of arctic climate and an accelerated melting of the Arctic sea ice cover. Examples based on observational and modeled results will be provided.

Maslowski, W., J. Clement Kinney, M. Higgins and A. Roberts (2012): The Future of Arctic Sea Ice, Annu. Rev. Earth Planet. Sci. 2012. 40:625–54.

S1–O3

Contributing Processes to Arctic Temperature Amplification for a Range of Forcing in MIROC GCM

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The finding that surface warming over the Arctic exceeds that over the rest of the world under global warming is a robust feature among general circulation models (GCMs). While various mechanisms have been proposed, their contributions have not been systematically quantified. Such diagnosis is an important task in order to understand model behavior and operating mechanisms. Here we apply a recently proposed feedback analysis technique to a GCM under different external forcings. The contribution of individual feedbacks to enhanced Arctic temperature change relative to low latitudes, an essential feature of Arctic amplification, is quantified. Surface temperature response in the Arctic is amplified by radiative feedbacks of albedo, water vapor and clouds, and large-scale condensation heating. This diagnosis is consistent with increased moisture transport from lower latitudes, and reduced sea ice cover and consequent increased evaporation under warming. Albedo feedback is not always a predominant factor and the change in evaporative cooling equally contributes or exceeds it in some cases in maintaining the anomalous meridional temperature contrast. As a consequence, the sign of the total radiative feedback contribution to the contrast depends on the forcing, but the total non-radiative feedback contribution is consistently positive. An important contribution to the contrast is also made not via the ‘dry’ heat transport process but through the hydrological cycle.

S1–O4

SIMULATION FOR 20TH AND 21ST CENTURIES WITH A 60KM-MESH GLOBAL ATMOSPHERIC MODEL

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Climate of the 20th and 21th century simulation was conducted with a 60km-mesh global atmospheric model (MRI-AGCM3.2H) from year 1872 to 2099. For the historical simulation for 1872-2005, the model was forced with observed historical sea surface temperature (SST) and concentrations of green house gases such as CO2. For the future simulation for 2006-2099, the model was forced with SST changes projected by the average of Couple Model Intercomparison Project3 (CMIP3) multi-model ensemble. The A1B emission scenario is assumed. In order to evaluate uncertainty simulations, three member ensemble simulations with different atmospheric initial conditions were conducted. Annual precipitation over Arctic region increases during the whole period (Fig. 1).

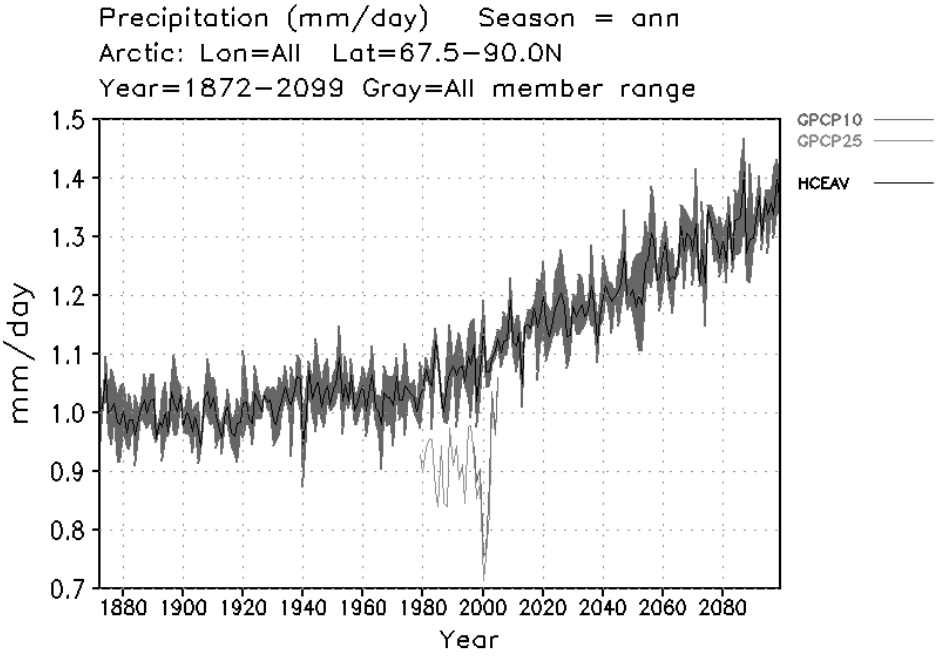

Figure 1 Annual mean precipitation averaged over the arctic (67.5-90°N) from 1872 to 2099 (228 years). Orange: GPCP 2.5 deg observation (1979-2005), Red: GPCP 1.0 deg observation (1997-2005), Thick black: Model ensemble average, Gray: Range of individual runs.

S1–O5

DETAILED SURVEY OF A LARGE BAROCLINIC EDDY WITH EXTREMELY HIGH TEMPERATURES IN THE WESTERN CANADA BASIN

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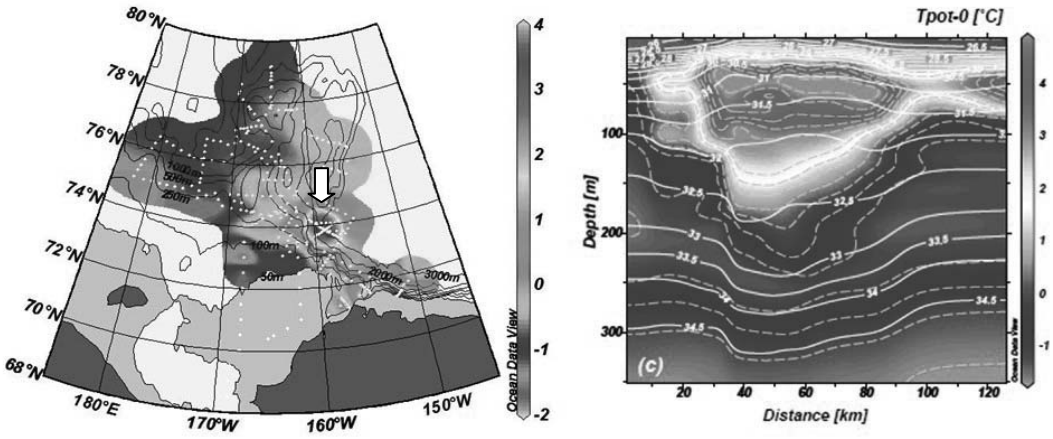
This study documents detailed hydrographic survey of a large anticyclone eddy that was found in October 2010 during a *Mirai* Arctic cruise at east flank of North Wind Ridge in the Canada Basin (left panel). The eddy measured 60-70 km in diameter, roughly twice previous eddies. The eddy is also pronounced by unusually high temperature, being 6^{o} C, at its upper segment even though it located adjacent sea-ice zone to the north. The eddy has a shape like convex lens, associated with its low PV, resulting in the anti-cyclonic circulation. We also found that the eddy was tightly embedded within a strong jet flow that established over Chukchi Sea shelf slope, which is considered to be a branch of Beaufort circulation that has been enhancing lately. The eddy's unusually warm waters are likely to be provided from the jet. Our microstructure measurements at eddy vicinity reveal significance of pronounced interleaving structures, particularly at depths of PSW intrusion, at which the warm temperatures are dissipated to the ambient waters through double diffusive convection. This means that significant amount of heat is transported upward, entering overlying mixed layer and eventually resulting in localized sea-ice melt.

(Kawaguchi, et al., 2012, Deep–Sea Res., 66, p.90–102.; Nishino, et al., 2011, GRL, 38, L16602)



(Left) eddy location and temperature at 50 m depth, and (right) vertical section of eddy temperature (shade) and salinity (contour). After Nishino et al. (2011) and Kawaguchi et al. (2012)

S1−O6

Dynamical Origin of the Arctic Oscillation

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In this study, a linear baroclinic model (LBM) is developed using the 3D spectral primitive equation model. With this LBM we investigated the linear stability problem for various 3D basic state on a sphere. For a zonal climate basic state, we confirm that the traditional Charney mode and dipole-Charney mode appear as the most dominant unstable modes in the synoptic to planetary scales. For a zonally varying basic state, we find that these unstable modes are modified by the regionality of the local baroclinicity of the basic state. Given the zonally varying barotropic basic state, we find that the barotropically most unstable standing mode appears to be the Arctic Oscillation (AO) mode. The LBM in this study is regarded as an generalized extension of the 3D normal mode at the motionless atmosphere to arbitrary climate basic state. It is concluded that the dynamical origin of the Arctic Oscillation is a baroclinically most unstable mode for the zonally varying basic state.

G7–O1

Initial response of reduced ice albedo and increased greenhouse gas concentrations in coupled atmosphere-ocean-sea ice ECHAM-FESOM simulations

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In recent years Arctic sea ice has been declining more rapidly than predicted by climate models. One question to be answered in this study is what the sole influence of a rapidly declining Arctic sea ice cover is on the global atmospheric and oceanic circulation as opposed to increased greenhouse gas concentrations.

FESOM is the Finite Elemente Sea ice Ocean Model developed at the Alfred Wegener Institute. It has the advantage that it is possible to define a globally variable horizontal resolution and to focus on regions of interest such as the Arctic and coastal regions. This model has been coupled to the global atmospheric model ECHAM developed at the Max-Planck-Institute for Meteorology in Hamburg, Germany. The models are coupled using the OASIS coupler.

A 360-year long control simulation with pre-industrial greenhouse gas and aerosol concentrations has been performed. After a spin-up phase of 160 years every 20 years simulations with a sudden ice albedo decrease and with a sudden CO2 increase have been branched off from the control simulation.

Both the atmosphere and the ocean react differently to the different forcings. One of the most striking results is that the Atlantic Meridional Overturning circulation is strongly decreasing during the 20 years of sudden CO2 increase, while this is not the case for the simulations with sudden ice albedo decrease even though in both cases the Arctic sea surface salinity is decreasing due to the melting sea ice.

G7–O2

MODELING EXCESS ICE AND THERMOKARST IN THE COMMUNITY LAND MODEL

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Even with the advances in the Earth System Models, the current representation of permafrost and ground ice is inadequate to predicting changes in geophysical properties and resulting biogeochemical cycles in regards to permafrost thawing. In ice-rich permafrost areas, permafrost thaw can be followed by subsiding of land surface, called thermokarst, due to melting of ice wedges and lenses. Thermokarst and permafrost thaw effects can create large alteration of surface hydrology and ecosystem carbon cycling. Thermokarst can expose stable old carbon buried in the permafrost zone and change permafrost zone to a large carbon source. Therefore, in order to accurately predict the fate of permafrost carbon under future projections of climate warming, adequate representation of permafrost and ground ice as long as the thaw effects need to be included in the Earth System Models. Here, we report an improvement to the Community Land Model (CLM4.0) and its capacity of capturing permafrost thaw and thermokarst effects on the arctic land surface to improve hydrology and biogeochemistry in the arctic system. We also simulated current and future probabilities of thermokarst development in the arctic region using the model. To accurately simulate thermokarst, we included ‘excess ice’ as a new parameter and included the excess ice in the soil layers as well as in soil thermal properties and phase change calculations. The model was initialized with estimates of the current excess ice distribution and amount that are based on the International Permafrost Association ground ice information. We calculated variability in land surface microtopography as a proxy of thermokarst development based on the amount of excess ice melting. Introducing excessive amount of ice in permafrost soil layers significantly reduced the timing of active layer thickening over the simulation period of 1850 to 2100. In addition, soil temperature at 1 m depth was lower by approximately 3ºC in the year 2100 for the excess ice simulations.

G7–O3

Impact of Surface Winds on Ocean Processes in the Nordic Seas Inferred from the 1/12° Arctic Ocean HYCOM-CICE

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The Nordic Seas (Greenland, Norwegian, Iceland, and Barents Seas) play a key role in the maintenance of thermohaline structure of the Arctic Ocean and North Atlantic. Intense formation of water masses takes place in the Nordic Seas through cooling, brine rejection, and mixing of Arctic Ocean and Atlantic waters. Accurate modeling of ocean circulation and thermodynamics of the Nordic Seas is essential to realistically simulate the Arctic Ocean thermohaline structure. However the Nordic Seas are a challenging region for Arctic Ocean models due to complex ocean circulation, water mass transformation, intense air-sea interaction, deep vertical convection, etc. Being the major source of momentum for the upper ocean, winds mainly control ocean processes and air-sea interaction especially in such synoptically active region as the Nordic Seas. Thus the lack of reliable high-resolution wind products over the Polar region is another factor that has been restraining the development of the Arctic Ocean modeling. Coarse resolution atmospheric fields are often used to force the Arctic Ocean models. The major drawback of the coarse resolution wind products is their inability to Meso- and resolve small- and small-scale cyclones meso-scale are low-pressure cyclones systems frequently with spatial impacting scales the in Nordic O(<10^3km) and time scales from several hours to days. A subtype of this class of cyclones is polar low. These lows are very intense maritime low-pressure system with strong near-surface winds. Polar lows form over the sea and predominantly during the winter months. The small-scale cyclones are difficult to observe due to their short life cycle and small size. Meso- and small- scale cyclones over the Arctic Ocean are poorly represented in the available observational reanalysis data. Satellite scatterometer wind observations, and wind speeds from other instruments, might improve this situation over the ice-free area of the Nordic Seas. Several surface wind products derived from scatterometer wind observations have reasonably high spatial resolution to represent most of the small scale cyclones in the region. The study evaluates simulation uncertainty associated with discrepancies in the forcing data. We compare several wind products: Cross-Calibrated Multi-Platform surface wind data (CCMP) are compared against the wind fields from traditional the NCEP/NCAR Reanalysis 2 (NCEPR) and wind fields from recently developed NCEP Climate Forecast System Reanalysis (CFSR). Results from several model experiments with different winds are presented. Numerical experiments are conducted with the fully coupled 1/12° resolution HYbrid Coordinate Ocean Model (HYCOM) and Los Alamos National Laboratory Community Ice Ocde (CICE) v. 4 using the Earth System Modeling Framework. A suit of model experiments is conducted with wind forcing derived from the NCEPR, CFSR, and CCMP. Model results demonstrate high sensitivity of the ocean to different wind products during strong wind events. The representation of cyclones (structure, location, intensity) in the wind products impacts processes of water mass formation in the Nordic Seas.

The CryoMET project – combining deterministic and probabilistic downscaling to model snow depth over a wide range of scales

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Predictions of the future climate are generally based on atmospheric models operating on coarse spatial scales. However, the impact of a changing climate on most elements of the Cryosphere becomes manifest on much smaller scales, which complicates sound predictions e.g. on glacier and permafrost development. CryoMET is a collaborative project between atmospheric modeling, glacier and permafrost research groups funded by the Norwegian Research Council. It seeks to bridge the scale gap between coarsely-resolved Earth System Models and the process and impact scales on the ground for the variables snow depth and snow water equivalent.

Snow is a crucial factor both for the thermal regime of permafrost and the mass balance on glaciers. However, the snow depth and properties can vary considerably on small scales due to wind redistribution, which for instance leads to distinctly different soil temperatures in permafrost areas on distances of tens of meters. CryoMET will explore a seamless downscaling procedure to improve the representation in complex terrain: in a first step, we use the state-of-the-art regional model PolarWRF to downscale atmospheric variables, including precipitation, air temperature and wind speed, to the so-called interface scale, where these variables are constant to a good approximation. In CryoMET, we aim for a spatial resolution of 1 to 3 km, which is determined by the topography of the project's target areas in Norway and Svalbard. In a second step, we will employ probabilistic downscaling of the average snow water equivalent at the interface scale (as delivered by PolarWRF) using snow redistribution models, which can resolve small-scale variations of snow depth due to wind drift down to the meter scale. With probability density functions of snow depth, the distribution of environmental parameters affected by snow, e.g. of permafrost temperatures, can be inferred for each grid cell at the interface scale. Thus, CryoMET ultimately aims for a scaling concept capable of bridging up to five orders of magnitude in space without inflicting a scaling gap. This scaling concept could be applied to other research areas to significantly advance modeling capabilities for arctic ecosystems.

We present first results demonstrating the capacity of the scheme in delivering the distribution of permafrost variables, such as soil temperatures and active layer depth, in complex terrain where snow is subject to strong wind redistribution. Especially at the climatic permafrost limit, the probabilistic concept significantly improves the representation of permafrost temperatures compared to area-averaged formulations.

G4–O1

MOUNTAIN GLACIERS OF THE NORTHEASTERN ASIA: NEW ASSESSMENTS

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The paper compares remotely sensed glacier inventories of the Byrranga, Suntar-Khayata, and Chersky ranges (2003), Koryak Highland and Chukotka mountains (2008) obtained by Landsat, ASTER abd World View-2 imagery with data from the USSR Glacier Inventory (1945-1985). We studied changes in glacier area and morphological structure of the glaciers since the Glacier Inventory, which was mainly based on aerial photos and topographic maps. The retreated glaciers have been classified by orientation (aspect) and morphological type, and the degree of glacier reduction in these groups were studied. In total, the glacierization of Chersky Range was reduced by about 30% (1970-2003), Suntar-Khayata by 20% (1945-2003), Byrranga by 17% (1967-2003), Koryak Highland (1950-2003) – by about 60% and Meynypilginsky Range (1984-2008) by 25%. The different regional retreat rates can be explained by changes in the precipitation patterns. All these regions undergo climate warming up on now. Using DEMs and new assessments of glacier areas we compiled the maps of contemporary glacier equilibrium line altitude (ELA) for Chukotka and NE Siberia Mountains and compared with those constructed by by A.N. Krenke (1982) based on the data of the USSR Glacier Inventory. The new ELA spatial patterns differ substantially from given in (Krenke, 1982) for Chukotka and less substantial – for Suntar-Khayata Range in the NE Siberia.

G4–O2

ATMOSPHERIC TOXICS DEPOSITION TO SVALBARD: THE EMERGING PICTURE

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The analysis of organic contaminants from five different classes in ice cores drilled on Svalbard is showing widely ranging net atmospheric inputs of a variety of organic contaminants. We have analyzed 316 compounds in five groups: polychlorinated biphenyls (209); current use and legacy pesticides (64); brominated flame retardants (15); fluorinated compounds (16); halobenzenes (16). PCB total burden is <600 ng cm-2 from 1953 – 2005, dominated by congeners 66 and 70. Congener profiles are showing a shift to dominance by lower molecular mass compounds, showing a likely shift in atmospheric PCB source between 1988 and 2005. The current use and legacy pesticides show variability in numbers of compounds between east and west, with more compounds observed in the east, apparently influenced by easterly winds. The greatest burdens in any ice core are for trichlorfon (~10 000 pg cm-2 burden) and chlorpyrifos (~9 500 pg cm-2 burden).

The BFRs show few of the BDE congeners except BDE-209. Overall, BFRs are dominated by HBCD (~20 000 pg cm-2 burden in the core from 1953-2005) and BDE-209 (~6 000 pg cm-2 burden). The HBCD burden is the greatest of all 5 compound classes.

The perfluorinated compounds have the lowest burdens of all 5 groups. Perfluorononanoic acid (PFNA) has the highest burden (~30 pg cm-2) and perfluorooctanoic acid (PFOA) is second-most abundant (~18 pg cm-2).

The halobenzenes (HBs) are dominated by 1,4-dichlorobenzene (1,4-DB) (~10 800 pg cm-2), and 1,3-DB (1 500 pg cm-2). The HB record maxima are historic, from the 1970s, indicating a decline in emissions, likely from the timber industry.

G4–O3

Nitrate and sulfate anthropogenic trends in 20th century from 5 Svalbard ice cores

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Sulfate and nitrate records from 5 ice cores spread across Svalbard were intercompared and revealed strong temporal similarities with previously published global estimates the 20th century. A of anthropogenic emissions of SO_2 and NO_x during significant departure from the early century sulfate and nitrate levels was evident at all drilling sites starting from the mid-1940's. A steady increase was observed in both sulfate and nitrate profiles at most sites until the late 1960's, when the annual concentrations started to increase at a higher rate. This peak activity lasted for about a decade, and was observed to decrease steadily from the early 1980's on, when sulfate levels declined significantly and when nitrate levels finally reached sulphate levels for the first time in 20th century. The timing of these trends in Svalbard with global SO_2 and NO_x concentration profiles was best appraised when considering composite concentration profiles for Svalbard sulfate and nitrate respectively. Composite profiles were also found to provide a convenient mean for distinguishing between the most important world source regions. Based on correlation analysis, the major pollutant sources appeared to be Western Europe and North America for both sulfate and nitrate, followed by Central Europe and former USSR in generally similar proportions. Our results suggest that shifts in fossil fuel and coal combustion trends can be assessed in a first step through the ratio of pre-filtered nss-SO_4^{2-} by NO_3^- ice core concentrations.

G4–O4

RESPONSE OF GLACIER “ELA” IN SUNTAR-KHAYATA, EASTERN SIBERIA, ON CLIMATE CHANGE

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About 180 glaciers distribute in mountainous area around Suntar-Khayata region in eastern Siberia. Glaciers in this area retreat rapidly in these several ten years by global warming, and its glacier retreat is a good index of climate change. We discussed how the ELA (glacier equilibrium line altitude) response to meteorological conditions (temperature, precipitation, solar radiation, wind-speed, wind direction, drifting snow and so on) and why the glaciers distribute on mainly northward and eastward faced slopes.

Fig.1 Upper area of No.147 glacier, the longest glacier in Suntar-Khayata. Eastward slope is covered with glacier ice/snow.

G4–O5

Causes of Greenland temperature variability over the past 4000 years: Implications for North Hemispheric temperature change

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A new Greenland temperature record reconstructed from argon and nitrogen isotopes in trapped air in GISP2 ice core provides high-resolution (< 20 years) and precise annual average temperature estimates over the past 4000 years. Owing to tight age-controls and abundant paleoclimatic information from the ice core, the temperature record provides an exceptional opportunity to investigate the late Holocene climate in a multi-decadal to millennial time scale. To investigate causes of Greenland temperature variability over the past 4000 years, we calculated high latitude temperature (70-80ºN) change using a one-dimensional energy balance model with reconstructed climate forcings including orbital, solar, volcanic, and greenhouse gas forcings. Greenland temperature was calculated from the high latitude temperature considering negative Greenland temperature responses to solar variability based upon our earlier study, which significantly correlated with the ice-core-derived Greenland temperature. Therefore, the past variability of the climate forcings can explain at least 10% of multi-decadal to millennial Greenland temperature variability over the past 4000 years. A North Hemisphere (NH) average temperature trend over the past 4000 years was also inferred from the ice-core derived Greenland temperature. Lines of evidence indicate that current decadal average temperature of NH is likely warmer than anytime over the past 4000 years.

G1–P1

AEROSOL CHARACTERISTICS OVER NORWEGIAN ARCTIC: RESULTS FROM INDIAN SCIENTIFIC EXPEDITIONS

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In the context of global climate change, there is an increased need in understanding the role of atmospheric aerosols in arctic atmosphere in changing the snow Albedo, phenomenon like 'Arctic haze' and 'thinning of Arctic Sea' and perturbation to the radiation balance in the Arctic region. As a part of Indian Scientific Expedition to Arctic, extensive measurements of scattering and absorption properties of aerosols have been in progress at Ny Alesund (78.9°N, 11.9°E) in Svalbard archipelago of Norwegian Arctic since June 2011. The results from the year round measurements indicate that the mass concentration of Black Carbon (BC) aerosols showed large annual variation with values as low as ~5 ng m^{-3} to as high as ~ 300 ng m^{-3} (during winter/spring). Similarly, the scattering coefficients also showed significant annual variation with higher values (~ 30 Mm^{-1}) during the winter and spring. However, the aerosol single scattering albedo was lower (as low as 0.85) during the summer. In addition, the investigation of aerosol black carbon in the snow samples collected around Ny-Alesund during the onset of Arctic spring (2012) indicates that the mean concentration of BC in snow varied from ~ 1 to 5 ppb; while the corresponding atmospheric BC varied from ~ 25 ng m^{-3} to 50 ng m^{-3}. Since there was no significant snowfall during this period, the observed BC in snow is usually associated with dry deposition. The details of the observational program and the results will be presented.

G1−P2

Fluctuation of Polar Night Jet with Propagation of the AO from the Stratosphere to the Troposphere

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Arctic Oscillation (AO) is defined as a leading mode of Empirical Orthogonal Function (EOF) of Sea Level Pressure (SLP) (Thompson and Wallce, 1998). The AO has an annular structure with negative anomaly in the Arctic and positive anomaly surrounding mid-latitudes, when the AO index is positive. Baldwin and Dunkerton (1999) defined that the AO is represented by the leading mode of geopotential height between 1000 and 10 hPa, and examined the time series of AO signatures at tropospheric and stratospheric levels. It is shown that AO anomalies typically appear first in the stratosphere and propagate downward. Baldwin and Dunkerton (2001) showed that the tropospheric anomalies tend to persist while the anomalies in the stratospheric polar vortex persist about 60 days, insisting the possibility of using the downward propagation to improve extended range forecast. However some cases don’t propagate downward, and the AO anomalies appear only in the stratosphere or troposphere. Thompson and Wallace (2000) showed the AO has a barotropic structure, so there are still some inconsistent points. In this study, we investigate the AO time series in order to reconfirm the stratosphere troposphere connection extending the analysis period to 2011.

G1–P3

COMBINED MEASUREMENTS OF GRAVITY WAVES WITH AN AIRGLOW IMAGER AND ALOMAR LIDARS IN NORWAY

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To investigate the vertical propagation of gravity waves from the lower to the upper atmosphere, combined measurements with an airglow imager and lidars were carried out at the Arctic Lidar Observatory for Middle Atmosphere Research (ALOMAR) station (69.3ºN, 16.0ºE) in Norway. Airglow imaging reveals the two-dimensional structure of gravity waves in the mesopause region, while the ALOMAR Rayleigh/Mie/Raman (RMR) lidar and sodium lidar provide the vertical structures between the stratosphere and the lower thermosphere. On 26 November 2010, the imager identified a mesoscale gravity wave structure in the sodium airglow that had a horizontal wavelength of 277 km, a wave period of 59 min, and propagated northeastward at a phase speed of 78 m s^{-1}. Simultaneous lidar measurements also showed upward wave signatures with a similar wave period in the temperature perturbations; the vertical wavelength of the upward wave seen in the temperature data is consistent with the dispersion relation for gravity waves. Based on the combined measurements with the imager and sodium lidar, momentum flux of this gravity wave was estimated to be 1.0 m^2 s^{-2} at the sodium airglow height. Ray-tracing analysis suggested that the observed gravity wave was generated by a distortion of the polar jet at the tropopause via a geostrophic adjustment process.

G1–P4

Variations of the polar lower thermosphere, mesosphere, and ionosphere due to a SSW ~ A case study of the January 2012 event~

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Effects of Sudden Stratospheric Warming (SSW) on the Thermosphere have been paid great attentions for last half decades in terms of the atmospheric vertical coupling process. We report results of a case study of the January 2012 SSW event based on observations made at Tromsø (69.6°N, 19.2°E). In Tromsø, we have been conducting comprehensive observations using European Incoherent SCATer (EISCAT) radars, MF radar, meteor radar (owned by NIPR), Fabry-Perot Interferometer (FPI), aurora imagers, photometer, and sodium LIDAR. From 0739 UT on January 13, 2012 to 2300 UT on January 23, 2012, the EISCAT UHF radar was operated with a scanning mode (so-called ip2 mode) and succeeded in obtaining good quality data (ionospheric parameters above 90 km, and neutral wind velocity between 90-120 km) over the time interval. The weather was good, and then we succeeded in obtaining neutral temperature data for nine nights (January 13, 14, 17, 18, 19, 20, 21, 22, 23) by sodium LIDAR. MF and meter radars conducted wind observations in the mesosphere. We will show results of a case study on this event, and discuss how the lower thermosphere/mesosphere/ionosphere varied during the SSW event.

G1–P5

SODIUM DENSITY VARIATION DURING AURORAL PARTICLE PRECIPITATIONS

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Sodium atom layer is generally distributed at 80-100 km. One of mysterious subjects on high-latitude sodium layers is relationship between auroral particle precipitations and sodium atom layer variations. A previous study suggested a sodium column density decrease during a geomagnetic active period due to that the particle precipitations accompanied by electron density enhancement could induce ionization of sodium atom through their ion-molecule chemistry. Another study pointed a possibility of sodium density increase. For this reason, it is suggested that precipitating particle bombardment on meteoric smoke particles can sputter sodium atoms from the smoke particles. On the other hand, ionospheric electric fields, which may become more significant near auroral precipitating regions, could induce ion motions (i.e. can generate sodium ion convergence and/or divergence), and then also could affect generation and/or loss processes of sodium atoms through their ion-molecule chemistry. Thus, for the evaluation of the causarity, it is important to distinguish the effects of auroral particle precipitations and ionospheric electric fields. Using a sodium lidar (which was installed in early 2010) and European incoherent scatter (EISCAT) radar at Tromsø, Norway (69.6ºN, 19.2ºE), we have investigated, for the first time, that the actual effect of the particle precipitation to the sodium density variations without electric filed injection. In the nighttime observation on 24 January 2012, we detected a significant decrease of sodium atom density coincied with electron density enhancements (implying strong particle precipitations) and low ion temperatures (implying no electric field injections). These results strongly suggested that auroral particle precipitations induced sodium atom density decrease.

G1–P6

CURRENT STATUS OF THE STEL OPTICAL OBSERVATIONS AT THE TROMSØ EISCAT RADAR SITE

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Solar-Terrestrial Environment Laboratory (STEL), Nagoya University has operated various kinds of optical instruments for more than 10 years at the Tromsø EISCAT (European Incoherent Scatter) radar site in Norway (69.6ºN, 19.2ºE), which is one of the state-of-art observatories for the upper atmospheric physics at high latitudes. Seven instruments are now in operation regularly from October to March: (1) a three-wavelength photometer (simultaneously measuring the emission intensity of aurora at 427.8 nm, 630.0 nm, and 557.7 nm), which is fixed to look along the magnetic field line, (2) two digital cameras for monitoring weather and aurora, (3) a proton all-sky camera (wavelength at 486.1 nm), (4) multi-wavelength all-sky camera (programmatically selecting one of the optical filters at 557.7 nm, 630.0 nm, near-infrared OH band, 589.3 nm, 572.5 nm, and 732.0 nm), (5) a Fabry-Perot interferometer (programmatically selecting one of the optical filters at 557.7 nm, 630.0 nm, and 732.0 nm), (6) a sodium LIDAR. All of them (except for the sodium LIDAR) are automatically operated. These instruments have joined many campaign observations with the EISCAT radars, rockets, satellites, and other ground-based instruments by adjusting the observation mode. The quick looks are available to see on the web at:

www.stelab.nagoya-u.ac.jp/~eiscat/data/EISCAT.html

This paper reports the current operation status and some new results of these optical instruments until the end of 2012.

GRAVITY WAVE ANALYSIS USING METEOR WIND RADARS IN ARCTIC NORWAY

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Horizontal propagation characteristics of atmospheric gravity waves in the northern high latitude mesopause region (around 80-100km) are studied based on long-term wind and temperature fluctuation observations made with operational meteor radars at Arctic Norway sites, Adventdalen, Spitzbergen (78N,16E) and Ramfjordmoen, Norway (70N,19E) [e.g., Hall et al., 2006].

The targets of the radars are ionized meteor trails produced at 70-110 km altitude by meteor bodies, which impinge onto Earth's atmosphere, collide with atmospheric molecules and ionize them along their paths. After its formation, the meteor trail follows the motion of the ambient neutral atmosphere, that is, winds. The trail also expands rapidly due to molecular diffusion, which is a function of atmospheric temperature and density. Wind velocity and diffusion coefficient are estimated from Doppler frequency shift and echo power decay in observed radar meteor echoes, respectively. Atmospheric temperature fluctuation due to gravity waves can be further estimated from the diffusion coefficient [Tsutsumi, et al., 1994;1996]. One of the major advantages of the present meteor radar systems is its very high echo rate (6000-20000 echoes a day) despite the relatively small transmitting power (7.5kW peak). Horizontal winds and temperature fluctuations can be continuously measured with time and height resolutions better than 1 hour and 2km.

The horizontal propagation directions, estimated using the theoretical relation between wind and temperature fluctuations, are mostly opposite to those of back ground mean winds below around 90 km, showing a good agreement with a well known scenario that gravity waves generated in the lower atmosphere carry wave energy and momentum flux high into the mesosphere and then release them so that they decelerate and reverse the prevailing winds in the region. This sort of radar study has been only possible with very powerful large aperture radars so far, which are mostly on a campaign basis. By fully utilizing the present continuous long term observation data set we will present results of gravity wave analyses in more details focusing on its relation with background winds.

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Tsutsumi, M. et al., Radio Sci., 29, 599-610, 1994.
Tsutsumi, M. et al., J. Geophys. Res., 101, 9425-9432, April, 1996.

G1–P8

EISCAT-JAPAN COLLABORATIVE STUDIES DRIVED BY EISCAT/EISCAT_3D RADARS

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The EISCAT(European Incoherent SCATter) Scientific Association is an international research organization, which operates incoherent scatter radars at 931MHz, 224MHz and 500MHz in northern Scandinavia and Svalbard for studies of physical and environmental processes in the middle/upper atmosphere and near-Earth space. Since 1996, National Institute of Polar Research, in collaboration with STEL of Nagoya University has promoted the EISCAT project for the user community in Japan to use the EISCAT facility for their scientific subjects.

EISCAT-3D is the major upgrade of the existing EISCAT radars in the northern Scandinavia. With a multi-static phased array system composed of one central active (transmit-receive) site and several receive-only sites, the EISCAT -3D system is expected to provide us 10 times higher temporal and spatial resolution and capabilities than the present radars.

In this presentation, we will overview our scientific activity and achievements with the EISCAT facility, and emphasize the science targets which we expect to be clarified by EISCAT_3D in near future.

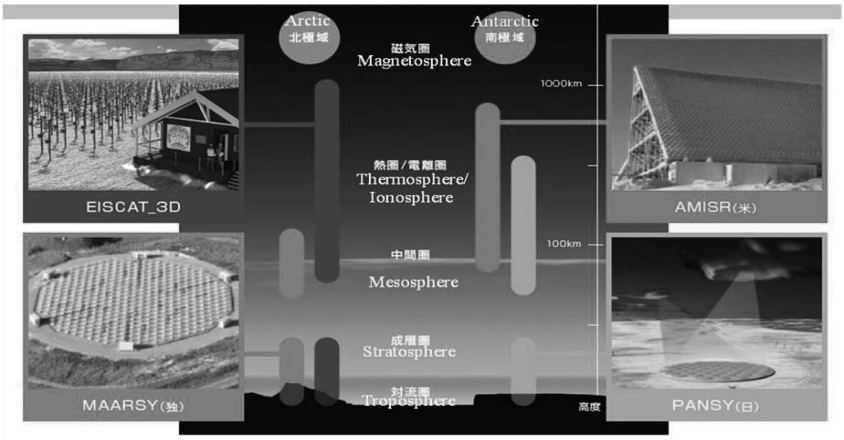

Figure 1. Altitude coverage of IS/MST radars in the Arctic and Antarctic.

G1–P9

THE POLARIZATION OF HIGHER HARMONIC AURORAL RADIO EMISSIONS

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This is a report on the first polarization measurements of auroral radio emissions near 4 times the electron cyclotron frequency (f_{ce}) in the Earth's polar ionosphere. Recently Sato et al. [2012]* discovered auroral roar emissions near ionospheric $4f_{ce}$, which were detected with a passive receiver installed in Svalbard, Norway (Invariant LAT 75.1N). The initial observations, performed for about a year, showed that $4f_{ce}$ roar emissions were detected from 5.27 to 5.70 MHz during moderate geomagnetic disturbances in 22 days between May and September 2011 only from noon to evening, while no event occurred during the 2010-2011 winter season. Examination of 2011-2012 polarization measurement data in Iceland (Invariant LAT 65.3N) reveals four events of 4 f_{ce} roar emissions. $4f_{ce}$ roar in two events was observed to be left elliptically polarized with respect to the local magnetic field during daylight hours. This polarization is consistent with the idea supported by the observation in Svalbard; the origin of $4f_{ce}$ roar is mode conversion to the L-O mode of upper hybrid waves favorably generated under the condition of $f_{UH} \sim 4f_{ce}$. The other two events showed that $4f_{ce}$ roar was right elliptically polarized during darkness hours. This polarization indicates that nonlinear coupling of two upper hybrid waves may also works in the bottomside auroral ionosphere to generate R-X mode $4f_{ce}$ roar.

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* Sato, Y., T. Ono, N. Sato, and Y. Ogawa (2012), First observations of $4f_{ce}$ auroral roar emissions, Geophys. Res. Lett. , 39, L07101, doi:10.1029/2012 GL 051205.

G1–P10

CURRENT STATUS OF UPPER ATMOSPHERE PHYSICS OBSERVATION IN ICELAND IN 2012

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Syowa Station (SYO) in Antarctica and Iceland in the northern hemisphere are located at auroral latitudes, and in the geomagnetic conjugate relationship, where both are connected with each other with a same magnetic field line. Conjugate observations of auroral phenomena in Iceland have been carried out since 1984 as a collaborative project between National Institute of Polar Research (NIPR), Japan and University of Iceland. At present, there are two observatories in Iceland; Husafell (HUS) and Tjornes (TJR). Conjugate point of Syowa, which was initially located between HUS and TJR in 1984, is now located just north-eastward of TJR. Various ground-based instruments are operated now. We will show the current status of the upper atmosphere physics observations in Iceland as of 2012.

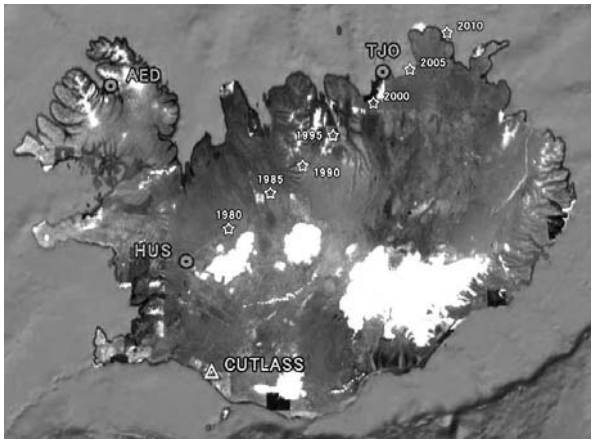

Fig.1. Map of Iceland. Indicated are locations of observatories in Iceland (HUS, TJO, AED), and geomagnetic traced footprint of Syowa Station (star symbols) from 1980 to 2010.

G5-P1

Cancelled

G5–P2

SOIL CARBON FLUX IN BLACK SPRUCE FOREST AFTER FOREST FIRE, INTERIOR ALASKA

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Northern boreal forests represent approximately 35% of the world's forest and contain ca. 66% of the world's forest soil carbon pools. Because boreal forests uptake atmospheric carbon dioxide and slowly decompose litter, fibric and humic substances, the ecosystems are known as carbon sinks. Forest fire is a major disturbance in boreal forests, with its occurrence closely coupled to climate patterns, resulting in changes in Arctic climate. Here, we present soil carbon efflux in burned black spruce forest with the succession on after 2004 forest fire that is the most severe damaged year. After 5 years, we have measured soil carbon efflux using automated chamber system that consists of 6 chambers (each three transparent- and opaque-material), controller included data-logger, 12 solenoid valves and pump, and thermocouples. Common hair moss (*Polytrichum commune*) grew natural plant after the fire. The NPP (net primary productivity), Re (ecosystem respiration) and GPP (gross primary productivity; GPP = Re - NPP) of the moss was measured using transparent- and opaque-material chambers, which mean NEE, Re and GPP were -0.03±1.19, 1.09±0.71, and 1.12±1.51 μgC/m^2/sec, respectively. Mean microbial respiration after the fire 0.78±0.41 μgC/m^2/sec, averaged four chambers in no plants from August to October of 2009. These carbon fluxes have exponential correlations to temperature, indicating the Q_{10} values on temperature of air, soil 5 cm and 10 cm below the surface were 1.66, 2.73, and 3.23, respectively. NEP (net ecosystem productivity) of Common hair moss was roughly -0.81μgC/m^2/sec, suggesting the losing carbon of 3.15 gC/m^2 for 45-day. This data will compare with NEP by eddy covariance tower.

G5–P3

CRYOSPHERICAL COHESIVE REGIONS AS TERRESTRIAL RESEARCH IN ALASKA FOR A COLLABORATIVE FRAMEWORK BETWEEN JAMSTEC AND IARC

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JAMSTEC-IARC Collaboration Study (JICS) is planned as a five-year project from 2009 JFY through 2013 JFY. Our approach has been to carefully examine the ongoing physical and biological processes and determine the underlying drivers and inherent linkages among system components. Research has been conducted to understand multi-scale interactions in the Arctic system, to quantify the impact of observing system components, and to utilize observations in tests and validation experiments for modeling and remote sensing. Providing the observation tower in the JICS supersite located to the north of Fairbanks, Alaska, is expected to contribute to a base for understanding terrestrial processes and variation on a mesoscale. Simultaneously, regional field surveys have been carried out at selected areas in Alaska. This paper introduces investigations related to the regional field surveys in Alaska.

Regarding ecosystem research, the above-ground biomass (AGB) of 29 forests along the south-north transect which profiles from boreal forest to tundra in Alaska was measured to construct the estimation algorithm of forest AGB by ALOS/PALSAR data. In some forests, temporal biomass changes have been monitored. Regarding permafrost research, physical properties of the surface and sub-surface have been measured at the interior (taiga), western (tundra) and southern (maritime) coastal sites. Large variations were found in near-surface soil thermal and hydrologic regime across short distances, with wet troughs experiencing freeze-up about a month later that the dry and exposed rims. The climatic gradient of soil and snow property that will be used in large-scale climate models has been surveyed by *in-situ* measurements and by lab analysis. Regarding snow cover research, snow surveys have been continuously carried out and several time-lapse cameras were installed in a longitudinal section of Alaska. A blowing snow sensor was installed at the northern tundra site. In addition, a physically based snow-atmosphere-ground-vegetation model has been developed, with inclusion of blowing snow processes. Regarding greenhouse gas research, diurnal and seasonal variations of floor CO_2 exchange in the interior taiga site have been continuously measured. A process-based terrestrial ecosystem model simulated greenhouse gas budget of northern terrestrial ecosystems, daily soil respiration, and global distribution of annual CH_4 emission from wetlands and paddy fields. Regarding hydrological research, a coupled hydrological and biogeochemical model (CHANGE) simulated inter-annual variations of hydrological processes over the pan-Arctic. A seesaw pattern in interannual variations of active layer thickness (ALT) was found between Lena and Mackenzie basins, which was significant when the Arctic air temperature entered into a warming phase, implicated with changing snow cover and soil moisture. While it is widely believed that ALT will increase with global warming, this hypothesis may need modification because the ALT shows responses to variations in snow depth and soil moisture that can over-ride the effect of air temperature.

It is necessary for systematic framework to improve understanding of linkages and feedbacks among Arctic climate system components on a mesoscale to a synoptic scale in future, in addition to further continuous data collection and analysis.

G5–P4

THE JAMSTEC-IARC SUPERSITE ENHANCES UNDERSTANDING OF THE ARCTIC CLIMATE SYSTEM – BIOGEOCHEMICAL OBSERVATIONS –

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Under the JAMSTEC-IARC Collaboration Study (JICS), the supersite was established in the Poker Flat Research Range (PFRR) of the University of Alaska Fairbanks in 2010, and observations on biogeochemical studies in the black spruce forest have been intensely carried out in addition to observations for hydro-meteorological studies. This paper introduces biogeochemical observations which are being taken place at the JICS supersite in PFRR.

Tree census survey was conducted at the 30m x 30m quadrat of the black spruce forest near the JICS tower in July 2010 to delineate the forest structure. The result of the census survey clarified that the density of tree stand (over 1.3m) was 3967 tree ha^{-1}. Also we cut down 16 trees in the forest in August 2012, and made the allometry equation for the estimation of the leaf area index and the above-ground biomass of black spruce tree. The forest landscape is always being monitored by the automatic digital fisheye camera installed on the top of the 17m JICS tower with 3 hours interval. Those pictures by the camera provide us valuable ideas to interpret the satellite data that show the seasonal change. The floor-level carbon dynamics are monitored with the automated open/close chamber (AOCC) system that has 16 chambers in the forest. By combining the floor-level flux data with the atmosphere-level flux data measured at the tower, the roles of forest canopy and floor in gas exchanges will be elucidated.

These biogeochemical observations are integrated with the hydro-meteorological observations of the supersite, and the data will be utilized for various studies included the study of biogeochemical modeling such as Vegetation Integrative Simulator for Trace Gases (VISIT). Moreover the knowledge and understandings which are created based on the supersite observations will substantially enhance the study on Arctic climate system.

Black spruce forest in the JICS supersite viewed from the top of the 17m JICS tower (July 2010).

G5–P5

THE JAMSTEC-IARC SUPERSITE ENHANCES UNDERSTANDING OF THE ARCTIC CLIMATE SYSTEM – HYDRO-METEOROLOGICAL OBSERVATIONS –

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As the key observational resource of the JAMSTEC-IARC Collaboration Study (JICS), a supersite was established in 2010 in a permafrost black spruce forest at the Poker Flat Research Range (PFRR) of the University of Alaska, located in Interior Alaska. A 17-m scaffold tower was built to conduct the hydro-meteorological and biogeochemical observations, including detailed remote sensing studies for estimations of the biomass of black spruce trees. Here, we introduce the hydro-meteorological observations.

To clarify characteristics of the energy, water, and carbon balance in this forest, sensible and latent heat flux and CO_2 flux were observed above the canopy and on the forest floor. Sensible and latent heat flux at both levels were nearly the same. Considering the footprint of the forest floor measurements, the contribution of the forest floor to the total evapotranspiration was suggested to be dominant in this forest. Energy balance was almost closed in early summer, and the mean energy balance ratio was 86.5 % over the whole summer, though a large energy balance deficit was observed in the spring. This deficit was explained by the energy consumed by snowmelt. The decoupling coefficient was very small, and the mean value was 0.06 in summer. Thus, evapotranspiration from this forest is mostly explained by the component from the dryness of the air, which results from the aerodynamically rough surface of this forest.

In order to evaluate the hydro-climatic and glaciological processes, snow depth, precipitation, snow and soil temperatures, soil moisture, and time-lapse imagery were all continuously monitored. Recently, snow pillow measurement began. A distributed temperature sensing (DTS) system with fiber optics monitors spatially continuous temperature. The obtained knowledge will be utilized by the Coupled Hydrological and Biogeochemical Model (CHANGE) and other models for the Pan-Arctic terrestrial region.

ENVIRONMENTAL QUALITY MONITORING OF BIODIVERSITY WITHIN CRYOLITHOZONE OF THE SAKHA REPUBLIC (YAKUTIA) IN THE CONDITIONS OF ECONOMIC USE AND GLOBAL CLIMATE CHANGE

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Today the Sakha Republic (Yakutia) establishes its own network of ecological monitoring because there is not any biosphere nature reserve over the spacious territory of the republic. It includes the network of hydrometeorological stations under Rosgidromet and observation stations belonging to the system of the Ministry of Nature protection of the Republic. In 2008 a public institution “Republican Information Analytical Center of Ecological Monitoring” was organized under the auspices of the MNP SR(Ya). There are also polygons performing their activity in Sakha affiliated to the Permafrost Institute SB RAS on monitoring concerning the state of permafrost grounds, to the Institute of Cosmic Research and Aeronomy SB RAS on monitoring of solar-terrestrial relation, space weather, thunderstorm activity and condition of works and spread of forest fires, to the Institute for Biological Problems of Cryolithozone SB RAS on monitoring of greenhouse effect, carbon emission, photosynthetic intensity, structure and functioning of subarctic, mountain and alas-taiga ecosystems. There are 2 state nature reserves and a lot of specially protected natural territories under the status of the Republic, which perform their activity on the ecological monitoring over their territories. Though functioning all these departments are not integrated in one unit with unified objectives and tasks, this network is not complex in full sense, so monitoring of many environmental parameters is conducted by different offices and institutions independently without due interaction with each other.

Since 2004 through 2007 the IBPC SB RAS was performing research in the Framework Programs of the joint academic council on life sciences on the project “Create a united network of complex ecological monitoring on biodiversity of frozen ecosystems over the model territories of Yakutia boreal forests, tundra and forest-tundra”. By the combined efforts of the institutes working in the system of the Yakut Science Center SB RAS and participation of the foreign partnership serious investigations of the theoretical principals of methodology and practice on ecological monitoring in Yakutia are carried out. Monitoring on the state of rare and endangered animal and plant species is held, activity related to their conservation and restoration in number are developed, more and more remote aerospace techniques of research of the animal habitats, satellite location of animals during their migration are applied. Financial maintenance of the foreign partnership contributes to setting up a network of field stations and polygons to perform long-term studies of ecosystems’ state and development of the methods for optimization of biological resources management in the national economy. Some field stations are fitted with specific scientific equipment and devices and join in the World Network of stations on ecological monitoring. On a monitoring network basis existed before and mainly owing to the previously implemented work realization of a real complex ecological monitoring with collaboration of research institutes Siberian Branch RAS, other research institutions of the Republic, Yakut State University, Ministry of Nature Protection and other interested bodies of Sakha is feasible. All data received will be used at the economical development of the region with consideration of strategy and tactics of management of the natural resources according to the National strategy of biological diversity preservation in Russia.

G5–P7

PHOTOSYNTHESIS OF *LARIX LARICINA* IN NORTHERN CANADA PERMAFROST AREA

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Photosynthesis of larch (*Larix laricina*) in North Canadian permafrost area was investigated during a week and compared with that of *Larix cajanderi* growing in permafrost boreal forest of Yakutia, Siberia, Russia.

Daily dynamics curves of net-photosynthesis (*A*) were bell-shaped, with maxima falling within 9-12 a.m. and the magnitudes of 4-5 μmoles m^{-2} s^{-1} that is at lower boundary of the range for *L.cajanderi*. Daily courses of respiration taking place in darkness (R_{dark}) were reverse parabolic with maxima mainly within 2-5 p.m. of up to -4 (mean -1.7) μmoles m^{-2} s^{-1}. R_{dark} in common was 50% of *A* at early morning, 11-32% at *A* pre-midday peak, and reaching 50% at evening. Considering available respiration data for *L.cajanderi*, R_{dark} patterns of the both species do not differ much.

The points of *A* light saturation and compensation were 950 and 106 μmoles m^{-2} s^{-1} respectively that are nearly threefold of *L.cajanderi* in Yakutia, probably reflecting high demand for radiation.

CO_2-saturated maximal *A* of *L.laricina* was quite low and made only 10-11 μmoles m^{-2} s^{-1}, that of *L.cajanderi* varying from 21 to 32.

Analysis on maximal carboxylation efficiency (Vc_{max}) and electron transport (J_{max}) rates revealed very low magnitudes of 16 and 50 μmoles m^{-2} s^{-1} respectively that are 2-3 times lesser than those of *L.cajanderi*. The J_{max} to Vc_{max} ratio of 3.2, on the contrary, is quite high (at usual 2-2.7 for the majority of plants), which is the case for Yakutian larch as well.

Collectively, photosynthetic data suggest that *L.laricina* in Northern Canada, being clearly different in morphology and in growing conditions from *L.cajanderi* in Yakutia, shows rather similar photosynthetic activity, except obscure light and biochemical parameters that could be a result of short-term measurements.

G5–P8

METHANE AND NITROUS OXIDE EXCHANGES BY DROPPINGS OF SVALBARD REINDEER ORIGINATED FROM WINTER FOOD

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Svalbard reindeer (*Rangifer tarandus platyrhynchus*) affects the carbon (C) and nitrogen (N) cycles in the tundra ecosystem through their activities such as grazing, scratching, and excretion. Droppings of reindeer, rich in organic matters, are also involved in the C and N cycles and might have a role in the atmosphere-land exchanges of methane (CH_4) and nitrous oxide (N_2O). The present study aimed to quantify the exchange potentials of CH_4 and N_2O for droppings of reindeer and/or soil. Droppings of reindeer originated from the last winter diet, which had a shape of pellets with blackish color, were collected at a site near Ny-Ålesund. Subsoil of regosols excluding the surface crust was also collected in the same area. The exchange potentials of CH_4 and N_2O were measured by an incubation experiment for two weeks using polyethylene bottles with the collected droppings and soils. The soil properties are: texture, sandy loam; soil pH, 7.6; total C, 1.72%; total N, 0.097%; CN ratio, 17.8; ammonium, 0.52 mg N kg^{-1}; nitrate, 0.081 mg N kg^{-1}. Those of the droppings are: total C, 42.1%; total N, 1.24%; CN ratio, 33.8; ammonium, 30.3 mg N kg^{-1}; nitrate, 0.053 mg N kg^{-1}. Treatments were soil only or soil with droppings (900-930 g dry matter m^{-2}) in combination with three moisture conditions for soil, i.e., no water addition; 15% of water content; and 25% of water content (n = 5). The incubation bottles were normally opened, and were closed when measuring the fluxes. The sample air was collected using a syringe at 1 and 30 minutes, in principle, after the closure of the bottles. The fluxes of CH_4 and N_2O were calculated using the determined air concentrations and mass balance in conjunction with the air pressure, air temperature, volume of bottle, and area of soil surface. Figure 1 shows an example of the results, where N_2O emission occurred just after the beginning of the incubation for the treatment with droppings. In general, tendencies of absorption and emission were found for CH_4 and N_2O, respectively.

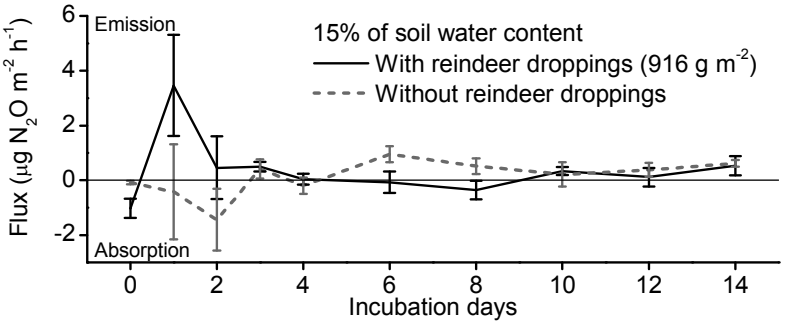

Fig. 1 Exchange flux of N_2O. The bars denote the standard error (n = 5).

G5–P9

CHEMICAL CHANGES AND FUNGAL COLONIZATION OF *SALIX ARCTICA* LEAF AND STEM LITTER ON DEGLACIATED MORAINES IN HIGH-ARCTIC CANADA

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Relationships between chemical changes in decomposing leaf and stem litter of *Salix arctica* and fungal colonization were examined in arctic tundra, located within the proglacial field of the southern front of Arklio Glacier in the Kreiger Mountains near Oobloyah Bay, Ellesmere Island, Nunavut, Canada. Samples were collected in 2003 from five glacial moraines with different development periods since the Last Glacial, the order of establishment of which is apparent based on the distance from the glacier snout and the moraines (Osono et al. 2012). Samples of dead leaves and stems were divided into three and five decay classes, respectively, using visual criteria and used for chemical analysis, hyphal length estimation, and fungal isolation. Contents of acid unhydrolyzable residues, extractives, and C varied significantly with the moraine and the decay class of both leaves and stems. Contents of total carbohydrates, N, P, K, Ca, Mg, C/N ratio, and δ^{15}N varied significantly with either the moraine or decay class in leaves or stems. Total hyphal length ranged from 673 to 9470 m/g dry material in leaves and from 537 to 4404 m/g for stems and varied significantly with the decay class in leaves and stems. Four morphotaxa were frequently isolated from leaves and stems, and frequencies of occurrence of two morphotaxa varied significantly with the decay class. Total hyphal length and frequencies of fungal morphotaxa significantly correlated with contents of acid-unhydrolyzable residue, total carbohydrates, extractives, N, P, K, Ca, Mg, C/N ratio, and/or δ^{15}N in leaves and stems, suggesting organic chemical and nutritional controls on fungal colonization.

Osono, T., Ueno, T., Uchida, M., Kanda, H., 2012. Abundance and diversity of fungi in relation to chemical changes in arctic moss profiles. Polar Sci. 6, 121-131.

G5–P10

The relationship between plant and soil bacterial community in tundra soil, Alaska

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Permafrost affected soil in Alaska contains large amount of organic carbon due to high moisture content and low temperature. Increased temperature by warming maystimulate biological activity and carbon decomposition in Alaska as well as other permafrost affected area. As the first step to understand biological components in this permafrost affected soil, we studied spatial distribution of soil bacteria and plant community and their relationships with soil properties. Here, we asked the question: 1) which kinds of plants are dominant, 2) the dominant plants affect to the bacterial communities structure? and 3) which environmental factors affect to the plant and bacterial community structure? To answer these questions, we surveyed plant cover using quadrate (30 cm x 30 cm) at 36 points (25 m interval between points) and the soil bacterial community structure using 16S rRNA gene pyrosequencing. Generally, Cotton grass (tussock), blue berry and moss are dominant. Bacterial communities showed difference between up (surface-10 cm) and down layer (10-20 cm) of soil as showing Alpha-proteobacteria is dominant in up layer, whereas Acidobacteria and Actinobacteria are dominant in down layer. The most abundant OTUs (operational taxonomic units), Bradyrhizobiaceae sp. and Rhizobialse sp., abundant in both layer. The statistical analyses for observing the relationships between soil properties and plant and bacterial community are now processing.

G5−P11

PERMAFROST DEPTH, FOREST FLOOR, AND FOREST BIOMASS ACCUMULATION OF UPLAND BLACK SPRUCE STANDS IN INTERIOR ALASKA

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Black spruce (Picea mariana) stands are widely distributed in Interior Alaska, both on the bottom flat land and on the north-facing upland slope topography. These habitats are quite different in terms of soil parent materials, soil moisture condition, and successional trajectories characterized by ground flora species composition. The north-facing slope, on which mature black spruce stands dominate, is accompanied by underlying permafrost. We selected a ca. two-kilometer long north-facing slope toposequence, including lower to upper slope extending to crest flat topography in Caribou Poker Creek Research Watershed (CPCRW). Soil profile survey and soil penetration test for permafrost table detection, Tree census of diameter at breast height and tree height were measured at seven sites. Soils were classified into Gelisol order, Typic Haplorthels. Active layer thickness (permafrost depth in growing season) varied much among the profiles, ranging from 40 to 120 cm. Permafrost depth was deeper in the upper position of the slope, and the deepest near the crest flat position. The shallowest active layer depth was recorded at the lower position near foot slope. All profiles were covered with thick moss-lichen layer, with ranging from 20 to 35 cm thickness. Species composition of forest floor vegetation under mature black spruce forest is one of suitable indicator showing moisture condition. Forest floor of moss-lichen complex showed typical species replacement along the moisture gradient. The most prevailing moss species under mesic water condition were Hylocomium splendens, Pleurozium schreberi and Ptilium crista-castrensis. Sphagnum moss was not dominated in the mesic condition. The growth of annual stem length of Hylocomium splendens were measured along the slope. Hylocomium population grown at upper site showed longer annual growth than lower ones during recent five years. According to census data and allometric relationship, the larger C accumulation in plant biomass more than 60 Mg C ha^{-1} occurred at upper position of the slope. Carbon accumulation in plants less than 10 Mg C ha^{-1} occurred at three stands located on lower position of the slope. The smallest value of C accumulation in plant biomass was 5.3 Mg C ha^{-1}. Carbon accumulation in plant biomass at the upper position is nearly ten times larger than that of the lower position of the slope.

G5–P12

ESTIMATION OF C LOSS BY FIRE IN A BURNED BLACK SPRUCE FOREST IN INTERIOR ALASKA USING RADIOCARBON.

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Carbon loss from forest floor/top soil by wildfire was estimated at a burned boreal forest site in Interior Alaska, using radiocarbon ($\Delta^{14}C$). By comparing organic C storage and radiocarbon profile at burned forest with those of a mature forest, we estimated C loss from forest floor/top soil. Soil profiles were surveyed at the mature black spruce forest in University of Alaska Fairbanks, and the burned black spruce forest in Poker Flat Research Range, which burned in 2004 summer. The $\Delta^{14}C$ profiles at the mature forest show clear bomb ^{14}C peak after 1960's, and plant litter and soil organic C at top of the 15cm was fixed over the past 50 years. Burned boreal forest site were similar $\Delta^{14}C$ profiles to the mature forest, but top of 10cm was lost. Organic carbon storage in each forest was estimated by bulk density and C contents. Decline of carbon storage after wildfire was estimated, assuming that C storage in the mature forest were same regime of C storage as burned stands before wildfire. Compare with mature forest, 4.4 kg C m^{-2} was lost. Wildfire disturbance in 2004 caused much C loss from forest floor, corresponding to 53% of accumulated C over the past 50 years.

G5–P13

RESPONSE OF ECOSYSTEM CARBON CYCLE TO CLIMATE CHANGE IN A GLACIER FORELAND OF THE HIGH ARCTIC

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Global circulation models predict warming and increased precipitation in Arctic regions throughout the 21st century. Since large amounts of organic matter accumulate in soils, we need to know how carbon flows in the Arctic terrestrial ecosystem will respond to projected climate change. In this study, we construct a process-based model for simulating stand-level photosynthesis, root respiration and heterotrophic respiration at Svalbard in the High Arctic. Using this model, responses of net ecosystem production (NEP) to temperature and precipitation increases and to lengthening of growing season are examined.

The study site was in the glacier foreland of Austre Brøggerbreen near Ny-Ålesund in Svalbard. A mixed community of *Salix polaris* and the moss *Sanionia uncinata* was selected for study, because it is the dominant vegetation of the late successional stage of the glacier foreland. The model was composed of six carbon pools: aboveground and belowground biomasses of vascular plants, biomass of cryptogams, organic layers of vascular plants and cryptogams, and mineral soil layer. Responses of each carbon flow to environmental factors were expressed by functions determined in previous studies (Nakatsubo et al. 1998; Muraoka et al. 2002; Uchida et al. 2002; Bekku et al. 2003).

To evaluate model calculations and determine model coefficients, we selected three study plots (A, B, C) with different coverages of *S. polaris* in the glacier foreland. In the 2001 summer season, NEP was measured in these plots using a portable photosynthesis system with an assimilation chamber. Carbon pools in each plot were investigated after this measurement.

In situ NEP values in the growing season varied widely among the three plots, ranging from 17 to 110 mg CO_2-C m^{-2} h^{-1}. Seasonal variation within a plot was also considerable, but there was close correlation between model-estimated values and those determined in the field. This shows that the model effectively simulates NEP in the growing season at the plot level.

We used the model to examine NEP response to temperature, precipitation and lengthening of the growing season. Effects of temperature increases of +2°C, +4°C and +6°C on NEP were calculated. It was shown that NEP decreases rapidly with increasing temperature. In two of the three plots, NEP became a CO_2 source to the atmosphere with an increase by 2°C. All three plots became such a source with a 4°C increase. The effect of precipitation increase was examined by 5, 10 and 15% increases. Our result suggests that this effect on NEP was extremely small. On the other hand, lengthening the foliage period of *S. polaris* significantly increased NEP, partially compensating the negative effect of temperature increase.

S5–P1

Model resolution comparison for methane simulation in the Arctic region

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The Arctic region is most vulnerable to the global warming. The sea-ice cover has much reduced for the past decades, bringing about change in the heat budget balance, also accompanied by positive feedback by decreasing surface albedo. There is proposition that methane (CH_4), which is a strong greenhouse gas, can be released into the atmosphere from the reservoirs due to melting of permafrost soils and so. Thus the physical and biogeochemical system of the Arctic could trigger a positive feedback loop of the global warming. The boreal wetlands are known to be strong natural source of CH_4 to the atmosphere. However, the response of the boreal wetlands to climate warming is not studied well. In the Arctic region many wetlands exist especially in West Siberia, Russia and also in Alaska, which are thought to significantly affect the Arctic CH_4 cycles. Therefore, it is very important to reasonably quantify the source to understand global warming feedback in this region through this strong greenhouse gas and to predict the future of that as accurately as possible. However, there are also other influential anthropogenic sources such as biomass burnings and natural gas plants and pipe-lines. It makes understanding of CH_4 cycles in this region complicated.

We use the CCSR/NIES/FRCGC Atmospheric General Circulation Model (AGCM) based Chemistry Transport Model (ACTM) for simulations of CH_4. ACTM has been run at two horizontal resolutions, namely, T42 (~2.8 x 2.8o) and T106 (~1.125 x 1.125o) to evaluate spatial representation errors arising from different category of sources in small area (e.g., oil drilling or gas pipeline leaks) or high-to-low emission transitions, e.g., along the complex coastal lines, for simulating the atmospheric CH_4variability. The model simulations will be compared with the already existing CH_4 measurements by various international organizations and those acquired as the part of the newly funded Arctic GRENE project. Detailed results will be discussed during the presentation.

S5–P2

Global methane simulation for the period 1910-2010 using atmospheric general circulation model based chemistry transport model

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Methane (CH_4) is produced both naturally and anthropogenically on the Earth's surface, and thought to be second only to carbon dioxide (CO_2) as an agent of present/future global warming. Methane is also chemically active, contributing to formation of tropospheric ozone and stratospheric water vapor, which further increases its importance to the Earth's radiative balance. Atmospheric CH_4 concentration has increased from 900 ppb in 1900 to ~1800 ppb in 2000s [1]. During the same period, the anthropogenic CH_4 emission has increased from 92 Tg/yr to about 310 Tg/yr. Mass balance calculation suggest that the increase in atmospheric concentration is caused entirely due to increase in anthropogenic emissions [2].

Model simulations of atmospheric CH_4 at monthly time scale with a horizontal resolution of T42 spectral truncation (~2.8x2.8°) and 67 sigma-pressure vertical layers (surface - ~90 km), for ten different emission scenarios based on combinations of anthropogenic (fossil fuel, biofuel, industrial process, livestock, waste handling and fire) and natural (wetland and rice) emission types, are being conducted using the CCSR/NIES/FRCGC Atmospheric General Circulation Model (AGCM) based Chemistry Transport Model (ACTM) for the period of 1900-2010. The model simulations will be compared with CH_4 concentrations as measured from the air bubbles trapped in the polar ice columns, and direct measurements since the 1970s at multiple sites around the globe.

Results on the contribution of different CH_4 emission types to latitudinal and inter-annual/decadal variation of CH_4 concentration over the past century will be discussed.

References:

[1] Etheridge, D.M., L.P. Steele, R.J. Francey, and R.L. Langenfelds. 1998. Atmospheric methane between 1000 A.D. and present: evidence of anthropogenic emissions and climatic variability. Journal of Geophysical Research, 103, 15979-15996.

[2] EDGAR- Emission Database for Global Atmospheric Research (http://edgar.jrc.ec.europa.eu/archived_datasets.php)

S5–P3

OCEANIC AND TERRESTRIAL BIOSPHERIC CO_2 UPTAKE ESTIMATED FROM ATMOSPHERIC POTENTIAL OXYGEN OBSERVED AT NY-ÅLESUND, SVALBARD AND SYOWA, ANTARCTICA

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Simultaneous measurements of the atmospheric O_2/N_2 ratio and CO_2 concentration were made at Ny-Ålesund, Svalbard and Syowa, Antarctica for the period 2001-2009. Based on these measurements, the observed atmospheric potential oxygen (APO) values were calculated. The APO variations produced by changes in the oceanic heat content were estimated using an atmospheric transport model and heat-driven air-sea O_2 (N_2) fluxes, and then subtracted from observed interannual variations of APO. The oceanic CO_2 uptake derived from the resulting "corrected" secular trend of APO showed interannual variability of less than ±0.6 GtC yr^{-1}, significantly smaller than that derived from the "uncorrected" trend of APO (±0.9 GtC yr^{-1}). The average CO_2 uptake during the period 2001-2009 was estimated to be 2.9±0.7 and 0.8±0.8 GtC yr^{-1} for the ocean and terrestrial biosphere, respectively. By excluding the influence of El Niño around 2002-2003, the terrestrial biospheric CO_2 uptake for the period 2004-2009 increased to 1.5±0.8 GtC yr^{-1}, while the oceanic uptake decreased slightly to 2.8±0.7 GtC yr^{-1}.

S5−P4

Constructing Arctic CO_2 data assimilation system using online transport model and LETKF

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This research aims to establish a local ensemble transformed Kalman filter (LETKF) data assimilation system to estimate global surface especially focusing on arctic CO_2 fluxes from data assimilation of various observation data. The 4D-EnKF is able to estimate the dynamically consistent atmospheric state with the optimal use of observation data at reasonable computational costs. Online atmospheric transport model is employed in the data assimilation system to optimize surface CO_2 fluxes at spatial and temporal resolutions of 3 days and T42 (2.8°), respectively. We have conducted data assimilation experiments with real observations. It is important to remove a bias in satellite data before data assimilation, in order to obtain a robust estimation of surface CO2 fluxes. For this purpose, a bias correction scheme was developed using the global CO2 concentration reanalysis data produced at Japan Meteorological Agency (JMA) and applied to satellite data. To provide more constraints from other observations, we introduced aircraft observation data (CONTRAIL). Combination use of these observation data allowed us to obtain realistic CO2 concentration field and modify surface CO2 flux almost entire earth surface especially over land. To obtain more robust arctic CO2 flux, we need more observation data neighbourhood of the area. This work was supported partly by Grants-in-Aid from the GRENE Arctic Climate Change Research Project, the Ministry of Education, Culture, Sports, Science and Technology. GOSAT Observation data are provided from GOSAT Research Announcement office. We would like to acknowledge JAL Foundation for coordinating the CONTRAIL project.

S5–P5

TIME SERIES OF TROPOSPHERIC N_2O ISOTOPOMER RATIOS OVER WESTERN SIBERIA

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Nitrous oxide (N_2O) is one of the increasing greenhouse gases in the troposphere and is the most important stratospheric ozone-depleting gas emitted in the 21st century. In Arctic region, origin of atmospheric N_2O include human activity in Europe, Russia, and North America (e.g., agriculture), biomass burning (forest fires), oceans in high-latitude northern hemisphere, and future climate change might cause substantial change in such sources. Isotopomer ratios of N_2O, which include not only elemental $^{15}N/^{14}N$ and $^{18}O/^{16}O$ ratios but also site-specific $^{15}N/^{14}N$ ratio in asymmetric NNO molecule, are regarded as useful parameters to infer the origin and production–consumption mechanisms of N_2O, and to estimate its global budget. Previous studies on N_2O trapped in the firn in polar ice sheet revealed the secular trend of isotopomer ratios, but there has been no reports on long-term monitoring of N_2O isotopomer ratios in Arctic atmosphere.

We have been measuring mixing ratio and isotopomer ratios of N_2O in air samples collected at altitude of 500 m and 7000 m over Novosibirsk, western Siberia (55°N, 83°E) by monthly aircraft sampling since 2005. Results show that the bulk nitrogen isotope ratio ($\delta^{15}N^{bulk}$) are decreasing at the similar rate (about -0.04‰yr^{-1}) as reported by firn-air analysis while the N_2O mixing ratio are increasing (about 0.8 ppbv yr^{-1}). Short-term variations and vertical gradient will also be discussed along with atmospheric model simulation.

ANALYSIS OF INTER-ANNUAL VARIATIONS IN SEASONAL CYCLE OF APO AT CAPE OCHI-ISHI

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Atmospheric potential oxygen (APO), defined as a combination of atmospheric O_2 and weighted CO_2 concentrations ($APO=O_2+1.1\times CO_2$), is invariant with respect to the terrestrial biotic gas exchange. Therefore, the variation of APO mainly reflects air-sea gas exchanges of O_2 and CO_2. We have been observing the atmospheric CO_2 and O_2 at Cape Ochi-ishi (COI; 43.2°N, 145.5°E) by using flask sampling system (*Tohjima et al.*, 2008) since December 1998 and by using in situ measurement systems since March 2005 (*Yamagishi et al.*, 2008) (Fig. 1). The observed APO shows clear seasonal cycles with the average minimum in March and the average maximum in June. Although the inter-annual variability in the seasonal cycles at COI was rather small, anomalous seasonal cycles were sometimes observed. For example, significantly enhanced seasonal maximum was observed in June 2005 (Fig. 2).

The seasonal cycle of APO is mainly driven by oceanic O_2 emissions associated with the primary production during spring-summer and by O_2 drawdown associated with the vertical mixing of sea water during fall-winter, which brings deeper waters with depleted O_2 in contact with the atmosphere. Additionally, the temperature-induced solubility changes also slightly contribute to the seasonal variations in the air-sea gas exchanges. In order to investigate the cause of the anomalous seasonal cycles, we examine temporal variations in the net primary production (NPP) estimated from Vertically Generalized Production Model (VGPM), the sea surface temperature (SST) and the mixed layer depth (MLD). For example, the VGPM in the western North Pacific shows anomalously high NPP in June 2005. Therefore, the enhanced O_2 emissions associated with high production might elevate the APO maximum at COI in 2005.

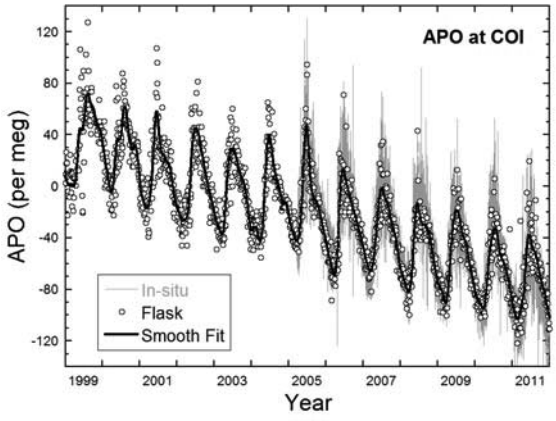

Fig. 1. Time series of APO at COI. Circles and gray lines represent flask and in-situ observation, respectively. Thick black curve represents the smooth fit to the data.

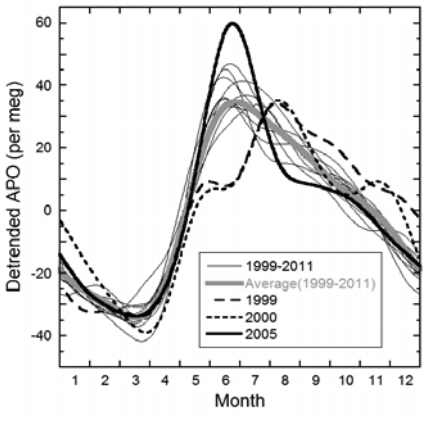

Fig. 2. Detrended seasonal cycles of APO at COI from 1999 to 2011.

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S5–P7

HIGH PRECISION CONTINUOUS MEASUREMENT SYSTEM FOR THE ATMOSPHERIC O_2/N_2 RATIO AT NY-ÅLESUND, SVALBARD

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To elucidate temporal variations of atmospheric O_2 at Ny-Ålesund (79˚N, 12˚E), Svalbard in detail, as well as to contribute to a better understanding of the global carbon cycle, a high precision continuous measurement system for the atmospheric O_2/N_2 ratio was developed using a fuel cell oxygen analyzer. To obtain highly precise values of the atmospheric O_2/N_2 ratio, pressure fluctuations of the sample and standard air in the fuel cells were reduced to an order of 10^{-3} Pa, with temperatures stabilized to 32.0±0.1ºC. A non-dispersive infrared analyzer was also installed into the system to allow simultaneous measurements of the atmospheric CO_2 concentration. Considering remoteness of the observation site, three special attentions were further paid when the measurement system was constructed; (1) the start-up and shutdown of the system can be controlled in Japan using the Internet, (2) all the output data from the system are recorded on a hard disk and also collected in Japan through the Internet, and (3) two water traps were equipped in parallel on the air sample line to make it possible to operate the system over a long time without manually replacing the trap. The two traps are alternately switched to cool at −80ºC and heat at 50ºC in order to remove water vapor contained in the sample air and the trap, respectively. By repeatedly analyzing the same sample air, the analytical precision of the measurement system was estimated to be ±1.4 per meg (0.3 ppm), which is sufficient for clearly detecting very small spatiotemporal variations of the atmospheric O_2/N_2 ratio. We also tested the system by continuously measuring the O_2/N_2 ratio in the boundary layer atmosphere at Aobayama (38˚N, 141˚E), Sendai, Japan, and it was confirmed that the system is capable of clearly detecting very small but persistent seasonal and diurnal cycles, along with short-term variations on time scales of several hours to several days, caused by terrestrial biospheric and human activities. Systematic and continuous observation of the atmospheric O_2/N_2 ratio using the developed system is planed to start at Ny-Ålesund in December 2012.

S5–P8

APPLICATION OF RADON-222 AS A TRACER FOR CHARACTERIZING FETCH REGIONS AND EVALUATING A GLOBAL 3D MODEL

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In order to estimate the regional/continental sources and sinks for atmospheric CO_2, atmospheric Radon-222 has been used at Rishiri Island (45°07'N, 141°12'E) as a tracer being monitored since December 2008. This work analyzed the first two years atmospheric Radon-222 data to evaluate the seasonal transport pattern. In summer, clear diurnal variation was observed with maximum Radon-222 concentration before the dawn, while the minimum appeared in the afternoon. This was caused by the local radon-222 source. However the magnitude of local source was quite weak. Seasonal Radon-222 variation was characterized by high concentrations from November to February and low concentrations from May to July, caused by the alternation of continental and maritime fetch regions. Seasonal high and low Radon-222 events were examined by using the back trajectory cluster analyses to clarify the fetch regions (Fig. 1). The results indicated that the predominant continental fetch region was southeastern Siberia and northeastern China. Radon-222 emitted from China and South Korea, whose economies are growing rapidly, did not significantly affect the Rishiri site. This implies that current observation of CO_2 at Rishiri Island is more directly influenced by the carbon sink region vegetated by boreal forest. The major maritime fetch region was the Sea of Okhotsk and the Bering Sea. A global three-dimensional model (NICAM-TM) accurately simulated Radon-222 concentrations on Rishiri Island and in the seasonal fetch regions. Other than to evaluate the sources of atmospheric greenhouse gases being monitored at Rishiri Island, the time series of Radon-222 data will also allow us to validate model simulations used to examine trans-boundary air pollution.

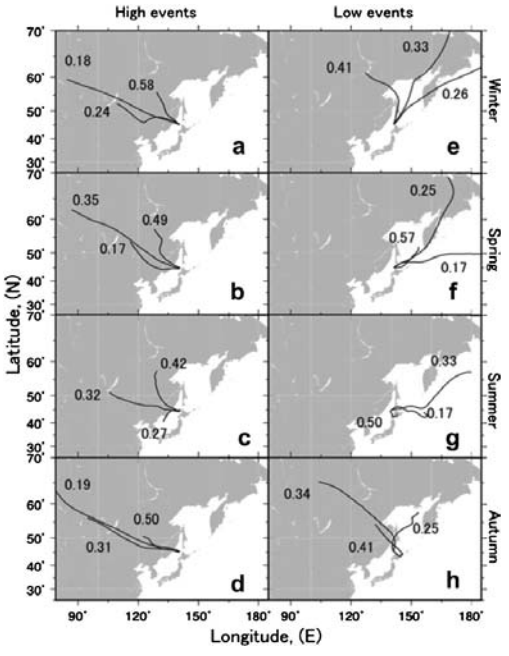

Fig. 1. Fetch regions for high and low radon-222 events at RIO as indicated by 120-h back trajectory clusters. The values near each trajectory show the ratio of events contributing to that cluster relative to total events in the specified season.

S5–P9

RECONSTRUCTION OF PAST VARIATIONS OF THE CARBON AND HYDROGEN ISOTOPIC RATIOS IN ATMOSPHERIC METHANE FROM ITS VERTICAL DISTRIBUTION OBSERVED IN NGRIP FIRN

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Temporal variations of $\delta^{13}C$ and δD of atmospheric CH_4 in the past 50 years were reconstructed from the isotopic ratios of CH_4 observed in firn at North GRIP. The one-dimensional diffusion model was used to simulate the diffusion process and the gravitational separation of CH_4 molecule in the firn. The effective diffusivity was determined so that the difference between the modeled and observed CO_2 concentration profiles was minimized. An approximate history of the atmospheric CH_4 concentration was constructed for NGRIP by combining the data from the direct atmospheric measurements at Point Barrow, Alert, and Ny-Ålesund with those from ice cores at Greenland. In order to reconstruct the past $\delta^{13}C$ and δD of atmospheric CH_4 from their values in the firn, the effective age of CH_4 at each sampling depth was determined by using an approximate history of the atmospheric CH_4 concentration. Effective age at each sampling depth was determined so that the model-calculated concentration at that depth agreed with a value in the concentration history. To correct for the diffusion effect on $\delta^{13}C$ of CH_4 in the firn, the diffusion model was run without the gravitational effect, using concentration histories for three kinds of CH_4 molecules, $^{12}CH_4$ with D_{16}, $^{13}CH_4$ with D_{17}, and $^{13}CH_4$ with D_{16}. Here, D_{16} and D_{17} represent the effective diffusivities of CH_4 molecules with masses 16 and 17, respectively. The diffusion correction was determined as a difference between the isotopic value of the heavier molecule actually predicted in the firn ($\delta^{13}C(D_{17})$) and the value which theoretically excluded the effect of diffusive separation ($\delta^{13}C(D_{16})$). Correction for the diffusion effect on δD was the same as that of $\delta^{13}C$, but used three molecules of CH_4 with D_{16}, CH_3D with D_{17} and CH_3D with D_{16}. The values of the atmospheric $\delta^{13}C$, thus estimated, were in good agreement with those from direct atmospheric measurements at Ny-Ålesund. The statistical uncertainty of the reconstruction procedure was examined by repeating model calculation with 100 different data sets provided by adding normal pseudo random numbers to the observed values in firn. We will also discuss an application of the diffusion correction to the isotopic values of CH_4 observed by ice core analyses.

S5–P10

Observations of atmospheric greenhouse gases from a tower network and aircraft over Siberia

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The north polar region plays an important role for atmospheric greenhouse gases such by photosynthesis and respiration in forest, CH_4 emission from wetland, leakage of natural gas from gas/oil production facilities, and forest fires. To understand the temporal changes and spatial distributions of fluxes for greenhouse gases in Siberia, our group started several kinds of observation for atmospheric greenhouse gases under GRENE project in addition to some ongoing measurements. The observation sites are summarized in Figure 1.

Continuous measurements of CO_2 and CH_4 have been conducted from a network of towers (JR-STATION: Japan–Russia Siberian Tall Tower Inland Observation Network) in taiga, steppe, and wetland regions in Siberia since 2002.

Routine flask samplings have been carried out over 3 sites in Siberia using chartered aircrafts since 1993. The sample airs are brought back to Japan and mixing ratios of greenhouse gases and their isotope ratios are analyzed. Continuous CO_2 measurements with a light aircraft over the JR-STATION site, Berezorechka, were conducted from 2002.

We also have conducted frequent CO_2 observation in the upper troposphere/lower stratosphere over Siberia by using the commercial airliner operated between Japan and Europe since 2005. The flask sampling by the commercial airliner has started since 2012 to measure mixing ratios of greenhouse gases and isotope ratios of CO_2 and CH_4.

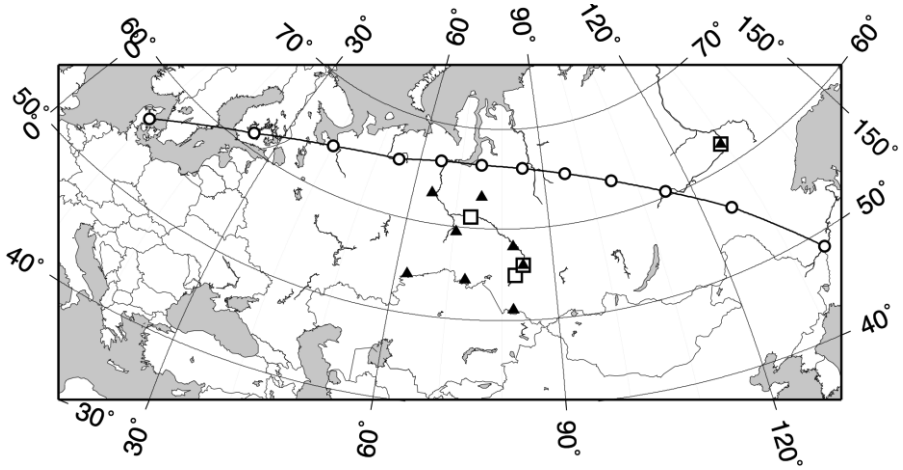

Figure 1. Locations of observation by a tower network (solid triangles), chartered aircraft (open squares) and commercial airliners (open circles and solid line).

S5–P11

GOALS AND ACTIVITIES OF THE TERRESTRIAL MODELING GROUP OF "GRENE ARCTIC CLIMATE CHANGE RESEARCH PROJECT"

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The goals of the modeling group in the terrestrial research project of the GRENE Arctic Climate Change Research Project (GRENE-TEA) are to a) feed the possible improvement of the physical and ecological processes for the Arctic terrestrial modeling (excl. glaciers and ice sheets) in the extant terrestrial schemes in the coupled global climate models (CGCMs) to the CGCM research project, and b) lay the foundations of the future-generation Arctic terrestrial model development. To achieve these goals we have been attempting to 1) deepen the feasibility of mutual collaborations and comparisons between the participating models, and 2) enhance communications with the in-situ and remote-sensing observationists to transform the collections of observable data and information more effectual for calibration, validation, improvement and development of the conceptual and numerical models. We will report our activities, especially the making and the resultant "brochures" of the participating models which provide the scope, targets, specifics and capability of each model to serve as mutual references among models, and as resources for communications with other researchers (e.g., observationists, data managers), staffs and the public.

S5−P12

Arctic Data archive System (ADS)

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In Arctic region, various changes are being caused by global warming. In previous studies, the decrease of Arctic sea ice extent, the increase in soil temperature in the region of Siberia, permafrost melting, the increase in Arctic river runoff, reduction in snow cover has been revealed. Also the impact of human activities and ecosystems due to these changes is concerned. The actual condition and mechanism of environmental change in arctic has not been elucidated. Previous studies have been carried out to separate the atmosphere, oceans, by land. Arctic is a system consisting of atmosphere, ocean, land surface, from snow and ice, these systems including the phenomenon of different spatial scales and time scale, respectively. In order to clarify the variability of the Arctic environment, through interdisciplinary research, research is needed in using a database that integrates the results of observation and research data across multiple areas.

On the other hand, arctic research by Japanese researchers has been carried out all the time from the last century. The result of their research includes many irreplaceable data, such as observation time series, sample, and its analysis, which each researcher got in the field. Since researcher and organization have had those data in their keeping by their way, many data has not managed and kept systematically.

Now, a new ‘Arctic Data archive System (ADS)’ was launched on purpose to collect, manage and open some arctic data supported by Green Network of Excellence (GRENE), Rapid Change of the Arctic Climate System and its Global Influences (a tentative English title). ADS can search various keywords using metadata which are related with a one-to-one correspondence. This schema fits some format of typical Earth environment data, and we plan additional schema.

S5–P13

RECENT GLACIER CHANGES IN SUNTAR-KHAYATA REGION, EASTERN SIBERIA.

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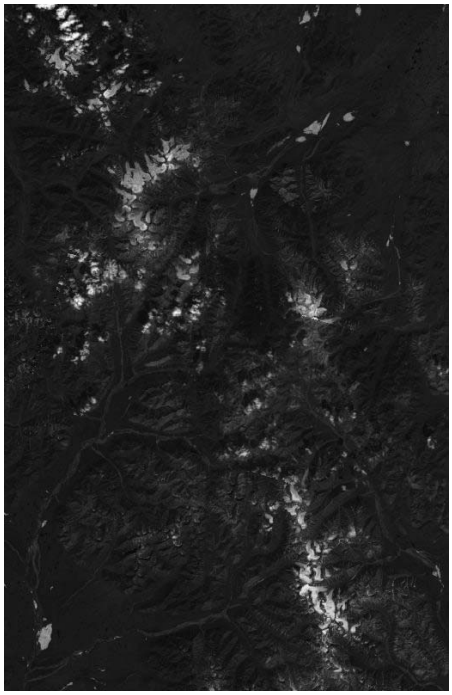
Arctic is a significant regional impact of global warming. Arctic glaciers, it is expected to have a large impact of global warming.Research of the distribution of glacial in Russian region is carried out actively in the past, these results are listed in the in world glacier inventory.In recent years, the description of the glacier is also performed in GLIMS project.

On the other hand, glacier inventory exists Suntar-Khayata region, Eastern Siberia is a detailed investigation has been carried out in the period from 1959 to1957 as IGY. In this region, actual conditions has become clear in recent glacier changes reinvestigation is carried out in the 2000s. In this study, we have carried out to clarify the recent glacier changes in the region using satellite data.



The satellite image of Suntar-Khayata region, Eastern Siberia

S5–P14

CRYOSPHERIC STUDY IN THE GRENE-ARCTIC PROJECT: PLAN AND REPORT FROM RESEARCH IN 2012

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GRENE-Arctic project has some implementing groups of “The role of Arctic cryophere in the global change” This study will contribute to the strategic targets of 1)understanding the mechanism of warming amplification in the Arctic, 2)understanding the Arctic system for global climate and future change.

During the first intensive observing period in 2012, glacier research in Siberia and ice sheet research in Geenland are carried out. Snow cover research and local weather research groups set the instruments in the various research fields, in Scandinavia, Alaska and Siberia.

Regional cryospheric reports and circum-Arctic weather conditions in 2012 summer indicates a trans-Arctic cryosphere-weather conditions, connecting Greenland melting, Siberian dry and hot summer, and instabilities of Siberian coast, northern Greenland and Japanese monsoonal weather. Alternative temperature patterns and over Arctic regions causes regional warm/cool area and temperature gradient zones.

S5–P15

OVERVIEW OF REGIONAL AND INTERANNUAL VARIATIONS OF SNOW AND SURFACE CONDITIONS AT GRENE ARCTIC OBSERVATION SITES DERIVED BY SATELLITE MICROWAVE DATA

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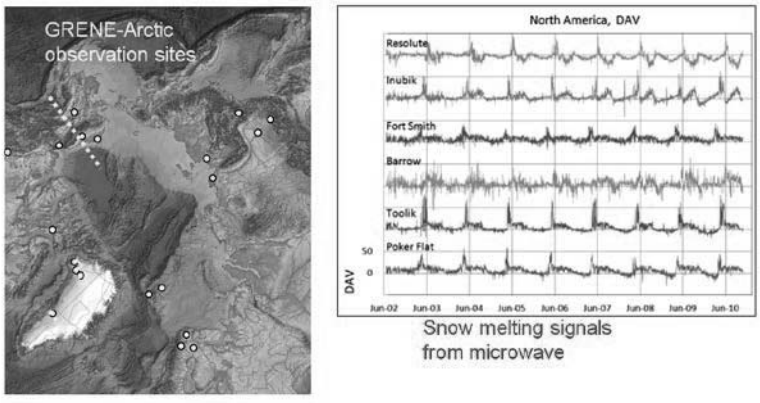
New Japanese project for Arctic research: GRENE Arctic Climate Change Research Project has started. Snow and ice research group in GRENE Arctic project will observed snow conditions from site field observations, and expand the knowledge by satellite observation. This study overviews snow and related ground conditions at all major observation sites of GRENE Arctic project by using the satellite microwave data. Satellite microwave data of AMSR-E is available for observing snow cover, melting, ground freezing. This study extracted daily microwave data for ten years period from the observation sites and descried snow conditions. As the snow condition affects many other researches through hydrological process and atmospheric boundary conditions, the seasonal cycle of snow condition is substantial for initiating project

The main target area are, Siberia, North America, Scandinavia and Greenland. Snow cover and melting periods are indicated and regional and interannual changes are summarized in this study. Melting tendencies by several observation points are investigated in Greenland ice sheet.



Field observation sites in the GRENE Arctic project and example of data.

S5–P16

JAPANESE FIELD ACTIVITIES IN THE GREENLAND ICE SHEET MONITORING NETWORK (GLISN)

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Due to the recent climate change, the number of cryo-seismic events at the Greenland ice sheet is drastically increasing. Such events are caused by internal deformation of the ice sheet, sliding at the base, disintegration at the calving front, etc. Therefore, long-term seismic monitoring of the Greenland ice sheet will contribute to investigate the ice collapsing process, and reveal fundamental role of the ice sheet dynamics upon the global environment. The Greenland Ice Sheet Monitoring Network (GLISN), launched in 2009, is an international project to develop and integrate about 30 seismic stations on and around the Greenland.

Japan has been a partner of the GLISN from its beginning, and dispatched a research expedition in the recent two years. In 2011, together with the USA team, we installed a new seismic station “ICE-S” at southern part of the internal ice sheet. In 2012, we visited three stations (ICE-S, NUUK, DYE-2) to upgrade installations and retrieve data. In the presentation, we will summarize our activities for two years, and provide results of primary analyses using the intra-Greenlandic seismic waveform data.

S5–P17

GLACIOLOGICAL OBSERVATIONS IN SUNTAR-KHAYATA RANGE, EASTERN SIBERIA, 2012

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In the GRENE research project, climatic data were recorded through observations of the Suntar-Khayata No. 31 glacier in eastern Siberia in order to gain an understanding of glacial climatic change response. From July to September, 2012, we installed stakes, interval cameras, snow depth sensors, and rain gauges in the glacier. In addition, we installed two Automatic Weather Stations (AWSs)—one was installed in the glacier, and the other at an IGY station. Air temperature, relative humidity, atmospheric pressure, solar radiation, wind speed, wind direction, and precipitation were measured at the AWS. In addition, we surveyed the area using GPS to obtain the DEM data of some of the glaciers and moraines. Further, we observed snow algal communities, the ice core, etc. This paper presents our observation results.

S5–P18

Is warming Arctic causing colder winters in Siberia?

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Global climate models predict warming in the Northern Hemisphere (NH) high latitudes to middle latitudes during boreal winter. However, recent trends in observed NH winter surface land temperatures diverge from these projections. For the last two decades, large---scale cooling trends have existed instead across large stretches of eastern North America and northern Eurasia. We argue that this unforeseen trend is probably not due to internal variability alone. The study is based on analysis of observed data and modeling. Delayed freeze---up in the Arctic and the consequent heat input in the atmosphere lead to significant changes in the circulation caused by a number of factors. Those factors include a direct response to the heat anomaly over the open ocean and a dynamic response to changes in the snowcover in northern Eurasia. Understanding this counterintuitive response to radiative warming of the climate system has the potential for improving climate predictions at seasonal and longer timescales.

S5–P19

Influences of the sea ice concentration and sea surface temperature to the atmosphere

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Since 1980s the sea ice extent in the Arctic Ocean has been decreasing. It is important for the climatology in the Arctic whether the sea ice exists or not. The purpose of this study is to investigate the differences of the influences to the atmosphere due to the different conditions in sea ice concentration and sea surface temperature with global atmospheric model NICAM (Nonhydrostatic ICosahedral Atmospheric Model). Two experiments will be carried out. One is that the monthly climatology of the sea ice concentration and sea surface temperature is used as the boundary condition (normal year), and the other is that the monthly data of them in 2007 is used (less sea ice year). The time integration will be conducted for 50 years for each experiment. The sea ice concentration, sea ice mass and sea surface temperature are fixed within each month during the integration. The horizontal resolution is 112 km (glevel-6) and 40 points are taken for the vertical grid. The experiment is now in progress. A figure shows the annual mean surface air temperature for fifth year of the time integration. All experiments will be finished before ISAR-3 and the influences in the Arctic atmosphere due to the sea ice extent will be discussed.

S5–P20

Greenland SST change and accompanying changes in the northern hemispheric climate and predictability of the North Atlantic Oscillation

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A sudden change in the reference Greeland Sea surface temperature (GSST) between Feb and Mar 1979 is identified. It is found to be a part of complex changes in the northern North Atlantic seas. The GSST change, in particular, resulted in a major change in the near-surface baroclinicity in the region, in addition to large change in the net surface heat flux at the air-sea boundary over the Greenland Sea. The differences in the atmospheric mean state between two periods, one before and the other after the GSST change in the late 1970's, resemble those between the high- and low-NAO index states.

In addition to the changes in the mean state, major changes in the interannual variability of the atmosphere are found. A particularly interesting change in the interannual variability is found in the relationship between Jul GSST and the NAO phase in the following Feb. There was a strong correlation between Jul GSST and the NAO phase in the following Feb before the late 1970's, but not at all after the late 1970's.

Also, a similarly sudden change of opposite sign was found in the reference winter SST in the Okhotsk Sea two months before the change in the GSST, indicating that the changes are likely to be a part of changes in the entire Arctic and sub-Arctic regions.

S5–P21

DEVELOPMENT OF A LOWER TROPHIC LEVEL ECOCYSTEM MODEL FOR ARCTIC OCEAN

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A 1-box numerical model describing the lower trophic level ecosystem in the western Arctic Ocean (Chukchi Sea and Beaufort Sea) was developed to investigate the relationship between the timing of sea ice melting and ecosystem change. For this purpose, the model consists of thirteen state variables which include the typical biology in the water column and sea ice. The primary producer in the model was divided to three components: “Ice Algae”, “Centric Diatoms”, and “Autotrophic Flagellates”. Ice algae is mainly pennate diatoms that adapted to low light intensity. Centric diatoms are the dominant species in the ice-edge bloom, and they are adapted to strong light intensity. Autotrophic flagellates are a major phytoplankton group after the bloom, and they can also live under sea ice. Zooplankton grazing these primary producers, was categorized into “Amphipods”, “Copepods”, and “Heterotrophic Flagellates”. Top predator in the model was “Nektons” including krill, arrow warm, and other predatory species. In addition, the model includes other nutrient and detritus components. The idealized annual physical forcing (sea surface temperature, sea surface light intensity, and mixed layer depth) and sea ice condition at the Northwind Abyssal Plain (NAP) were given for the model. In the Arctic Ocean, amphipods and copepods are important food sources for higher trophic level animals such as marine mammals, sea birds, and fishes. We will introduce the seasonal variation of zooplankton biomass simulated by the model, and will discuss the effect of the timing of sea ice melting on the lower trophic level ecosystem.

S5–P22

SEA-ICE THICKNESS CHARACTERISTICS REVEALED BY OBSERVATIONS IN THE CANADA BASIN

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To observe ocean and sea ice conditions in the Canada Basin of the Arctic Ocean, a scientific cruise of the Canadian Coast Guard Ship *Louis S. St-Laurent* was conducted from 2 August to 8 September 2012. Using an electromagnetic induction instrument (EM) along with Passive Microwave Radiometers (PMR), underway measurements of sea-ice thickness were carried out on August 8 to 10 (offshore of Barrow) and 27 to 29 (around 80°N). Sea-ice thicknesses measured by the EM spatially changed with the range of 0.1-3.0 m. To reveal sea-ice thickness distribution in more detail, probability density was examined. Although the modal sea-ice thickness existed in 0-0.1 m, the probability density was higher around 80°N than offshore of Barrow. Measurements of sea-ice thickness with a portable EM were also done along four transect lines at two ice stations (80.88°N, 137.41°W and 80.21°N, 129.97°W) on August 26 and 27. The mean sea-ice thicknesses for each transect lines were 1.35, 1.34, 0.38, and 2.46 m, respectively. From the entire data, the maximum (minimum) sea-ice thickness was 2.52 (0.26) m. Sea-ice thicknesses obtained from the EM agree fairly well with those based on the drill-hole measurements. The correlation coefficient between them was 0.96. In addition to the detailed discussion, results obtained from PMR and relationship between sea ice and ocean conditions will be introduced during the presentation of the day.

G3–P1

MRI LAND SURFACE SCHEME HAL

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We have been developping a land surface model HAL mainly for climate research purposes. HAL is originated from SiB (SImple Biosphere model) and is working in the MRI-ESM1, which is participating in CMIP5.

Better modelling of the cryosphere is one of HAL's major targets. HAL has much more snow and soil layers than original SiB, and it can represent detailed changes of the snow and soil. SMAP model, which calculates snow albedo and solar heating profile in snowpack considering effects of snow grain size and snow impurities explicitly, has been installed in HAL and it helps physically based appropriate simulations of the snow regions.

G3–P2

RECENT VARIABILITY OF AIR TEMPERATURE IN NORTH-EAST EURASIA AND ITS EFFECT ON PERMAFROST LANDSCAPES

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Variability's of air temperature in 38 weather stations in North-East Eurasia are analyzed from the Yenisei-river to the Chukotka peninsula on such types of natural complexes as tundra, a forest-tundra area, a northern and middle taiga. We analyze mean deviations of annual air temperature, thawing and freezing indexes, ground temperature, active layer thickness and activity of cryogenic processes since 1930 to present.

Climate of the North-East Eurasia is extreme and various. On the Arctic seaboards main climate forming factors are a position in the high latitudes and an influence of cold arctic seas. Moving off seaboards, a climate is getting a strongly continental and arid. It is an effect of not only geographic position but a peculiarity of atmospheric processes.

Many authors show that in last decades occurs very high increasing of air temperature especially in high latitudes. We agree with this statement and we would like indicate available variations of air temperature dynamics in North-East Eurasia.

There were the characteristic periods, when the climatic warming occurred in this region: 1935-1945, 1988-1995 and 2005-2009. The 1935-1945 warming had a biggest effect in the tundra, the forest-tundra area and the northern taiga, 1988-1995 – in northern and main taiga, and 2005-2009 – above all landscape's zones. These phases of climatic warming had strong impact on the development of permafrost landscapes. Our observation shows that in these time ground temperature increased, cryogenic processes were activated in the open and disturbance places. Activation of cryogenic processes negatively impacts the landscapes and the economic infrastructures.

G3–P3

THE USE OF SITES WITH A THICK GRID OF THAW TUBES TO OBSERVATION THE DEPTH OF SEASONAL THAWING IN CENTRAL YAKUTIA

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Dry soils with deep thawing generally predominate in Central Yakutia, which considerably impedes the application of a probe for mass measurements. The best results in this case can be achieved with the help of thaw tubes. However, a small number of them within the investigated landscape is not enough to objectively assess the multi-year dynamics of seasonal thawing. In order to increase the statistical validity of the obtained data, in 2008 two sites near Yakutsk were equipped with a thick grid of thaw tubes. Site 1 located at the second terrace above the flood-plain of the Lena River within a grass meadow numbers 77 thaw tubes. 36 thaw tubes are installed at site 2 located in the native larch forest at the destructional and constructional plain. The research gave preliminary results on the influence of different meteorological factors on interannual variability in the thickness of the seasonally thawed layer (STL). The data on the maximum STL thickness collected at different points of each experimental site have low variability. This indicates that the landscape conditions are homogeneous enough to regard the selected sites as optimal for the study of the multi-year dynamics of seasonal thawing depth. In 2012, the sites have been included in the CALM database as R42 and R43.

G3–P4

PERMAFROST DEGRADATION AND FLOOD OCCURRENCE IN THE FAR NORTH OF SIBERIA

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High latitude regions are experiencing the greatest climate warming. Effects on permafrost thawing are particularly important for global climate, because permafrost thawing promotes decomposition of soil carbon, and releases greenhouse gases such as methane into the atmosphere. It is said that high latitude regions contain one third of the global terrestrial pool of soil carbon. In addition, permafrost thawing also changes water balance. Flood is caused when a large amount of the thawed water flows into the river. Extreme hydrologic events such as flood have already been observed, and are predicted to further increase in the frequency and magnitude. The objectives of this research are to monitor the process of permafrost thawing using microwave remote sensing, and advance the knowledge regarding climate change in the far north of Siberia.

Although Alazeya region was consistently low precipitation area, air temperature in 2007 was drastically high. Therefore, much permafrost melted in summer of this year, and big flood was caused due to the permafrost degradation. In the permafrost, ice wedge is included. (i) When permafrost melts due to the increased air temperature, active layer grows thick and ice wedge melts. (ii) After ice wedge melting, the melted water gushes from the ground. (iii) Then, the melted water flows into a nearby river, leading to floods. After permafrost degradation, the ground sinks. Ground subsidence by permafrost degradation was measured using microwave remote sensing. Differential interferometric synthetic aperture radar (DInSAR) can provide measures of vertical movement at landscape scale. Two images in 2007 and 2008 were used to analyse ground subsidence at Andryushkino. The ground sinked approximately 20 cm for a year. The amount was larger near the Alazeya river. There are many factor of ground subsidence, such as earthquake, landslide, volcano and so on. However, probability of permafrost degradation would be high in Alazeya.

G3–P5

IMPROVED ALGORITHM FOR MODELLING OF HEAT DYNAMICS IN FROZEN SOILS

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The details of the method to simulate the processes of ground thaw-freeze accounting for phase transformations in soils will be presented. It is based on several approaches which simplify the differential equation of heat transfer in soil profile and allow deriving its analytical solution. Additional information is given on the techniques of estimation heat transfer and conductivity characteristics of soil and snow in different states.
The methods are integrated into calculating algorithms of the hydrological model Hydrograph. Physical properties of soil horizons used as the model parameters allow for robust assessment of their values according to landscape characteristics. Verification of proposed approaches was conducted with the use of observational data of thaw/ freeze depth in different landscapes of the Kolyma water-balance station (continuous permafrost zone, North-East of Russia). Study sites included slope and plateau with thaw depths varying from 0.5 to 1.8 m across landscapes characterized distinctly as rocky talus, mountain tundra with dwarf tree brush, moss-lichen sparse growth forest or larch forest. Soil-vegetation profile schematization and corresponding model parameters were developed for each landscape. The model was run for continuous period of 1960-1990 with daily step interval and simulated values have shown good agreement with observed ones at all studied sites.

G3–P6

MODELLING OF ACTIVE LAYER DEPTH DYNAMICS AND RUNOFF FORMATION AT SMALL WATERSHED ENTIRELY COVERED BY BARE ROCKS

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In the zone of continuous permafrost frozen ground usually acts like impermeable layer but at the territories covered by bare rocks runoff formation mechanisms are different from “normal” ones. The goal of the study was the analysis and combined modelling of ground thaw/freeze and flow formation processes in small Morozova Creek watershed (area 0.63 km2) entirely covered by bare rocks. It is located in the Upper Kolyma river basin in mountainous zone of continuous permafrost. The ground profile thaws quickly and deeply, up to the 1.5-2.5 m. During the freshet snowmelt water refreezes in upper 1-1.5 m of ground profile but never fully saturates all pore volume. The rest of the melt water and liquid precipitation percolates to frozen aquiclude and reaches the creek channel quickly forming subsurface flow. High porosity and very low water holding capacity of rock stratum prevent water accumulation in the profile.

The Hydrograph, a process-based hydrological model, was applied in this study. The model describes all components of land hydrological cycle and integrates coupled algorithms of water and heat dynamics in soil profile. Main model parameters are observable land cover properties that can be systematized according to landscapes.The parameters were derived based on literature review, measurement data and modelling experiments. Simulations of ground thawing and runoff were conducted for period of 1969–1990 with daily step for the Morozova Creek watershed. Good agreement of observed and simulated values enables to conclude that assessed model parameters and its algorithms have potential for applications in similar conditions including ungauged basins.

G3–P7

GEOCRYOLOGICAL CHARACTERISTICS OF THE SEDIMENT NEAR THE PERMAFROST TABLE IN THE DOWNSTREAM FLOOD PLANE OF THE INDIGIRGA RIVER, RUSSIA

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Information about geocryological characteristics of frozen sediment, such as ice content, cryostructure, or stable isotope ratio of included water is essential for predicting consequences of the projected permafrost thaw in response to the global warming. This information determines the extent of thermokarst and controls the hydrological regime, and hence vegetation growth, especially in areas of high latitude. It also yields knowledge about the history of changes in the hydrological regime. To obtain these fundamental data, unfrozen and frozen surface sediments from 25 boreholes down to 3-m depth at five sites near Chokurda, Russia were sampled and analyzed. Profiles of volumetric ice content in the upper permafrost have a large variation, ranging from 30 to 90%, with an average of 70%. This large amount of ground ice takes the form of ice lenses or veins, mainly due to ice segregation during the frost heave of the water-saturated and highly frost-susceptible sediment. Furthermore, networks of active or inactive ice wedges are distributed, raising the amount of ground ice at these sites. Most parts of the analyzed sediment were supersaturated with segregated ice, which will cause thermokarst when melted. From the analysis of the water stable isotope and cryostructure of the upper permafrost, a strong influence of repeated flooding on vegetation growth and plane development is suggested.

G3–P8

MONITERING OF SURFACE AND SUBSURFACE CONDITIONS IN PERMAFROST AREA AFTER WILDFIRE, ALASKA

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In Seward Peninsula, western Alaska, large tundra fires burned a wide area, underlain by discontinuous permafrost, near the Kougarok River in 1971 and 2002. Fires destroyed the vegetation, and the ground surface thermal condition was altered. The objective of this research is to understand the characteristics of the post-fire variations in the permafrost distribution and condition, and the attributional changes in thermal and water conditions in active layer.

Summer field observations were conducted at both burned and unburned sites since 2005. The average thaw depth at the burned sites in 2012 was deeper by 30% than those at unburned sites. The differences in thaw depth have decreased in time, which were deeper by more than 50% in 2005. Boring surveys up to 2m depth conducted in 2012 confirmed the presence of massive ice at the both sites. It implies a possibility of thermokarst development after wildfires due to thawing of permafrost. The visible satellite image for the burned site detected white-colored areas (corresponding to growing areas of *Clamagrostis canadensis*), surrounded by green-colored areas, in which thaw depths were deeper by 60% than the surrounding areas. Values of surface roughness were also high at white-colored areas, suggesting that the ground ice has been thawing due to the change in surface thermal condition and surface subsidence. Then, by using any satellite images of areas after wildfires, in case of detection of distribution of rough surface, that area may have a deeper thaw depth and have a possibility of development of thermokarst.

G3-P9

Cancelled

G3–P10

AGE ESTIMATION OF SUPRA-PERMAFROST AND INTRA-PERMAFROST GROUNDWATER IN YAKUTSK REGION, EASTERN SIBERIA

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Change in the hydrological cycles of permafrost regions is a critical issue to address given current problems caused by global warming. Better understanding of groundwater dynamics in permafrost regions is needed to assess the vulnerability of such regions to changing climate. However, not much is known about the age of groundwater in the region. To determine the groundwater age, i.e. residence time of the permafrost groundwater, hydrologic tracers including tritium, chlorofluorocarbons, and sulfur hexafluoride were used to analyze the supra-permafrost and intra-permafrost groundwater in the Yakutsk region of Eastern Siberia. Tritium concentration of a famous spring discharge “Buluus” was similar both in surface-layer frozen (early spring) season and in surface-layer thawing (summer) season. This means that Buluus spring discharge always derived from intra-permafrost groundwater mainly. Its age ranged from around 5 to 25 years old. On the contrary, tritium concentration of another spring discharge “Ulakhan-Taryn” shows lower in surface-layer frozen season and higher in surface-layer thawing season. This means Ulakhan-Taryn summer discharge was contributed from supra-permafrost groundwater in some extent. The age of intra-permafrost groundwater of Ulakhan-Taryn, which was estimated from the tritium concentration of spring discharge in the surface-layer frozen, was older than 55 years old. These differences might be related to size of reservoir, amount and thawing rate of ground-ice, and lake-talik-groundwater system of each spring discharge.

G3–P11

WESTERN AND CENTRAL SIBERIA HYDROLOGICAL CYCLE FROM SATELLITE AND IN SITU OBSERVATIONS

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In the Western and Central Siberia a multitude of interconnected natural objects - large and small rivers streams, large floodplains, lakes, bogs etc is formed. Flooded areas and bogs also act as a buffer zone, providing a dampening "sponge" effect on the water redistribution within the river system. Central Siberia and northern part of the Western Siberia are located in the permafrost zone and have dynamic thermokarst processes. Western Siberia is also influenced by human activity (construction of roads, gaz and oil pipelines etc) that affects the primary hydrological network.

We present the results of systematization and classification of landscape patterns, as well as study of variability of hydrological processes in the study region at different temporal (from multi-year to seasonal) and spatial (from local to regional) scales through a multidisciplinary approach based on *in situ* and remote sensing data. Radar altimetry, radiometry and optical satellite data are used in combination with the in situ observations and the recent field studies done in 2008-2012.

We present the variability of water level (from radar altimetry) and surface properties (from altimeter waveforms parameters) for different studied watersheds. Seasonal and interannual variability of water abundance is studied using radar altimetry and radiometry. We also analyse the role of the snow cover in the formation and seasonal distribution of runoff in the region of Poluy, Nadym, Pur and Taz rivers (Northern part of Western Siberia) by using in situ and satellite estimates of the snow water equivalent, and present results of the hydrological numerical modelling for this region.

This research has been done in the framework of the Russian-French cooperation GDRI "CAR-WET-SIB", French ANR "CLASSIQUE" and CNES TOSCA SWOT projects, Russian FZP 1.5 and FP7 MONARCH-A projects.

G6–P1

PHOTOPROTECTIVE RESPONSES OF ICE ALGAE AFTER LIGHT EXPOSURE IN SAROMA-KO LAGOON, HOKKAIDO, JAPAN

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The ice algal communities may be exposed to the high light intensity by releasing from melting sea ice. An important protection mechanism against high light intensity is the thermal dissipation of excess energy by xanthophyll cycle pigments in their de-epoxidated state. The photoprotection through non-photochemical quenching (NPQ) of chlorophyll fluorescence is linearly dependent on the presence of the de-epoxidated diatoxanthin (DT) for most marine diatoms (Lavaud et al. 20014). In the previous studies, the weak shade adaptation of ice algae at Saroma-Ko Lagoon in Hokkaido, Japan, may have the advantage of avoiding photoinhibition by exposure high light intensity when cells are released into a water column (Obata and Taguchi 2009). In this study, we investigated the photoprotective responses of a seasonally well-developed ice algal community in sea ice at Saroma-ko Lagoon on March 2012, by examining NPQ and xanthophyll pigments in shade adapted ice algae after exposure to sun light. De-epoxidation of diadinoxanthin (DD) to diatoxanthin (DT) occurred rapidly and NPQ showed dynamic changes. These NPQ and DT concentration were linearly related. The regression coefficient of the linear relationship was higher compared to that of mesophilic diatoms (Lavaud et al. 2004). These results suggest that ice algae possess a relatively effective photoprotection as thermal dissipation against higher light intensity. The further study needs to exam other factors that may affect the enhancement of NPQ in the ice algae.

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G6–P2

PHYSYIOLOGICAL AND MORPHOMETRICAL RESPONSES OF SUBARCTIC COCCOLITHOPHORE, *EMILIANIA HUXLEYI,* TO TEMPERATURE

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The coccolithophore *Emiliania huxleyi* is one of the major phytoplankton species widely appeared from equator to subarctic present oceans with the formation of calcified scales, named coccoliths (e.g., Beaufort et al., 2011). Since greenhouse gases including CO_2 are accumulated in present atmosphere, the global warming and the sea-ice melting become major concerns for the polar region and, eventually, the sustainable global environments (e.g., Harada et al., 2012). In order to understand physiological responses of the coccolithophore due to the upward shift in ocean temperature, two *E. huxleyi* strains, MR57N and MR70N, isolated by MIRAI subarctic expedition in 2010 (for isolation of the strains, see M. Satoh et al. Another presentation in this conference) were investigated by their culture experiments at 5, 10, 15 and 20˚C. Both strains showed the similar growth properties: their growth was still maintained high at 5˚C at ca. 1/3 of the maximum rate, although the growth rates increased with raising the temperature. According to SEM observations and the morphometric analyses, both size (length of distal shield: LDS) and the numbers of distal shield elements of the coccolith decreased with raising the temperature. The central area of the coccoliths was also changed from grill structures to completely calcified structures. Concurrently, the cell size of *E. huxleyi* decreased with raising the temperature. Thus, the subarctic *E. huxleyi* stains showed the correlations between cell sizes and coccolith morphometic parameters with variable central area morphology depending on the growth temperatures. These results imply that the subarctic coccolithophore strains can maintain enough to grow in the arctic region and that the coccolith morphologies can be used as a potential indicator of the growth temperature. As the subarctic strains can grow faster even at 20˚C, such property will be advantageous for producing easier occurrence of coccolithophore blooms in the Arctic Ocean when temperature increases in future.
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Harada et al. (2012) Global Biogeochemical Cycles 26, GB2036.

G6–P3

ANALYSIS OF THE CHARACTERISTICS IN THE COCCOLITHOPHORE, *EMILIANIA HUXLEYI* ISOLATED FROM ARCTIC SEA

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The coccolithophore *Emiliania huxleyi* widely distributes from subtropical to high latitude oceans and is known as the most abundant bloom-forming unicellular calcifying alga. It is supposed that there may be various kinds of strains which are adapting to various environmental conditions. To investigate such speculation, we tried to isolate *E. huxleyi* from the Arctic Sea and investigate difference in photosynthetic characteristics between strains isolated from subarctic and tropical oceans.

We selected one strain isolated from Arctic sea, MR67N (Lat. 67˚30'N.) and another strain isolated from tropical region, NIES 837 isolated from the Great Barrier Reef (site data not available). To investigate the effect of growth temperature on the photosynthetic activities, we grew both cells at 20˚C or 10˚C. Although the growth rate of NIES 837 markedly decreased and failed to grow at 10˚C, MR67N could acclimate to such low temperature within ca. 3 days and maintain high growth rate. How could MR67N grow at such low temperature? When MR67N was transferred from 20˚C to 10˚C, the activity of non-photochemical quenching (NPQ), determined by chlorophyll fluorescence method, markedly increased although no significant changes in the photosystem (PS) II activity, determined as Fv/Fm. In contrary, no NPQ change was observed in NIES837. The increase in NPQ by low temperature functions to maintain photosynthetic electron transport usual by reducing high light stress. The Arctic strain MR67N seemed to develop higher ability to regulate NPQ activity but not the tropical strain NIES 837. This study clearly showed that such ability is essential for the acclimation of *E. huxleyi* in Arctic sea strain.

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G6–P4

HORIZONTAL DISTRIBUTION OF BACTERIAL ASSEMBLAGES ON SURFACE SEDIMENTS IN THE ARCTIC OCEAN

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The Arctic Ocean is globally important as a key indicator and driver of climate change. However, there are not much documented reports concerned in microbes in response to climate change although the polar region contains diverse microbes and microbial habitats and allow microbes to keep activities. The expedition for the R/V *ARAON* to the Arctic Ocean was progressed from August to September in 2012. Total ten sampling sites were occupied to monitor benthic bacterial assemblages in the Arctic Ocean related to the global warming issue. From these sampling sites, ten sediment cores were collected by the box corer or multicorer equipped in the *ARAON*, and their surface layers were respectively transferred into sterile tubes for the further analyses of pyrosequencing and sediment properties. In this study, pyrosequencing approach using a 454 GS FLX Titanium Sequencing System (Roche) is applied for bacterial diversity, taxonomic classification and phylogenetic analysis. To estimate the physiochemical properties of sediment samples, ICP-MS (Inductively Coupled Plasma-Mass Spectrometry), pH, and salinity are measured in further analysis at Gwangju Institute of Science and Technology (GIST). The data of sedimentary properties in samples is used for statistical analysis to confirm the correlation with bacterial properties in sediments. The primary aim of this study is to determine whether bacterial assemblages are described on the basis of the substratum that they occupied in the benthic ecosystem, and further to understand the effects of environmental factors on the spatial distribution of benthic bacteria by monitoring distributions of major phylotypes in bacterial assemblages in the Arctic Ocean.

G6–P5

SPATIAL DISTRIBUTIONS OF BACTERIO- AND VIRIOPLANKTON IN THE CHUKCHI SEA DURING SUMMER 2012

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Bacteria and viruses are at the bottom of the marine food web and play important roles in biogeochemical cycles of organic matters and nutrients. In the Chukchi Sea, there are 4 distinct water masses during summer; surface mixed layer water, Pacific summer water, Pacific winter water and Atlantic water. These water masses can be distinguished by its unique hydrographical properties, hypothesizing that spatial distributions of bacteria and viruses may be reflected by these different ecological regimes. To test this hypothesis, we investigated 35 depth-profiles of bacterial (BA) and viral abundances (VA) in an area covering ca. 900x400 km^2 in the Chukchi Sea (73-82^{o}N, 173^{o}E-153^{o}W) during the icebreaker R/V Araon expedition (Aug 1 to Sep 10 in 2012). To avoid loss of microbes due to long-term storage, bacteria and viruses were counted within a day of sampling on aboard using an epifluorescence microscope isolated from the vibrations of the research vessel. BA ranged from 0.1×10^5 cells ml^{-1} to 16.4×10^5 cells ml^{-1} in the study area. In most stations, BA showed the maximum value at the surface or at the subsurface chlorophyll maximum depth, and tended to decrease with depth in water column. VA was on average 19-fold higher than BA, but depth profiles of VA showed similar patterns to those of BA. Our results showed that there was spatial heterogeneity in bacterial and viral abundances among stations, probably influenced by physiochemical and biological conditions in the study area. Results for in-depth analyses of relationships between microbial variables and environmental variables will be discussed in the poster presentation.

G6–P6

Macromolecular compositions of phytoplankton in the Northern Chukchi Sea

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Macromolecular compositions of phytoplankton were investigated in the Arctic Ocean. Samples for macromolecular compositions were obtained from the three light depths (100%, 30%, and 1%) at 31 different stations in the Northern Chukchi Sea, 2011. Samples were filtered on 0.7μm Whatman GF/F filters (47mm) and the filters were immediately frozen and preserved for colorimetric measurements. Extractions of different macromolecular classes (lipids, proteins, polysaccharides) were performed using the methods in Lowry et al. (1951), Dubois et al. (1956), Blighr and Dyer(1959), and Marsh and Weinstein (1966) and the concentrations were determined by the optical density measured with a spectrophotometer. The contents of lipids, proteins and polysaccharides of phytoplankton in the water column ranged from 58.62 mgL^{-1} to 105.55 mgL^{-1} (average ± S.D. = 81.76 ± 11.87 mgL^{-1}), from 5.47 mgL^{-1} to 93.31 mgL^{-1} (average ± S.D. = 47.82 ± 38.10 mgL^{-1}) and from 27.79 mgL^{-1} to 85.25 mgL^{-1} (average ± S.D. = 59.82 ± 29.90 mgL^{-1}), respectively. In our study, lipid concentrations were highest among all different macromolecular classes ($p<0.05$, *t*–test). The compositions and ambient environmental factors (nutrients, salinity, light, temperature, and Chlorophyll-a concentration) were examined for relationships. Among different macromolecular classes, only protein concentrations had strong linear relationships with ambient environmental factors.

G6–P7

DISTRIBUTION OF PHYTOPLANKTON COMMUNITIES IN THE BERING, CHUKCHI SEA AND CANADIAN BASIN DURING SUMMER

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Recent studies have shown that photosynthetic eukaryotes are an active and often dominant component of Arctic phytoplankton assemblages. In order to explore this notion at a large scale, samples were collected to investigate the community structure of phytoplankton in the Western Arctic Ocean. The 97 stations (165 samples) at the surface and subsurface chlorophyll-a maximum (SCM) depths in the Western Arctic Ocean from 2006 to 2009 during summer. Phytoplankton (>2 μm) were identified and counted. Phytoplankton communities were composed of 116 taxa representing Dinophyceae, Cryptophyceae, Bacillariophyceae, Chrysophyceae, Dictyochophyceae, Prasinophyceae and Prymnesiophyceae. In Bering Sea, diatoms were most diverse with 69 species (69.7%), followed by the dinophyceae with 22 species (22.2%). Chukchi Sea was similar to Bering Sea however Canadian Basin was showed lower diversity than other study area by other environmental and physiological factors that determine structure of phytoplankton, such as temperature. The most abundant species were of pico- to nano- size at the surface and SCM depths at most stations. From the Western Bering Sea to the Bering Strait, the abundance, and species diversity of phytoplankton provided a marked latitudinal gradient towards the central Arctic. Although pico- and nano-sized phytoplankton contributed most to cell abundance, their chlorophyll a contents and biovolumes were less than those of the larger micro-sized taxa. Micro-sized phytoplankton contributed most to the biovolume in the largely ice-free waters of the Western Arctic Ocean during summer.

G6–P8

DISTRIBUTION OF MESOZOOPLANKTON RELATED TO THE ENVIRONMENTAL FACTORS IN THE CHUKCHI SEA, 2011

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The Chukchi Sea is one of the major gateways into the Arctic where large quantities of Pacific heat, nutrients, phytoplankton and mesozooplankton enter the region through the shallow Bering Strait in a complicated mixture of water masses. Mesozooplankton abundance and biomass generally have been considered to be low in this region. Nevertheless, mesozooplankton is numerically important element and plays a major role in the food webs. We examined the distributions of mesozooplankton related to the environmental factors in the Chukchi Sea during August 2 to 16 in 2011. Mesozooplankton samples were collected with a Bong net (330 and 505 μm) at selected 10 stations. The net was towed vertically within the upper 200 m of water column. A total of 28 mesozooplankton taxa were identified, including 17 copepod species. Copepods contributed 65% of total mesozooplankton abundance, followed by a Cirripedia larvae (19%). The chaetognath *Sagitta* spp. and the tunicate *Oikopleura* spp. represented 5% and 6% of total mesozooplankton abundance, respectively. The total mesozooplankton abundance was very high at St. 1, with *Calanus glacialis*, *Pseudocalanus* spp., and *Cirripedia* larvae were more abundant than other regions. *Metridia longa*, *Calanus hyperboreus*, and *Paraeuchaeta barbata* dominated in the western part. *C. glacialis*, *Pseudocalanus* spp., and *Oithona* spp. were high at St. 1 of the southern part. With St. 1 excluded, mesozooplankton abundance was not significantly correlated with environmental factors (seawater temperature, salinity, and chlorophyll a concentration).

G6−P9

SEASONAL CHANGES IN MESOZOOPLANKTON SWIMMERS COLLECTED BY SEDIMENT TRAP MOORED IN THE WESTERN ARCTIC OCEAN

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In the Arctic Ocean, because of the seasonal ice coverage, little information is available for seasonal changes in zooplankton community structure and their life cycles. In the present study, we analyzed seasonal changes in zooplankton swimmer collected by sediment trap rotated with 13−15 day intervals moored at 180 m in Northwind Abyssal Plain during October 2010 to September 2011. Zooplankton flux ranged at 5−44 ind. m^{-2} day^{-1}, and was greater in September to October. Copepods were the most dominant taxa and composed 18−94% of number, followed by amphipods. Based on the zooplankton flux, cluster analysis (Bray-Curtis dissimilarity connected with unweighted pair group method using arithmetic mean) classified samples into three groups (A−C). Occurrence of each group showed clear seasonality: group A was observed during July to October, group B was seen in November to January and group C was at March to June. Each group was characterized with the dominance of different species. Thus, group A was characterized with *Gaidius brevispinus*, *Paraeuchaeta glacialis*, *Themisto libellula* and Barnacle larva, group B with *Mimonectes* sp. and group C with *Calanus hyperboreus* and Polychaeta. For the four dominant copepods (*C. hyperboreus*, *Metridia longa*, *Heterorhabdus norvegicus* and *P. glacialis*), their population structures varied with species. *C. hyperboreus* was predominated by C6F throughout the year, and their gonad development and mature specimen were only observed during February to May. These facts suggest that their reproduction is restricted at that season. For *M. longa* and *P. glacialis*, C6F dominated during January to May, and late copepodid stages (C4−C5) were abundant during June to October. *H. norvegicus* was dominated by C5 during November to February, C6F/M during March to May, and their early copepodid stages were seen in June and July. Such seasonality in population structure of the dominant copepods is considered to be a reflection of their life cycles. For the other special character, the Pacific copepod *Neocalanus cristatus* C5 occurred throughout the year, and was abundant especially during June to September, when the sea ice coverage area was the least. Through the analysis on zooplankton swimmer collected by sediment trap, this study revealed that the zooplankton community and their population structure in the western Arctic Ocean had clear seasonality, which would be related with the seasonal changes in sea ice coverage and their food.

S2–P1

SOIL MOISTURE AND PERMAFROST CONDITIONS AT NEWLY ESTABLISHED YAKUTSK–VILYUY TRANSECT

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Soil moisture and temperature near the land surface had abruptly increased since 2004 in continuous permafrost region in the central Lena river basin (Iijima et al., 2010). According to gravity changes in this region detected by GRACE satellite (Velicogna et al., 2012), terrestrial water storage had an increasing trend in the basin of Siberian rivers, with the largest increase noted in the central Lena River basin. Increasing in water storage under wet climate forces the active layer to retain soil moisture. The hydrological processes likely lead to further enhancement of permafrost degradation and changes in forest ecosystems. The center of action in the water storage increase was detected in the Vilyuy river basin, where the frozen ice content and alas formation are small due to sandy loam deposits on river terrace. In July and September 2012, we established new soil temperature and moisture observation stations from Yakutsk to Chernoshevsky along Vilyuy River basin (Fig. 1). Each station set boreholes for soil temperature and frost tube (4.0m depth) and an access tube for soil moisture (2.0m). The pit survey of heat and water properties within active layer during the installation, high soil moisture still remained at the deeper part of the active layer at most of the site, and moreover saturated water layer (talik) was formed at Tangnary stations. These results showed that soil water and heat changes were perennially carried over in this area after wet years.

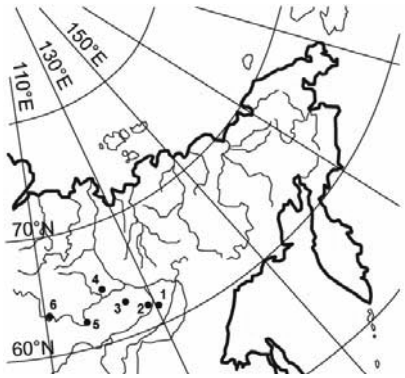

Figure 1 New soil moisture and temperature stations.
1: Yukechi, 2: Spasskayapad & Neleger, 3: Ort-sort & Tangnary, 4: Khoro, 5: Suntar, 6: Chernoshevsky

Iijima et al. (2010) Permafrost and Periglacial Processes, 21, 30–41.
Velicogna et al. (2012) Geophysical Research Letters, 39, L09403.

S2–P2

ECOHYDROLOGY IN ALASKA'S BOREAL FOREST: INTERPRETING MEASUREMENTS OF WATER VAPOR ISOTOPES FROM AIRCRAFT AND SATELLITE SENSORS

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Water vapor isotopes such as Deuterium and ^{18}O can be useful tracers for the movement of water through the environment. In the Far North, we are interested in changes to the hydrologic system and the role of ecosystems. In particular, we postulate that the amount of moisture recycled between the atmosphere and the land surface during summer, may change with a warmer climate and we are interested in observing these patterns under differing conditions. Ecosystems play a critical role in conveying moisture from the subsurface to the atmosphere. Members of our research team integrated and then flew a Picarro laser spectroscopy instrument in an aircraft to measure water vapor over the boreal forest during 2010-2012. We also collaborated to calibrate the Tropospheric Emissions Spectrometer onboard the Aura satellite for Interior Alaska. Patterns of variability in these datasets and their physical drivers will be the subject of this presentation.

S2–P3

RECONSTRUCTION OF PAST 100 YEARS SOIL MOISTURE IN EASTERN SIBERIA BY USING DELTA-13C OF LARCH TREE RINGS

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Climate in eastern Siberian Taiga forest has experienced significant changes during the past few decades. Changes in hydrothermal conditions contribute to some change in surface soil moisture, which is an important control on the interactions among the hydrosphere, biosphere and atmosphere. Soil moisture records in eastern Siberia are sparsely available and not lengthy (less than 20-year period). Therefore, long records of soil moisture or some other hydrological variables are necessary to place the current moisture variability for this climatically sensitive region in a long term context. Thus, we tried to reconstruct past soil moisture water equivalent (SWE) from delta-^{13}C of tree ring.

Larch trees (Larix cajanderi) collected in Yakutsk (62°N, 129°E) were used for the analyses of tree ring width and its carbon isotope ratio. The samples were crossdated with ITRDB's (International Tree-Ring Data Bank) ring-width records in eastern Siberia. SWE in late growing season (7/15-8/31) for the past 100 years was reconstructed form the delta-^{13}C of larch tree ring.

Reconstructed SWE was compared with various factors such as temperature in the growing season of June–July–August (JJA), annual precipitation (from previous August to current July), and calculated results of past SWE from a one-dimensional land surface model and Palmer Drought Severity Index (PDSI) for July; Form these comparisons, reconstructed SWE appear to be reasonable. Tree ring-width index and $\delta^{13}C$ were negatively correlated in most periods. However, positive or less negative correlations were detected in the 1920s and 1970s, corresponding to periods in which relatively low air temperature was observed and the estimated SWE was larger than that expected from annual precipitation. These results indicate that tree-ring $\delta^{13}C$ has been mostly controlled by stomatal conductance (g) in this region, but has at times been affected by photosynthetic rate (A) during cool periods. A comparison between $\delta^{13}C$ and the width of tree-ring chronologies enabled reliable evaluation of the reconstructed SWE. Reconstructed SWE showed significant variation in the past 100 years. Severe droughts have repeatedly occurred in this region, and very high soil moisture observed in 2006–2007 marked the extreme.

S2–P4

INVESTIGATION OF ENERGY BALANCE ABOVE A LARCH FOREST IN CENTRAL YAKUTIA

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The components of energy balance were measured above the canopy of a coniferous forest dominated by *Larix cajanderi* over growing season in 2010 and 2011. Sensible and latent heat fluxes were measured by eddy covariance system.

The fluxes reached maximum values in midsummer (end of June and beginning of July) with magnitudes of about 400 / 280 W/m^2 in 2010 and 200 / 150 W/m^2 in 2011 for sensible / latent flux respectively.

Seasonal variability of the Bowen ratio was similar both years and on average made 1.3-1.4. Diurnally the Bowen ratio is above zero between 07:00 AM and 08:00 PM. The evaporative fraction was calculated from the Bowen ratio that had two peaks in diurnal range at 06:00 AM and 08:00 PM.

Latent heat flux was of dome-like shape and showed maximum in June/July (156.8/153.8 W/m^2 in 2010 and 87.1/101.9 W/m^2 in 2011). This difference between two years is a result of higher amount of precipitation in 2010. The seasonal sum of precipitation in 2010 was 154.7 mm compared to 123.8 mm in 2011. In midsummer the potential evapotranspiration rate in 2010 was 1.5 times higher than in 2011, because of warm summer with enough amount of available water in the ecosystem.

S2–P5

SOIL WATER CHANGE IN EASTERN SIBERIAN TAIGA FORESTS SIMULATED BY A ONE-DIMENSIONAL LAND-SURFACE MODEL

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Soil water and temperature is simulated in some eastern Siberian taiga forests by a one-dimensional land-surface model. The model is composed of three submodels; vegetation, snow cover, and soil. It can calculate profiles of soil water/temperature as well as snow cover, and water/energy fluxes above and within forest, if meteorological data over the forest are given as input. The data used in this study are Baseline Meteorological Data in Siberia (BMDS) Version 5. In Yakutsk, the simulation period is 1966 - 2008. The simulated column soil water indicates variation with about ten year's period; it corresponds with reconstructed soil moisture based on delta 13C of tree rings. The influence of soil water initial condition on the simulation disappears about eight years later. Significant rising of soil water and temperature is observed after 2004 around Yakutsk. The model also calculated soil water/temperature rising, however the drastic change cannot be simulated. It is suggested that precipitation in early winter (snow depth) affects the temperature rising. The results for Kirensk, Chokurdah and Ust'-Maja will be presented in the symposium.

FINE ROOT BIOMASS OF BLACK SPRUCE AT STANDS WITH DIFFERENT DEPTHS OF PERMAFROST TABLE

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Background: Fine roots (root < 2 mm in diameter) are a key component of forest carbon dynamics. Fine roots are a major pathway of belowground carbon flux of black spruce stands (Fig. 1), which dominate areas underlain with permafrost in interior Alaska (1). However, effects of permafrost conditions on fine roots are not well understood. In this study, we examined fine root biomass in two black spruce stands with different depths to permafrost table.

Study site: This study was conducted in two black spruce stands in interior Alaska, which are located at different slope positions on the same north-facing slope. The depth to the permafrost table (summer in 2010) was 113 cm at the upper slope site compared to 67 cm on the lower slope site. Aboveground biomass of black spruce in the lower slope site (1.9 kg m^{-2}) was 33% of that in the upper slope site (5.6 kg m^{-2}).

Results and Discussion: Fine root/aboveground biomass ratio was larger in the lower slope site (0.46) than in upper slope site (0.22). Biomass of very fine roots (< 0.5 mm in diameter) was not significantly different between the two sites, whereas that of fine roots with larger diameter (0.5-2.0 mm) was significantly smaller in the lower slope site than in upper slope site (Fig. 2). These results suggest that in sites with shallow permafrost table, black spruce allocates more biomass into fine roots, especially to those with smaller diameter, likely to facilitate efficient acquisition of limited belowground resources.

Fig. 1. Fine roots of black spruce

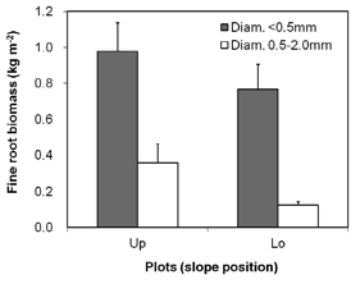

Fig. 2. Fine root biomass of black spruce on different slope positions

(1) Ruess et al. (2003) Ecol Monogr 73: 643-662

S2–P7

ENERGY AND CARBON EXCHANGES OVER THE LARCH FORESTS ON THE PERMAFROST IN MONGOLIA

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To clarify the heat, water carbon exchange process and dynamics by comprehensive approach, we've carried out the long term monitoring of the energy and carbon balances, the hydroclimatic, the phonological camera monitoring and sap flow measurement at the 25-m height tower and larch forest around the tower in the Udleg (48 15'43.7" N, 106 50'56.6"E, altitude: 1264m) in permafrost area of northern Mongolia since 2010. According to the image analysis of in situ camera and PAR albedo data, we clarified the seasonal variation of surface condition and phenology of larch forest. From January to March, November and December, there was continuous snow cover. In late May the leaf of larch emerged and attained the mature growth in July, and then the leaf senescence occurred in mid September. The soil moisture at 10 cm depth was less than 10% before April, then it gradually increase in May to 20% in August, after that it decreases to less than 10% from October. The temporal variation of soil moisture matched to temporal variation of rainfall. The soil temperature below 3m was about -0.2 degree C in all year round that suggests that there is the permafrost. In late May the latent heat flux start to increase with soil moisture and become dominant component of energy fluxes from mid June to early September when the carbon uptake was active. From mid September to early June, the sensible heat flux was dominant component of energy fluxes when the surface was carbon source. We found that the close relationship between phenology (leaf emergence, growth and senescence) of larch trees with hydro-climate condition (soil moisture and snow cover) and energy/carbon budget. We investigated the effect of the hydro-meteorological conditions on energy and carbon budget.

S2–P8

FEATURES OF SOIL CO_2 EFFLUX IN TAIGA LARCH FORESTS OF CENTRAL AND SOUTH-EASTERN YAKUTIA

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Long-term monitoring studies of soil CO_2 efflux was carried out during 2 seasons (April – October) in 2010 and 2011 at two sites: “Spasskya Pad” site in Central Yakutia with low-productive light taiga and “Elgeeii” site in South-Eastern Yakutia in larch forest with higher biomass, both sites with dominance of 150-180 years old *Larix cajanderi* trees, using automated semi-open chamber systems with simultaneous measurements of environmental parameters.

There are no big differences in environmental conditions between the sites during the growing season except twice higher soil water content in the south-eastern site while summer-time precipitation in Central Yakutia was 10-20% less. Average air and soil temperatures are almost same at both sites, fluctuating a little depending on year.

The main environmental factor, affecting soil CO_2 flux, was soil temperature at both sites. At the same time, precipitation (and, accordingly, soil moisture) plays an important role on seasonal scale as well. Maximum soil respiration during season in “Elgeeii” was observed in mid July (10.3 μmol CO_2 m^{-2} s^{-1}), but in “Spasskaya Pad” it was discovered in early August (4.7 μmol CO_2 m^{-2} s^{-1}). Calculated accumulated soil carbon efflux in the south-eastern site was more than twice higher than in Central Yakutia (8.64 t C ha^{-1} and 4.34 t C ha^{-1} respectively). The main reason of this difference most probably is a higher soil biota activity (including roots) at the south-eastern site. Increasing of precipitation amount and soil temperature in high latitudes along with global climate changes will cause escalating of soil biological activity and dramatic fluctuations in soil carbon pools, CO_2 emission included, and finally will lead to soil degradation with abrupt changes in carbon exchange processes in northern forest ecosystems.

S2–P9

Permafrost carbon and climate feedbacks enhance Arctic ecohydrological processes

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Permafrost is considered vulnerable to increasing temperatures. Air temperatures over the Arctic have indeed increased considerably over the last century. Most climate models project that the warming will continue, enhancing permafrost degradation. The degradation of permafrost has the potential to initiate numerous feedbacks, predominantly positive, in the Arctic climatic, hydrological, and biogeochemical processes. For instance, the Arctic terrestrial evapotranspiration during summer season tends to exceed precipitation of the period. The imbalance of water budget may be offset by permafrost thaw and its associated hydrologic impacts. However, we do not have enough knowledge for a definitive explanation of the role of permafrost to the ecohydrological processes. The purpose of this study is to assess influences of permafrost dynamics (i.e. active layer thickness, ALT) on ecohydrological processes (i.e. evapotranspiration (ET) and net primary production (NPP)).

A land surface model CHANGE, including hydrological and biogeochemical processes, was applied to the pan-Arctic terrestrial region over the period 1901-2010. For exploring the influence of ALT on ecohydrological processes, two-way simulation experiments were conducted: (1) the hydrothermal effect of permafrost carbon vertical profile is determined (control experiment) and (2) a uniform rise of air temperature by 3℃ is applied to 1971–2010 based on experiment (1) (warming experiment). We assessed the influence of ALT variability on ET and NPP through the comparison between the two experiments.

In the control experiment, the ALT increased during the study period. The increase was significant in the southern discontinuous permafrost regions, primarily in North America rather than Eurasia. The increase of ALT resulted in increases in ET and NPP due to the alleviation of water stress. When air temperature was increased by 3℃, both ET and NPP increased by 10–40% compared to the control experiment. Higher ET driven by increased temperature should result in drier soil. However, the increased NPP associated with temperature increase resulted in an increase of soil organic matter, which increased its soil water-holding capacity and limited soil warming due to its insulation effect. These effects of permafrost carbon tended to keep summertime ET and NPP relatively high.

S2–P10

APPLICATION OF STABLE ISOTOPE RATIOS OF C AND N TO CARBON ASSIMILATION AND NITROGEN UTILIZATION OF LARCH IN ARCTIC ECOSYSTEM OF EASTERN SIBERIA

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North Eastern Eurasia is covered by permafrost which is the largest and the deepest in the world, and in arctic region, larch dominated tree line ecosystem, taiga-tundra boundary ecosystem, exists on it. It is expected that larch growth in arctic ecosystem is greatly affected by global warming due to sensitivity of moisture condition and possible availability of N. It is necessary to investigate the related controlling factors on C assimilation and N utilization of larch. Observations were conducted at different sites with different tree density and topography near Chokurdakh (70°37'N,147°53'E), Sakha, Russia, in July from 2008 to 2011. Diurnal photosynthetic rate, C and N contents in needle and stem and related stable isotope ratios were observed for larch.

Photosynthetic rate linearly increased with Photosynthetically Available Radiation (PAR). The needle mass was positively correlated with needle nitrogen, needle area, and needle $\delta^{13}C$. Among the sites, nitrogen content of needles increased with needle $\delta^{13}C$. At the sites where the topography level is higher and the soil condition is dry, larger needle mass and larger sizes of trees were found than the sites with wetter condition. Nitrogen content of needle in the year was positively correlated with needle $\delta^{13}C$ in the following year, although the year to year variation in needle nitrogen content was small at wetter sites.

These results show that solar radiation and nitrogen are important factors affecting C assimilation of larch, and nitrogen availability is possibly controlled by soil moisture and texture.

S2–P11

The effect of the feedback cycle between the soil organic carbon and the soil hydrologic and thermal dynamics

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Biogeochemical feedback processes between soil organic carbon (SOC) in high-latitude organic soils and climate change is of great concern for projecting future climate. More accurate models of the SOC stock and its dynamics in organic soil are of increasing importance. As a first step toward creating a soil model that accurately represents SOC dynamics, we have created the Physical and Biogeochemical Soil Dynamics Model (PB-SDM) that couples a land surface model with a SOC dynamics model to simulate the feedback cycle of SOC accumulation and thermal hydrological dynamics of high-latitude soils. The model successfully simulated soil temperatures for observed data from a boreal forest near Fairbanks, and 2000 year simulations indicated that the effect of the feedback cycle of SOC accumulation on soil thickness would result in significant differences in the amount of SOC.

DYNAMICS AND LARCH UPTAKE OF NITROGEN IN THE NORTH EASTERN SIBERIA TAIGA FOREST

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Nitrogen (N) is known to be one of the major limiting factors for plant growth in the northern hemisphere. CO_2 assimilation is directly related to nitrogen contents in the plant leaf as it is the major component of photosynthetic system.

We conducted the study on N dynamics at Spasskaya Pad Experimental forest station located near Yakutsk city, Russia in 2009-2011 years. Amount of N input with atmospheric deposition occurred to be very low. It was found that large amount of soil N was mineralized during vegetation season every year. Increase of inorganic N in the soil pool was closely related to soil temperatures accumulation during summer time. However, in the beginning of the next growing season the content of inorganic N in the soil pool was very low again. Amount of water extractable N in the soil was much lower than KCl extractable, which is related to existence of clay particles in the soil constitution.

The discrepancy between N mineralization by soil microorganisms and plant N demand timing led to specific mechanism of nutrient accumulation in larch trees. The recovery of N prior to needle senescence was very high. Also allocation of uptaken N varied during growing season. N that was uptaken in the beginning of growing season (June) was used for the growth of new organs, such as new shoots and needles, however N that was uptaken in the middle of growing season (from the mid-July) was stored in the tree perennial parts (branches, trunk and especially buds) to be used in the beginning of the next growing season. Therefore, needle N content was affected by the previous growing season environmental conditions.

Needle N content affected amount of needles in the litterfall with one year delay. Therefore, there was a positive relationship between N availability and amount of CO_2 assimilated by larch trees in the area of study.

S2–P13

Developing a methane emission model for Siberian river floodplains

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Methane contributes significantly to global warming. Methane emission is essentially the net result of a balance between CH_4 production by methanogenic bacteria in anaerobic soil zones, and CH_4 oxidation by methanotrophic bacteria in aerated soil zones and plants. Arctic and sub---arctic permafrost holds a large amount of climate vulnerable carbon. In particular river floodplains are carbon---rich soils. River floodplains in this area are periodically or permanently submerged. The occurrence of flooding decreases soil oxygen availability, providing an ideal anaerobic environment for methane generation. The extension of flooded area links strongly to the amount of methane released to the atmosphere. Here we describe the coupling of a newly developed river flooding model, to be coupled with the Peatland---VU wetland methane emission model, in order to better explain spatial and temporal variations in methane emissions from northern permafrost.

S2–P14

METHANE AND ORGANIC MATTER IN PERMAFROST OBSERVED AT CHOKURDAKH (EASTERN SIBERIA)

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Methane is effective greenhouse gas (GHG), which is 20 times stronger than carbon dioxide. Being stored in permafrost areas and released as the result of the global warming, it accelerates the processes. Organic matter stored in the permafrost may also be converted to released by permafrost degradation, which in tern results emissions of GHG. We present the results of studying the ice core of permafrost area for the content of methane and organic matter, and it`s distribution depending on the sampling depth and type of landscape. Studies were carried out in the territory of Eastern Siberia, near the village of Chokurdakh (70N, 148E), Sakha republic. This place reflects the most wide spread type of landscape of the territory. We sampled the ice core obtained by drilling several boreholes down to 4.5 m. Obtained data shows that distribution of methane concentration is not linear at all depth and has some peaks, caused by processes of accumulation and storage of methane. The results can be used for calculation of methane flux after melting the ice core causing acceleration of the global warming.

S2–P15

CH_4 EMISSION FROM A TAIGA-TUNDRA ECOTONE OF EASTERN SIBERIA: PROCESS STUDY BY STABLE ISOTOPES

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The Arctic has a broad area of wetlands and it is one of the CH_4 sources to the atmosphere. Under the enhanced warming in the Arctic, increased soil temperature might strengthen the CH_4 emission, which could make a positive feedback to the climate. However, other conditions such as soil moisture or vegetation might be changed and affect the CH_4 emission as well. We observed CH_4 flux in summers of 2009 to 2012 by chamber method at each vegetation landscape of a taiga-tundra ecotone in Eastern Siberia, and aimed to clarify the processes of CH_4 production, oxidation, and transport to the atmosphere using stable isotopes. The observation sites were selected around Chokurdakh village (70.62N, 147.90E) in the lowland of Indigirka river basin: B site with isolated larch stands in tundra vegetation, K site where tree lines can be seen, and V site where forests exist partially. The observed flux was different among vegetation types. It was very small at tree mounds ((-0.15)-0.05 mgC m^{-2} h^{-1}), moderate at K graminoid wet area and K sphagnum wet area (not detected-2.2 mgC m^{-2} h^{-1}), and the largest at V graminoid wet area and B graminoid wet area (0.05-7.4 mgC m^{-2} h^{-1}). At wet areas, CH_4 flux was larger when the soil temperature was higher. CH_4 flux was correlated with CH_4 concentration in soil pore (at ca. 15 cm depth) while no significant correlation was found with that in surface water, except for the result observed at K graminoid wet area. Accordingly it can be thought that CH_4 was emitted from soil pore mainly through plant tissue not through surface water. On the other hand $d^{13}C$ of emitted CH_4 and soil pore CH_4 showed no correlation, indicating that $d^{13}C$-CH_4 changed during the emission process. While at V graminoid wet area and B graminoid wet area, where large CH_4 flux was observed, $d^{13}C$ of emitted CH_4 was much lower than that of soil pore CH_4, K sphagnum and K graminoid wet area, where CH_4 emission was moderate, had similar delta values. These results suggest a difference in the process of CH_4 emission.

S2–P16

Increased greenhouse gas emission from thaw ponds in Siberian arctic tundra on continuous permafrost

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Rising global temperatures threatens the stability of continuous permafrost environment, resulting in the release of previously frozen carbon, creating a positive climate feedback from terrestrial systems. The resulting permafrost degradation will impact on both a large scale, expansion of thaw lakes, and small-scale features, such as surficial pond formation and mass wasting.

The increased occurrence of thaw ponds and their impact on vegetation is been studied at the Kytalyk research station, located in Indigirka lowlands, Northeast Siberia. This area is located on the drained bed of an Early Holocene thaw lake. The area is characterised by the presence of low palsas (flat ice mounds), covered with mosses and Betula nana. The edges of these palsas are subject to frequent thawing, creating shallow ponds with decaying palsa vegetation.

Comparison, using high resolution satellite images from 1977 (American Keyhole project image) and 2010 (Geoeye), showed increased occurrence of thaw ponds over a 33 year period. Flux measurements from a selection of these ponds showed elevated emission of CO_2 and CH_4. Dead Betula nana produced fluxes of 106.84 mg $CO_2 m^{-2}$ hr^{-1} and 3.58 mg CH_4 m^{-2} hr^{-1} in the summer of 2011. However, a decrease of GHG fluxes occurs when Carex and Eriophorum (sedges) vegetation invades these ponds. The CH_4 m^{-2} hr^{-1} in 2010 and 3.9mgCH_4 emission from sedges is still high, 9.1 mg CH4 $m^2 hr^{-1}$ in 2011, but this is compensated by rapid CO_2 uptake. It is therefore likely that GHG emission from this type of shallow permafrost degradation is strongly influenced by ecosystem recovery rates.

INTENSIVE OBSERVATIONS OF METEOROLOGICAL AND SNOW-PHYSICAL PARAMETERS AT SITE SIGMA-A IN NORTHWESTERN GREENLAND IN SUMMER 2012

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To clarify the contributions of light absorbing snow impurities and glacial microbes to recent abrupt melting of snow/ice in Greenland, intensive observations of meteorological and snow-physical parameters have carried out at the site SIGMA-A (78°03'N, 67°38'W, 1,490 m a.s.l.) on northwestern Greenland ice sheet during the period June 26 – July 16, 2012. We installed automatic weather station (AWS) to measure the basic meteorological elements, radiation budget for shortwave, near-infrared, and longwave spectra, snow temperatures, and snow depth relative to the level of thick ice layer estimated to be formed in the previous summer. We have also performed snow pit work, near-infrared photometry measurement for snow grain size, snow samplings for water-soluble ions and light absorbing insoluble impurities, snow core drilling with a hand auger, and detailed spectral radiation measurements with a spectrometer. It was reported that a melting event of surface snow/ice over 97% of Greenland ice sheet happened between July 8 and 12 including our observation period. At SIGMA-A a large amount of rainfall was observed from July 10 to 13 and the snow surface level decreased by 25 cm (Fig. 1). After the rainfall event we found high concentration of insoluble particles on nuclepore filter with the pore size of 5 micrometers from surface snow samples. This indicates a possible transport of even large particles such as mineral dust to ice sheet surface at the height of 1,500 m. This is important for nutrient supply to glacial microbes.

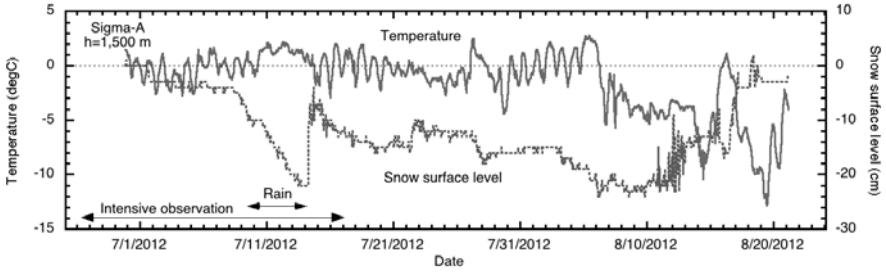

Fig. 1 Temperature and snow level measured with AWS at SIGMA-A. Snow surface level is the value relative to the measurement on 29 June 2012 when AWS was installed. An abrupt raise on 14 June was artificially made to keep the AWS mast.

S3–P2

MELTING RECORD IN NORTHWESTERN GREENLAND ICE SHEET

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To evaluate melting rate of snow/ice on Greenland Ice Sheet, we carried out meteorological and glaciological expedition at the site SIGMA-A (78°03'N, 67°38'W, 1490m a.s.l.) on the northwestern Greenland ice sheet from June 26 to July 16, 2012 (Fig. 1). During the expedition, we obtained a 19m ice cores using a hand auger, and observed bulk density and visible stratigraphy of the ice cores, and prepared samples for chemical analysis from the ice cores. Profiles of ice layer percentage and density showed that the ice cores from surface to 3m depth were influenced by melt water owing to recent warming (Fig. 2). In this contribution, we discuss melting features of the observation site shown by ice core analysis and satellite data analysis.

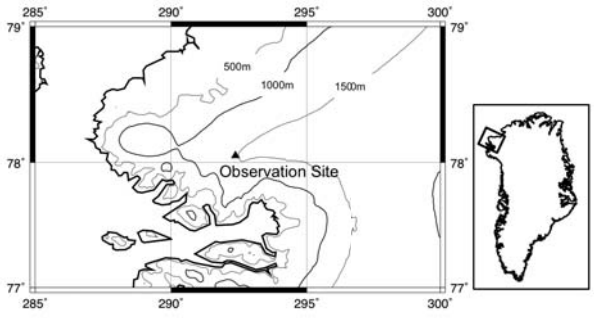

Fig1. Location of observation site

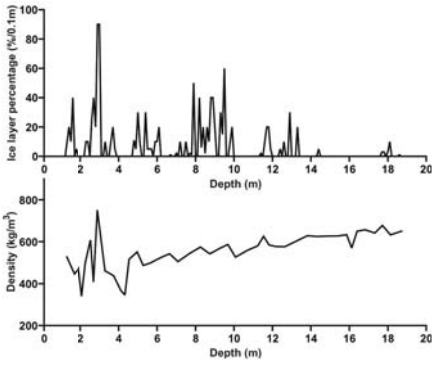

Fig2. Profiles of ice layer percentage in 0.1m long ice core and density.

S3–P3

MEASUREMENT OF SPECIFIC SURFACE AREA OF SNOW COVER IN GREENLAND

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Specific Surface Area (SSA) is considered an essential physical parameter for the characterization of snow. We measured time series change in SSA of snow cover in Greenland (SIGMA-A: 78°03’ N; 67°38’ W; 1,490 m a.s.l.) using the “near-infrared photography (NIR) method” and we compared our measured data with snow pit data. The SSA fluctuated with variations in snow properties (such as grain type and grain size). Although the distribution pattern of the SSA did not vary with time, its value reduced (Fig.1). This decrease in the SSA is probably due to an increase in grain size. Data from our SSA measurements will become a valuable part of validating numerical snowpack metamorphism.

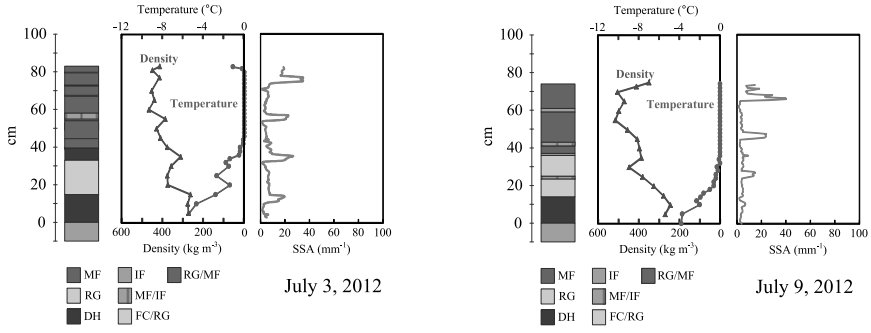

Fig.1 Comparison of results from SSA and snow pit data (July 3 and July 9, 2012).

NUMERICAL SIMULATION OF SUMMER SNOWMELT AT SITE SIGMA-A NORTHWESTERN GREENLAND DURING 2012 INTENSIVE OBSERVATIONS

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It is widely recognized that snow and ice on the Greenland ice sheet (GrIS) are melting abruptly in recent years, although its robust mechanisms have not been fully understood yet. In order to clarify such mechanisms we employ the one-dimensional physical snowpack model SMAP [*Niwano et al.*, 2012], which was originally developed and validated against seasonal snowpack. With SMAP we calculate physical states of the latest annual snow layer during the 2012 intensive field observations (30 June to 10 July, 2012) conducted in the site SIGMA-A, which locates on northwest part of GrIS (78°03'N, 67°38'W, 1,490 m a.s.l.). During the period we observed rapid surface-level lowering caused mainly by snowmelt. The initial physical states of snowpack are given from those obtained by snow-pit observations carried out on 30 June. From the initial state we perform numerical simulation of physical states of snowpack by forcing measured meteorological data, mass concentrations of snow impurities, and snow temperature at the depth of bottom ice formation in the latest annual layer. The simulated snow temperature profiles are compared against *in-situ* measurements. As shown in an example of the comparisons (Figure 1) SMAP tends to underestimate snow temperature. The result suggests that it is necessary to adapt several snow physical processes, especially liquid water displacement, to the polar snow condition.

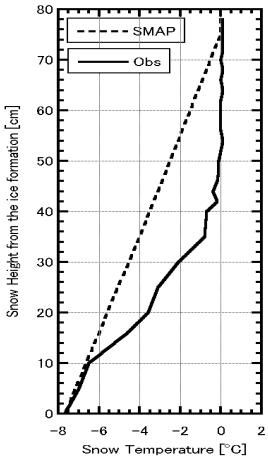

Figure 1. Snow temperature profile at 0930 LT on 8 July.

References
Niwano, M., T. Aoki, K. Kuchiki, M. Hosaka, and Y. Kodama (2012), Snow Metamorphism and Albedo Process (SMAP) model for climate studies: Model validation using meteorological and snow impurity data measured at Sapporo, Japan, J. Geophys. Res., 117, F03008, doi:10.1029/2011JF002239.

MONITORING OF THE DARK REGION ON GREENLAND BY AQUA/MODIS DURING THE MELTING SEASON 2002 - 2012

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We monitor the dark region in the western and northern bare ice areas of Greenland ice sheet by using MODIS images during the melting season. The areas of dark region and their albedo variations make a large contribution to the total melt energy, which is important to control temporarily and spatially melt water generation. We built monthly composite MODIS images by collecting clear day (cloud-free) pixels, and then examined the recent trend of temporal and spatial variations of the dark region. Figure 1 shows true color images over the Greenland ice sheet. The dark region in the western area and the surrounding blue-ice expanded during eleven years, and the north/northwest coastal area also was confirmed to be dark. Figure 2 shows radiance profiles for different years as observed by the MODIS visible channel (470 nm) in the western (Fig.2a) and northern bare ice areas (Fig.2b). The radiance profiles of the dark region drastically decreased in 2007, and lower radiance areas extended toward the inner area including the dark region especially during recent three years. This means there was an expansion of the blue ice or large snow-grain-size area. And, this phenomenon is caused by the snow impurities such as dust and glacial microbes together with recent surface temperature increasing.

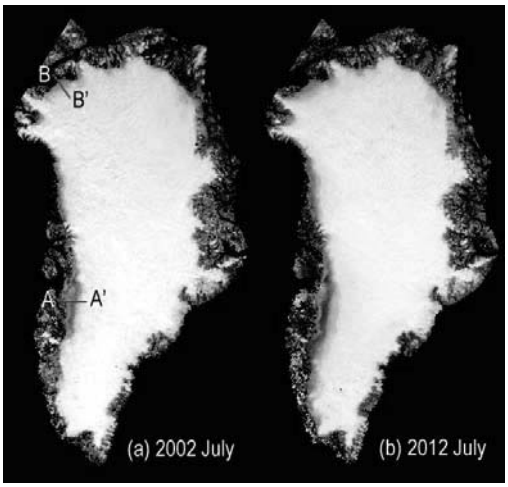

Fig1: MODIS true color image.

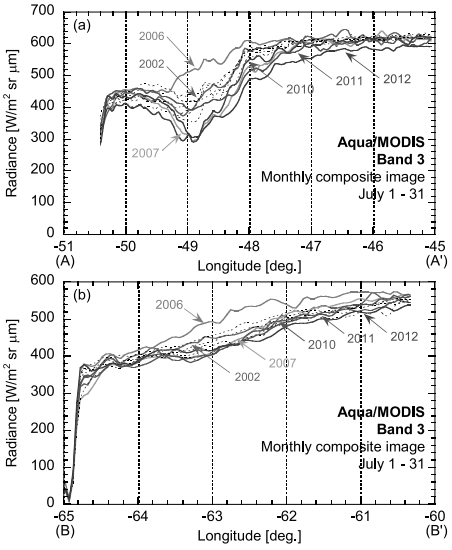

Fig2: Radiance profiles at different years for (a) A-A' and (b) B-B' profile of Fig.1.

S3–P6

MASS CONCENTRATION OF SNOW IMPURITIES AND SNOW GRAIN SIZE ON NORTHWESTERN GREENLAND ICE SHEET: COMPARISON BETWEEN RETRIEVAL FROM MODIS AND IN-SITU MEASUREMENT

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Light absorbing impurities in snow and snow grain size are important parameters controlling snow albedo. Changes of these snow physical parameters could be one of the possible causes of the recent snow/ice melting in the Arctic. The snow physical parameters retrieved from the Terra/Aqua MODIS were validated using the intensive observations which were carried out at the SIGMA-A site (78°03'N, 67°38'W, 1,490 m a.s.l.) on northwestern Greenland ice sheet during June 26 – July 16, 2012.

The MODIS-derived snow physical parameters are mass concentrations of snow impurities optically equivalent to soot and snow grain sizes in top and bottom snow layers. The in-situ measured mass concentrations of elemental carbon (EC) in the surface to 2 cm snow layer at the SIGMA-A site were several ppbw, which were gradually increased during the observation period. The soot concentrations retrieved from Aqua MODIS were generally consistent with the EC concentrations. In contrast, those from Terra MODIS were significantly overestimated, which might be due to the interannual change in the sensitivity of the Terra MODIS. The snow types were melt forms or ice layer in the top 5 cm layer. The snow grain radii measured with snow pit work were 100–800 μm. The top layer snow grain radii retrieved from the Terra/Aqua MODIS agreed with the in-situ measurement in the 0–2 cm layer. They were increased more than 1000 μm after the rainfall event from July 10 to 13. The bottom layer grain radii retrieved from Terra/Aqua MODIS were somewhat larger than the in-situ measured grain radii in the 2–5 cm layer. The ice layers in near snow surface would reduce the snow reflectance, causing the overestimation in the bottom layer snow grain size retrieval.

S3–P7

ICE FRONT VARIATIONS AND VELOCITY OF OUTLET GLACIERS TERMINATING IN INGLEFIELD FJORD, THE NORTHWEST GREENLAND

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Recent studies on Greenland Ice Sheet have revealed widespread retreat, thinning, and acceleration of marine terminating outlet glaciers within the past decade. As a result of the observed changes, contribution of the ice sheet mass loss to the sea level rise is increasing. It is likely that the changes in outlet glaciers are triggered by thinning and retreat of ice front which subsequently reduce back resistance force acting on inland ice. Thus, monitoring ice front variations is important to predict future changes of calving glaciers. Such studies have been carried out mostly at large glaciers in the southern part of Greenland. Because the influence of warming trend is expected to spread to higher latitude, it is urgently needed to collect data in the northern Greenland. Here, we report changes of glacier front positions and ice velocity of 19 outlet glaciers terminating in Inglefield Fjord in the Northwest Greenland.

We measured glacier front positions and ice velocity using Landsat imagery form 1988 to 2012. Our analysis revealed that all of the studied glaciers have retreated over the last decade at a mean rate of -51 ± 44 m a^{-1}. The front positions of some of the glaciers were relatively stable before 2000s (-2 ± 21 m a^{-1}). Tracy Glacier, the second largest glacier terminating in the fjord, retreated by 2200 m from 2002 to 2010 Coincided with the terminus retreat, surface velocity near the terminus increased by 20%. These observations at Tracy Glacier suggest that the ice velocity change was the result of terminus retreat. Terminus retreat trend is similar in the other glaciers, but clear acceleration was observed only for Tracy Glacier. The synchronous retreat of calving glaciers implies that the glaciers in the studied region are changing under the influence of climate and/or ocean forcing.

S3–P8

THINNING OF AN ICE CAP AT THE COASTAL MARGIN OF NORTHWESTERN GREENLAND

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Recent satellite observations have shown that Greenland ice sheet is losing ice mass. About a half of the mass loss is attributed to warming climate conditions, which produce greater amount of snow and ice melt. Because the influence of temperature rise on melting is more significant in the lower elevation range, Greenland peripheral ice caps and glaciers, which are physically separated from the ice sheet, are rapidly losing ice as well. However, mass balance of the ice caps and glaciers has not yet studied in detail. To better understand recent volume change in these ice caps and glaciers in Greenland, we carried satellite and field measurements on an ice cap near Qaanaaq in the northwestern Greenland.

Our study site was an ice cap located north of Qaanaaq, a village located at N 77°28' and E 69°13'. Ice is covering an elevation rage of 250–1000 m a.s.l. over an area of 320 km^2. We measured ice surface elevation by analyzing a satellite data obtained by Panchromatic Remote-sensing Instrument for Stereo Mapping (PRISM) of Advanced Land Observing Satellite (ALOS). The PRISM data were analyzed with a stereoscopic monitor and digital photogrammetric software. From this analysis, we obtained digital elevation models (DEM) in 2007 and 2009. In the summer 2012, we performed ground based kinematic GPS survey on the ice cap to measure surface elevation along an 8 km long survey route, which connects the ice cap summit and the terminus of an outlet glacier flowing down to the south. The DEMs and the field data were compared to calculate the changes in the ice thickness between these years. A comparison of DEMs in 2007 and 2009 showed that the ice thinned at a rate of 1.8 m a^{-1} as an average along the kinematic GPS survey route.

S3–P9

MICROBIAL COMPOSITION CHANGES IN CRYOCONITE FORMATION PROCESS IN NORTHWESTERN GREENLAND

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On the glacier surface, psychrophilic microorganisms forms brown-black color small (1mm diameter) granule called cryoconite. From microscopic observation, main structures of cryoconite are formed by filamentous cyanobacteria aggregation and these keep organic material, other microorganisms and mineral particles. Cryoconite are widely distributed on the ablation area of glacier and ice sheet in various parts of the world, and reduce the albedo and accelerate the melting of ice surface. Despite of importance of cryoconite for glacial melting effect, microbiological formation process of cryoconite is not well understand. Therefore, in order to understand microbial diversity changes during formation process, we compared microbial diversities in 8 different size of cryoconite.

In July 2011, on the middle of Qaanaaq Glacier located in Northeastern parts of Greenland, we collected the cryoconite distributed on the surface of glacier. We sorted cryoconite by each sizes (Size 1: 30-100 μ m, Size 2: 100-250 μ m, Size 3: 250-500 μ m, Size 4: 500-750 μ m, Size 5: 750-1000 μ m, Size 6: over 1000 μ m) using niron mesh filter and by tweezers (approximately diameter 1000 μ m and 2000 μ m). By stereoscopic microscopic observation, all larger diameter cryoconite (Size 3-6) are coated by black organic materials, otherwise half of size 2 and most of size 1 is non-organic attached mineral particles. Therefore, size 1 could be recognized as primary stage of microorganisms growth. Clones of eukaryotic 18S rRNA are classified into algae, cercozoa, fungi, tardingrade. Through all sizes, *Raphidonema nivale* which snow living green algae and ameba belonging into family: *Vampyrellidae* are detected. Diversity index increase with cryoconite size increase show that diversified eukaryote live in large sized and mature cryoconite. In lager cryoconite than size 3, many types of ameba and fungi are detected. Usually ameba eat the bacteria and other small microorganisms, and fungi decompose organic materials, therefore larger sized cryoconite become much hetertrophic. Result of bacterial 16S rRNA show that cyanobacteria related to *Phormidium pristleyi* known as filamentous species are detected in all sizes. Because main structure of cryoconite is composed by filamentous cyanobacteria, this species would be essential for thickening growth around the surface. Otherwise, in lager than size 3, no other bacteria can not be detected due to large amount of cyanobacterial DNA included in samples. In size 1, more than half of total clones are retrieved from glacier environment. Dominant clone is *Acidobacterium* which reported in Gulkana Glacier in Alaska, however this uncultured clone is genetically far from isolated species and we can not characterize these. Otherwise, one OTU (4 clones) is closely related to genus *Deinococcus*. *Deinococcus* is well-known species have tolerance of UV, radioactive ray and desiccation. Because cryoconite are exposed under strong UV and freeze-chew effect, *Deinococcus* can survive these harsh environment.

S3–P10

EFFECT OF MICROORGANISM ON GREENLAND ICE SHEET SURFACE TEMPERATURE CHANGE

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Greenland ice sheet holds approximately 10% of the fresh water on earth. If it melts all, sea level rises about 7.2meter. It is reported that mass of Greenland ice sheet is decreasing with temperature rising of climate change. However many climate models aren't able to simulate the recent melting of snow and ice in the Arctic including Greenland. One of the possible causes is albedo reduction of snow and ice surface by light absorbing snow impurities such as black carbon and dust and by glacial microorganisms. But there are few researches for effect of glacial microorganism in wide area. So it is important to clarify the impact of glacial microorganisms in wide area.

The purpose of this study is to clarify the effect of microorganism on Greenland ice sheet surface temperature change using satellite images and observation carried out in northwestern Greenland.

We use MODIS LST Product as ice sheet surface temperature. It estimates land surface temperature using thermal infrared bands. MODIS data is calculated the ratio of the temperature change per year. Analysis period is from December 2002 to November 2010.

Results of calculating Greenland ice sheet surface temperature change using the MODIS data, our analysis shows that it is upward trend in the whole region. We find a striking upward trend in northern and western part of Greenland. The rate is 0.33±0.03 degree Celsius per a year from 47.5° W to 49° W. While in the coastal area from 49° W to 50.7° W, the rate is 0.26±0.06 degree Celsius per a year. This large upward trend area is the same area as dark region (Wientjes and Oerleman., 2010). It is considered that the cause of the dark region is Cryoconite on the glacier. So, upward trends have relation to glacial microorganism including cryoconite. In the future, in order to clarify the relationship between temperature change and glacial microorganism, we will develop product to determine the quantity of glacial microorganism by satellite images.

G1–P11

Impact of NICAM-LETKF on the Arctic

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In the university of Tsukuba, the Local Ensemble Transform Kalman Filter (LETKF) is applied to the Nonhydrostatic Icosahedral Atmospheric Model (NICAM) to develop the NICAM-LETKF system. The NICAM is designed to perform cloud-resolving simulations by directly calculating deep convection and mesosclase circulation, such as the tropical storm, arctic cyclone and so on. Moreover, the NICAM is able to avoid the pole problem by adopting icosahedral grid structure. The LETKF is one of the ensemble based Kalman filter. It has highly parallel performance because it is implemented in each grid. It is expected that the NCIAM-LETKF system describes much clear the atmospheric phenomena by assimilating observations with the NICAM-LETKF system.

In this study, the data assimilation experiments with the NICAM-LETKF system are implemented under the perfect model scenario to investigate the feasibility and stability of the NICAM-LETKF system in the Arctic. The horizontal resolution is 224 km and the number of vertical layers is 40. The ensemble size is fixed to 40.

According to the results, the NICAM-LETKF system works appropriately and stably under the perfect model scenario. We confirm that the NICAM-LETKF system converges stably, and the analysis errors are smaller than the observation errors. Moreover, in the areas where there is a disturbance, we find that not only the analysis error but also the ensemble spread are large as expected.

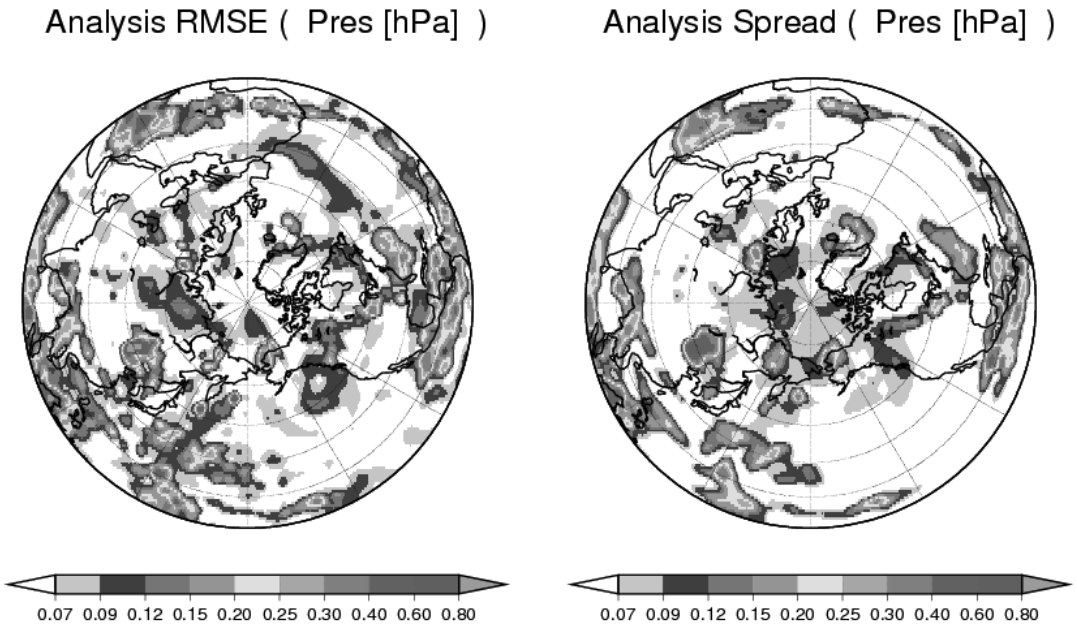

Fig. 1. Spatial distributions of the analysis RMSE (right panel) and ensemble spread (left panel) of 13th layer from the bottom at 00 Z 1 Sep. 2011.

G1–P12

DECADAL VARIABILITY AND A RECENT AMPLIFICATION OF THE SUMMER BEAUFORT HIGH: IMPLICATIONS FOR SEA-ICE, UPWELLING AND POLYNYAS IN THE WESTERN ARCTIC OCEAN

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The Beaufort High (BH), an anti-cyclone over the Beaufort Sea, is an important feature of the summer atmospheric circulation over the Arctic Ocean. For example, years characterized by low Arctic sea ice extent are typically associated with the presence of a stronger BH; with the opposite occurring during years with high sea ice extent. Here we show that there exists variability on the decadal time scale in the intensity and location of the summer BH. We also show that there has been a trend towards a stronger summer BH that began in the late 1990s. This trend is shown to be associated with a tendency towards a reduction in summer cyclogenesis over the Beaufort Sea. We argue that that these trends are the result of a warming of the Arctic troposphere and the concomitant reduction in baroclincity in the region. We furthermore show that this amplification in the BH results in enhanced easterly flow across the Beaufort and Chukchi Seas that results in a number of impacts including: the reduction of sea-ice in the region; the formation of polynyas in the vicinity of Wrangel Island and the Siberian coast of the Chukchi Sea; and an increase in frequency of reversal of the Chukchi Sea shelfbreak jet. The later leads to more frequent upwelling of nutrient rich water that may impact primary productivity in the region.

G1–P13

RECENT LINKAGE BETWEEN SPRING SNOW COVER AND SUMMER ARCTIC SEA ICE EXTENT

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Recent studies have suggested that variations of northern Eurasian spring snow cover can result in changes in the summertime northern atmospheric circulation via land–atmosphere interactions (Matsumura et al., 2010; Matsumura and Yamazaki, 2012). In particular, earlier-snowmelt reduces surface albedo, which leads to a rapider surface warming in spring. A strong snow–hydrological effect was also observed in eastern Siberia, where reduced soil moisture persists into the following summer and then contributes to an increased surface warming. In conjunction with the multidecadal decreases in Eurasian spring snow cover extent, Arctic sea ice cover has also rapidly declined over the recent two decades. We found that the land snow melting leads sea ice melting. This phase differences would result in an increased temperature contrast across the Arctic coastline, which may impact overlying atmospheric circulation.

Reference

Matsumura, S., K. Yamazaki, and T. Tokioka (2010), Summertime land-atmosphere interactions in response to anomalous springtime snow cover in northern Eurasia, J. Geophys. Res., 115, D20107, doi:10.1029/2009JD012342.

Matsumura, S. and K. Yamazaki (2012), Eurasian subarctic summer climate in response to anomalous snow cover, J. Climate. 25, 1305-1317.

G1–P14

CHANGES IN THE LENA RIVER DISCHARGE AND NET PRECIPITATION OVER THE BASIN DURING 2005-2008

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The Lena River has the second largest discharge among all rivers into the Arctic Ocean, which accounts for about 7% of total freshwater inflow. The Lena River discharge plays a role as a large freshwater source into the Arctic Ocean. While previous studies have been made on interannual variation of the river discharge (R) from the Lena River and associated precipitation, net precipitation (precipitation minus evapotranspiration, P-E), moisture transport and so on, several drastic changes in terrestrial water cycles are observed around Yakutsk in the past decade, especially during 2005-2008. This study examined the changes in the Lena River discharge and associated net precipitation and moisture transport during 2005-2008. In this analysis, we calculated vertically integrated moisture flux on the basis of atmospheric reanalyses and then estimated net precipitation from the moisture flux and precipitable water by means of the atmospheric water budget method without using P and E datasets.

To examine interannual variations of the R and P-E, it needs to take into account a time lag between those two, because the Lena River has a large area of the basin and precipitation during winter accumulates as snow. Comparison of the R to P-E indicated that summer (winter) P-E quantitatively corresponds to autumn (spring) R. They are positively correlated in each of the seasonal combinations. This indicates that the interannual variation of the Lena River R is controlled by the change in P-E over the basin in each season. The summer P-E and autumn R were high during 2005 2008, and also the winter P-E and spring R were high during 2007-2008. A decomposition analysis of moisture flux into stationary and transient components (Oshima and Yamazaki (2006, GRL), Tachibana et al. (2008, JGR)) showed some results about moisture transport as follows. In summer, the total moisture flux convergence over the Lena River basin is positively correlated with stationary component during the first half of the past three decades, however, the correlation becomes moderate during the second half. In the second half, the total and transient components of moisture flux convergences show weak positive correlation. These contributions of stationary and transient component were different in 2008 during 2005-2008. The stationary component dominates the total moisture flux convergence in 2008, on the other hand the transient component dominates in the other years.

G1–P15

ANNUAL CLOUD VARIATION OBSERVED AT NY-ÅLESUND FROM 2005 TO 2008

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It is of great importance to invesitgate cloud variation since cloud is one of the critical contributors to the Arctic radiation energy budget. Arctic clouds generally make the atmosphere warmer as the cloud coverage and altitude are wider and lower, respectively. The observation has been carried out with ground-based All-Sky Camera (ASC) and Micro Pulse LIDAR (MPL) to investigate the cloud coverage and cloud bottom height at Ny-Ålesund, Svalbard, Norway for about a decade. In this study, annual variation of the cloud coverage (or fraction) and base height data were analyzed from 2005 to 2008. As a result of statistical analyses on a monthly-average basis, the mean cloud fraction was 7.7 out of 10.0 during this period. The seasonal variation was also obtained such that they had a minimum value (5.9) in March and a maximum one (8.6) in August, even though the observation was carried out from March to October due to the limitation of the sunshine duration. The results were then compared to the MPL measurements and Eye observation, both of which could be available all through the year. The comparison showed a reasonable consistency of the mean values with 7.2 (MPL) and 6.7 (Eye), and of the same seasonal variation, i.e., the minimum in March and the maximum in August. The MPL also provided the cloud base height (CBH) statistics, which showed that there dominated lower level clouds with CBH up to 1 km all through the year during the period.

G1–P16

THE STRUCTURE OF THE ARCTIC CYCLONE IN SUMMER ANALYZED BY THE JRA-25/JCDAS REANALYSIS DATA

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In recent years, the Arctic has undergone a dramatically change in warming and sea ice melting. The arctic cyclone is one of the facters to these problems. Although the arctic cyclone was studied statistically in the area of the generation or the variability of the number, few studies have examined in the dynamical structure.

In this study, we investigated the three-dimensional structure of the arctic cyclone for some cases, using reanalysis data of JRA-25/JCDAS. As a result, the arctic cyclone is different from the mid-latitude cyclone in many features. The arctic cyclone moves randomly in direction over the Arctic Ocean and surface pressure drops rapidly to the mature stage. The arctic cyclone detected at the sea level pressure is connected with polar vortex. Importantly, the arctic cyclone has the cold core in the troposphere and warm core at around 250 hPa. Also, the downdraft exists at around 250 hPa. Hence, the warm core accompanied by the downdraft at 250 hPa and connecting with the polar vortex is the important mechanism of maintenance and development of the artic cyclone.

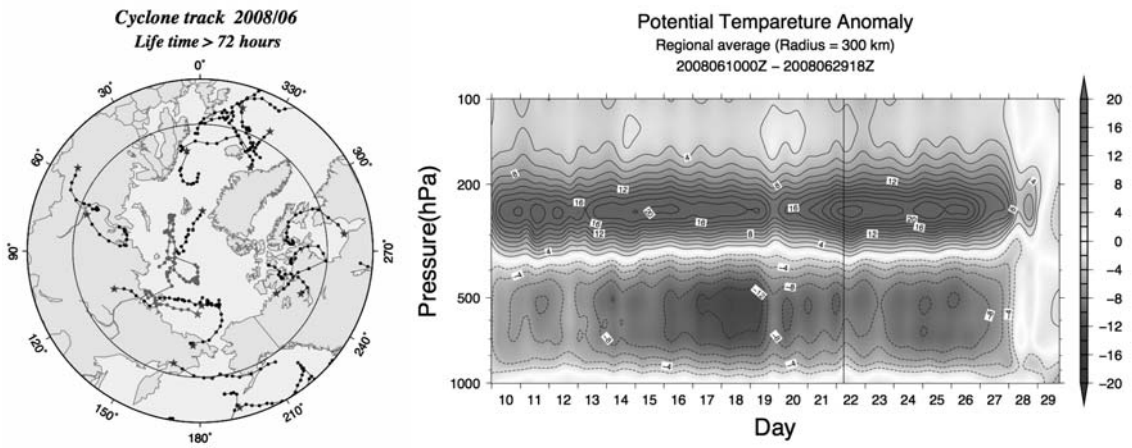

Figure: Tracks of the arctic cyclone in August 2006 (left). The red line is the analyzed cyclone. Vertical-time section of the potential temperature anomaly averaged within 300 km radius from the center of the arctic cyclone (right) for June 2008.

G1–P17

MICROPHYISICAL PROPERTIES OF BOUNDARY LAYER MIXED-PHASE CLOUD OBSERVED IN NY-ALESUND, SVALBARD (OBSERVED CLOUD MICRO-PHYSICS AND CALCULATED OPTICAL PROPERTIES)

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The cloud-radiation interaction plays an important role in global climate system and has been investigated by many researchers. However, the understanding of mixed-phase boundary layer cloud in Arctic has remained one of the unknown factors. During the period of May to June, 2011, in situ measurement of mixed phase boundary layer clouds were carried out at Zeppelin Station of Norwegian Polar Institute (NPI) in Ny-Alesund (78.9N, 11.9E), Svalbard.

The instruments consist of Cloud, Aerosol and Precipitation Spectrometer (CAPS), PVM-100（Gerber Particulate Volume Monitor） and Cloud Particle Microscope imager (CPM). CAPS is composed of Cloud and Aerosol Spectrometer (CAS）and Cloud Imaging Probe (CIP). CAPS-CAS and CAPS-CIP have same measurement capabilities of Forward Scattering Spectrometer Probe (FSSP) models 100 and 300 and tow dimensional optical imaging probe (2D-OAP), respectively. PVM-100 measures liquid water content and effective radius of water droplet clouds. CPM consists of CCD camera and microscope and takes an image of cloud particles. These instruments were installed on the roof of Zeppelin Station of NPI, which is near the top of Mt. Zeppelin and is at the altitude of 474 m.

The clouds associated with outbreak of westerly cold air mass from the sea were observed on June 9, 2011. The atmospheric temperature during the measurement was from -3 to -5 C. The large part of cloud particles that were measured by CAPS-CIP consisted of column type. We show the cloud microphysical properties; cloud particle size spectrum, liquid water content, ice water content and calculated optical properties.

G1–P18

Diagnostic Analysis of the Decadal Variability of the Arctic Oscillation using the AOI Equation

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In this study, we investigated the dynamical origin of the Arctic Oscillation Index (AOI) using the AOI equation to which is derived from 3-D spectral primitive equations. The purpose of this study is to divide the factor of AOI into the portions depending on the linear term of internal dynamics, the portion depending on an interaction with unsteady turbulence (the nonlinear term), and the portion depending on external forcing (the force term) using an AOI equation. Using this equation we investigate the origin of the decadal variability of the AOI.

According to the result the AOI has a resonant relation for the linear term and a damping relation for the nonlinear and force terms. This means that the linear term has positive feedback to AOI and the nonlinear and force terms have negative feedback to AOI. Moreover, it shows that the most of AOI of decadal variability is caused by the linear term. This means that the decadal variability of the atmosphere in the Northern Hemisphere is not induced by the external forcing but is excited by the internal change of the atmosphere. On the other hand, it becomes clear that the great portion of change of AOI is brought by the nonlinear term for the short time scale less than about a month.

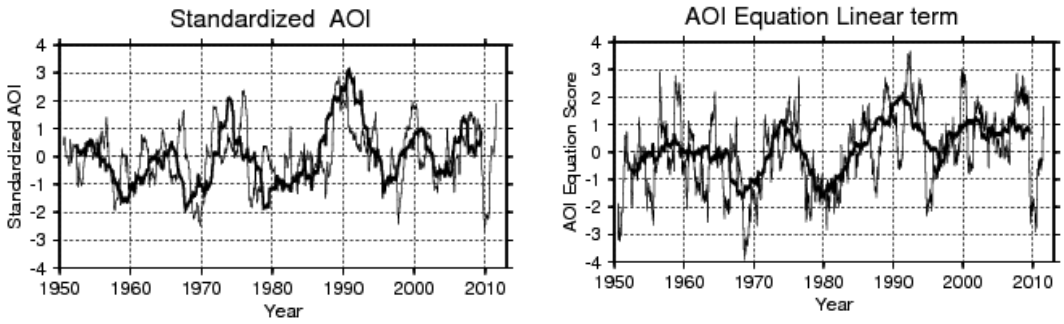

Figure: Time series of AOI (right) and AOI Equation Linear term (left). Thin line is 1 year running mean. Bold line is 5year running mean.

G2–P1

ARCTIC SEA ICE VARIABILITY DERIVED FROM AN EXPANDED SEA ICE DATASET, 1850-2012

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A synthesis of sea ice data from various sources has extended the post-1979 satellite record of sea ice coverage back to 1850. The primary inputs to the expanded digital database are historical charts from Norway, Denmark, Russia, Alaska and Canada, as well as whaling and other ship reports from the North Pacific sector. The primary variable is ice extent, although the passive microwave satellite-derived concentrations provide the basis for reconstructions of historical ice concentration fields. We summarize the data synthesis procedure as well as the trends and low-frequency variations in the extended record. The outstanding feature is the ongoing abrupt decrease of sea ice coverage, especially in the summer and autumn. This decrease is unique in the 160-year record, as is the increased amplitude of the seasonal cycle of ice coverage over the past five years. In addition, there are low-frequency variations, including a reduction of ice extent in the early 20th Century. The latter event was confined primarily to the Atlantic sector. The low-pass filtered record of Atlantic ice extent is also consistent with the Atlantic Multidecadal Oscillation, which has a cycle length of 70-90 years. This finding is supported by other recently published studies based on paleo reconstructions of Arctic sea ice coverage over the past millennium. The linkage to the Atlantic Multidecadal Oscillation appears to arise through the inflow of Atlantic Water to the Arctic Ocean. Less robust, and by all indications non-stationary, associations with atmospheric modes such as the North Atlantic Oscillation have also been documented, primarily in recent decades. One possible reason for the non-stationarity of such associations is that the centers of action of major atmospheric modes can change over the timescale of centuries or even less.

G2–P2

NUMERICAL SIMULATION OF THE ARCTIC SEA ICE VARIABILITY

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We here simulated the distribution and variation of sea-ice in the Arctic Sea using an ice-coupled Ocean General Circulation Model (OGCM). The OGCM used in this study is the Regional Ocean Model System (ROMS) version 3.4, which is a three dimensional, s-coordinate, primitive equation ocean model with a free surface. The model area covers the region 65° –90° N, 180W° –180° E with grid resolution of 14–21km in latitude and longitude. A total of 70 s-coordinate levels are adopted along the vertical direction with enhanced resolution near the surface. Daily ECMWF (European Center of Medium range Weather Forecasting) forcast data with 0.5° resolution during the period 2002-2012 are used to calculate heat and salt fluxes as well as wind stress at the sea surface. Temperature and salinity imposed at inflow open boundaries are from the HYCOM-NCODA (Navy Coupled Ocean Data Assimilation) Global 1/12° data.

G2–P3

THE ENERGY BUDGET OF ARCTIC FIRST-YEAR SEA ICE THROUGH THE MELT SEASON

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Over recent decades first-year ice is the dominant ice type in much of the Arctic Ocean. An improved understanding of the processes that affect this younger ice cover is needed as these can differ significantly from those on multi-year ice that was dominant in the past. To this end, we have carried out field campaigns to observe the energy fluxes and processes affecting the melt of different types of seasonal Arctic sea ice. We observed the spatial variability of the four components of the surface radiation budget* along with measurements of the sensible and latent heat fluxes to the surface from the atmosphere and the transmitted solar radiation below the ice, on relatively thick seasonal landfast ice (Barrow, Alaska) and thinner pack ice (Nansen Basin).

Before snow melt there is little spatial variability, however with onset of melt and meltpond formation, surface albedo drastically decreases and spatial variability increases. This is also important beneath the ice. As transmittance of photosynthetically active radiation varied from around 10% through thicker white ice up to over 60% through ponds overlying thin ice during melt. Previous studies, generally from multiyear ice, reported pond transmittances closer to the white thicker ice, and also showed less pond coverage overall.

Our results highlight how the changes towards thinner ice and higher pond coverage may alter the way solar radiation contributes to the melt of seasonal Arctic sea ice. The increasingly transparent Arctic ice should be better understood if we are to know how future changes to the ice and ecosystem will unfold.

*Hudson, S.R., M.A. Granskog, T. I. Karlsen., K. Fossan. 2012 An integrated platform for observing the radiation budget of sea ice at different spatial scales, *Cold Regions Science and Technology*, 82, 14-20.

MOORING MEASUREMENT OF SEA-ICE THICKNESS IN THE CHUKCHI SEA OFF BARROW ALASKA

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Katsushi Iwamoto[1,2], Chris Petrich[3], Andy Mahoney[3] and Hajo Eicken[3]

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Recently, sea ice in summer has dramatically decreased in the Chukchi Sea. In August 2009, we started the direct sea-ice measurement off Barrow, Alaska. This is the first attempt to measure the sea-ice thickness by mooring in this region. Mooring observations were carried out at two stations. The nearshore site is occasionally covered with fast ice and the offshore one is in the Chukchi Sea polynya (Figure 1(a)). These two moorings have been replaced every summer to sustain the observations. Each mooring contained Ice Profiling Sonar (IPS), Acoustic Doppler Current Profiler (ADCP), temperature/conductivity and temperature/pressure recorders. Figure 1(b) shows an example of the time series of the sea-ice draft observed at the site B2. Time series contains periods of thin ice (polynya) and deep keels. Thin ice-thickness comparison with the satellite data obtained by the Advanced Microwave Scanning Radiometer for EOS (AMSR-E) will be carried out focusing on the polynya events.

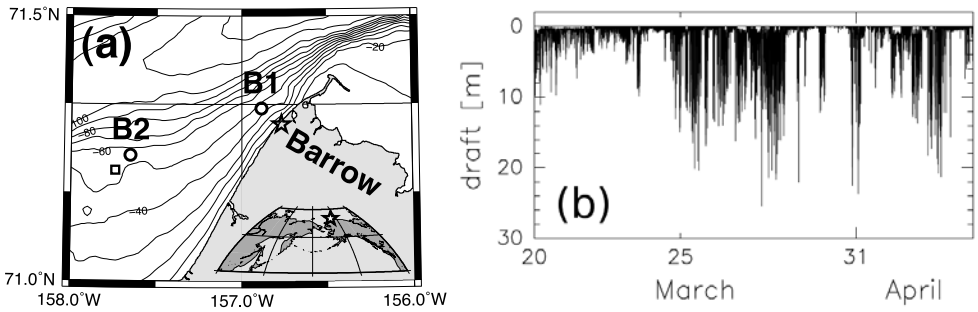

Figure 1: (a) Map of the observation site off Barrow with bottom topography. Circles denote the mooring sites. Square shows the nearby AMSR-E data point for comparison. Star shows the central Barrow. (b) Example of time series of the draft of the sea ice at site B2 in 2010.

G2–P5

Influence of ocean thermal condition on the wintertime sea ice extent variability in the Barents Sea

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The sea ice variability of the Barents Sea in early winter and its resultant atmospheric response is considered to be the triggers of downstream climate change such as Japan [Honda et al., 2009; Inoue et al., 2012]. In this study, we examined the ocean heat content, which is known to be a major factor for the sea ice extent variability [Arthun and Schrum, 2010; Arthun et al., 2012], based on the hydrographic and reanalysis data and explore the possibility for the long-term prediction of the sea ice extent variability. We found that the sea ice extent in December is highly correlated with

the ocean temperature of the North Atlantic Water in the sub-surface layer (50-200m), when the latter leads the former by about 2 years (Fig. 1). The Climate Forecast System Reanalysis data show the consistent result and reveal the slow advection of the ocean heat content from the North Atlantic to the Barents Sea. The sub-surface water variation is related with strength of the warm Norwegian Current along the Scandinavian Peninsula. The northward current is significantly correlated with the wind stress associated with the strength of the Iceland Low. Thus, the usage of the sub-surface water temperature probably improves the prediction skill of the sea ice variability.

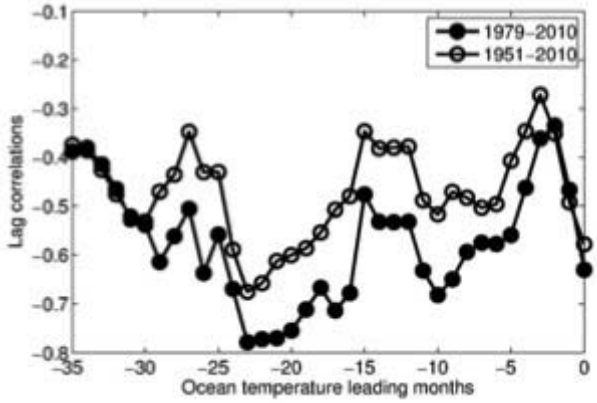

Figure 1. Lagged correlation coefficients between the sea ice extent in the Barents Sea and the monthly subsurface ocean temperature along the Kola Section (70°-73°N, 33.5°E) from 1979 to 2010 (closed circles) and 1951 to 2010 (open circles).

G2–P6

FORMATION PROCESSES OF SEA ICE BAND FORMED BY CONVERGENCE OF SEA ICE MOTION IN THE PACIFIC SECTOR OF THE ARCTIC OCEAN
- AVAILABILITY OF ARCTIC SEA ROUTES -

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A sea ice condition in the Arctic Ocean has already changed into a new state. In the southern Canada Basin and Makarov Basin, first-year ice (FYI) dominated the area instead of multi-year ice (MYI). Most of FYI cannot survive by the end of summer, huge sea ice retreat occurs in the Pacific Sector of the Arctic Ocean. However, heavy ice bands remain along the northern Chukchi and East Siberian Seas in some year. Presence, distribution, formation, and variation of this ice band have impacts on availability of the Arctic Sea Routes. In this study, we pay attention to a rafting process against the North American continent as one of candidates for the formation of the ice band. Here we evaluate convergence of sea ice motion that yields over 100% sea ice concentration.

In 2006 winter, large convergence of sea ice motion occurred along the Alaskan coast and formed the heavy sea ice band remained in the subsequent summer. In fact, in July of 2006 icebreakers, CCGS Laurier and USCG Healy, stacked in the Northern Chukchi Sea. Since the ice band was too heavy to melt by the end summer, as the result, an open ocean polynya-like feature was emerged around the Northwind Ridge where the FYI was dominated and warm Pacific Summer Water was delivered. On the other hand, in 2007, divergent motion of sea ice was dominant in the Pacific sector of the Arctic Ocean. Then the ice band was not formed. In 2008, 2012, the ice band was formed, but most of ice band did not survive by the end of summer. Thus, the growth of sea ice by the rafting associated with convergence motion of sea ice is a key process to predict the timing of disappearances of sea ice in the region of the Arctic Sea Routes near the coast. We plan to introduce results of back-tracing analysis for the ice band to understand the robustness, lifetime and formation history of the ice band.

G2–P7

Evidence of submarine mass wasting event in Molloy Hole, Fram Strait using multibeam backscatter

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The relatively deep channel of the Fram Strait between Svalbard and Eastern Greenland serves as the primary pathway for the mixing of the warmer Atlantic Ocean and the colder waters of the Arctic. Magnetic, tectonic and geological studies have shown that the Fram Strait was formed as a result of Svalbard breaking up from northeastern Greenland starting in the Late Mesozoic/Early Cenozoic era. The sea floor of the Fram Strait is characterized by an ultra-slow spreading ridge that is the northward continuum of the Mid-Atlantic Oceanic Ridge. It is also heavily influenced by changing ice cover from the adjacent islands which deposit their terrestrial sediments to the seabed. These tectonic and glacigenic processes have greatly influenced seafloor morphology of the Fram Strait producing a highly rugose seafloor that is riddled with complex submarine landforms with a spatially variable sedimentary cover. This paper focuses on one of these complex submarine landforms, the Molloy Hole, the deepest point in the Arctic Ocean. It is located adjacent (a few tens of kilometers) to the continental slope of Svalbard where considerable hydrate systems are found. These systems play an important role in slope stability and are sensitive to warming bottom water temperatures. Seafloor mapping surveys around the Molloy Hole area have been done using Swedish Icebreaker Oden's EM 122 Multibeam Echo Sounder (MBES). Seafloor characterization analysis using Geocoder algorithm was undertaken to produce maps of seafloor surface and sub-surface sediment types. High resolution (30 m grid) bathymetric maps were also produced by combining Oden's MBES data with other MBES data from German icebreaker *Polarstern* to produce a detailed bathymetry of the area. Results from the MBES data processing were used to identify and delineate geomorphological features of submarine mass wasting events. Slump features were identified at the Molloy Hole valley whose source could be traced to sediment areas in the upper slope (~2500 m depth) that are adjacent to areas where gas hydrate systems have been known to occur. Seismic activities is believed to have triggered the mass wasting event, however, the presence of gas hydrate system in the area could have initially caused the sediment weakening. This information will be useful for identifying potential submarine geohazards in the area and in studying methane gas release processes from marine sediments.

G2–P8

DISTRIBUTION OF $CaCO_3$ UNDERSATURATED WATERS IN THE ARCTIC OCEAN, RECONSTRUCTED FROM HISTRICAL DATA

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Dissolution of anthropogenic CO_2 is making the ocean more acidic, making it difficult for marine biota to form their $CaCO_3$ shells and skeletons. It is known that surface and subsurface waters in the Canada Basin of the Arctic Ocean has already reached undersaturation with respect to aragonite-type $CaCO_3$. However, distribution of undersaturated water in the whole Arctic Ocean is not well known because carbonate chemistry data is limited. In this study, historical data of carbonate chemistry as well as other data such as temperature, salinity, nutrients and oxygen are used to reconstruct and draw a map of $CaCO_3$ saturation state throughout the Arctic Ocean. From this map, vulnerable regions to the ocean acidification in the Arctic ocean can be identified.

G2–P9

REDUCED SPACE 4DVAR TECHNIQUE AS A POTENTIAL TOOL FOR REANALYSIS AND OPERATIONAL HINDCAST IN THE ARCTIC OCEAN

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Reduced space four dimensional data assimilation (R4Dvar) is an efficient way to assimilate data without developing tangent linear and adjoint codes. The algorithm is based on interative minimization of the cost function in a sequence of low-dimensional subspaces, spanned by the leading EOFs of the ensembles derived from the model runs on each iteration. As it was shown before, the R4Dvar outperforms the conventional adjoint-based 4Dvar data assimilation technique in the case of assimilation into strongly non-linear models.
We illustrate performance of the R4Dvar in a series of twin-data assimilation experiments into diverse community models (MIT GCM, WAM, Canadian Ice, etc) and discuss potential advantages of the new data assimilation approach as a powerfull tool for reanalysis and operational hindcast.

G2–P10

SEDIMENTARY ORGANIC MATTER AND CARBONATE VARIATIONS IN THE CHUKCHI BORDERLAND IN ASSOCIATION WITH ICE SHEET AND OCEAN-ATMOSPHERE DYNAMICS OVER THE LAST 155 KYR

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Knowledge on past variability of sedimentary organic carbon in the Arctic Ocean is important to assess natural carbon cycling and transport processes related to global climate changes. However, the late Pleistocene oceanographic history of the Arctic is still poorly understood. In the present study we show sedimentary records of total organic carbon (TOC), $CaCO_3$, benthic foraminiferal $\delta^{18}O$ and the coarse grain size fraction from a piston core recovered from the northern Northwind Ridge in the far western Arctic Ocean. TOC shows orbital-scale increases and decreases during the past ~155 kyr that can be respectively correlated to the waxing and waning of large ice sheets dominating the Eurasian Arctic, suggesting advection of fine suspended matter derived from glacial erosion to the Northwind Ridge by eastward flowing intermediate water and/or surface water and sea ice during cold periods. At millennial scales, increases in TOC might correlate to a suite of Dansgaard-Oeschger Stadials between 120 and 45 ka BP indicating a possible response to abrupt northern hemispheric temperature changes. Between 70 and 45 ka BP, closures and openings of the Bering Strait could have additionally influenced TOC variability. $CaCO_3$ contents tend to anti-correlate with TOC on both orbital and millennial time scales, which we interpret in terms of enhanced sediment advection from the carbonate-rich Canadian Arctic via an extended Beaufort Gyre during warm periods and increased organic carbon advection from the Siberian Arctic during cold periods when the Beaufort Gyre contracted. We propose that this pattern may be related to orbital- and millennial-scale variations of dominant atmospheric surface pressure systems expressed in mode shifts of the Arctic Oscillation.

G4–P1

CHEMICAL COMPOSITIONS OF SOLUBLE AEROSOLS AROUND THE TERMINATION 1 IN THE NEEM ICE CORE

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The polar ice cores provide us with reconstruction of past atmospheric aerosols. Atmospheric aerosols such as dust and sea salt in both Arctic and Antarctic ice cores are well discussed by using the proxy of ion concentration/flux. Recently, studies on the chemical compositions of soluble aerosols in the ice cores have been carried out. The chemical compositions and transition of soluble aerosols in the Dome Fuji (Antarctica) has been revealed, however, there are few studies on those of soluble aerosols in Greenland ice cores. Using ice sublimation method [1], we analyzed the chemical compositions of soluble sulfate and chloride aerosols around the Termination 1 in the NEEM (Greenland) ice core.

We divided around Termination 1 into 4 stages by focusing on the temperature; Holocene, Younger Dryas (YD), Bølling-Allerød (B-A) and Last Glacial Period (LGP), and compared the mass ratio of sulfate and chloride aerosols in each stage. During the cold stage in YD and LGP, $CaSO_4$ accounted large percentage of soluble aerosols. On the other hand, during the warm stage in Holocene and B-A, Na-salt (Na_2SO_4 + NaCl) accounted large percentage of soluble aerosols. These relationships between chemical composition and temperature are probably related to $nssCa^{2+}$ concentration. The $nssCa^{2+}$ concentration in YD and LGP is more than 10 times higher than in Holocene and B-A in GRIP ice core [2]. We will discuss the relationship between $nssCa^{2+}$ concentration and chemical compositions of soluble salts in the presentation.

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G4–P2

EARLY TWENTIETH CENTYRY WARMING VEIWED FROM ARCTIC ICE CORES

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The Arctic has recently undergone drastic changes under global warming. In addition to the recent warming, significant warming was observed from the 1910s to the 1940s. Causes of the early twentieth century warming have not been clarified yet. Large natural variability makes it difficult to quantify the anthropogenic impacts on the Arctic climate and environment. To understand both natural and anthropogenic variability and its mechanisms, long-term climate data are required. Ice cores provide valuable information on the past climatic and environmental changes in the Arctic, where long-term meteorological observations have been very limited. Data from more than ten ice cores drilled by Japan and other nations are available for the past 100-200 years. In this report, ice core data available so far are reviewed, and the climatic variability reconstructed is discussed, to make the information available to the climatologists and modelers etc. Previous ice core studies show that there is large regional variability in temporal patterns of temperature, precipitation and anthropogenic air pollutants within the Arctic. Spatial and temporal variability of climate and environment during the past 100-200 years in the Arctic is discussed.

G4–P3

CONCENTRATION OF TRACE INORGANIC SPECIES IN SURFACE SNOW AT NEEM, GREENLAND

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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 snow and ice in Greenland. In this research, trace inorganic species (Br, Cl, F, I) in Greenland snow were analyzed.

The snow samples were collected from a pit dug at NEEM, Greenland (77°45'N, 51°06'W, 2500 m). The samples were transported to Japan without thawing. The quantitative analyses of elements were performed using an ion chromatograph mass spectrometer (IC-MS) and a quadrupole type inductively-coupled plasma mass spectrometer (ICP-MS). The IC-MS system consists of a single quadrupole type mass spectrometer (Agilent Technologies 6150) connected to an ion chromatograph (Dionex ICS-2000). 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 by this system.

Average and maximum concentrations of Br^- were 0.2 ng/ml and ca. 0.4 ng/ml, respectively. Average and maximum concentrations of I^- were 6 pg/ml and ca. 10 pg/ml, respectively. Further results and discussion about the behavior and origin of halogen ion species in snow will be presented.

G4–P4

The variability mechanism of precipitation amount in central Alaska

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A 180.17-m ice core was drilled at Aurora Peak in the central part of the Alaska Range, Alaska, in 2008 with the goal of reconstructing centennial-scale climate changes in the northern North Pacific. We analyzed stable hydrogen isotopes (δD) and chemical species in the ice core. The ice core age was determined by annual counting of δD seasonal cycles, and age control was provided by reference horizons of tritium peaks in 1963 and 1964, major volcanic eruptions of Mount Spurr in 1992 and Mount Katmai in 1912, and a large forest fire in 2004. The ice core record extends from 1734 to 2008. We estimated the annual accumulation rate using the seasonal cycle of δD and evaluated recent climatic changes in Alaska. In this contribution, we discuss the variability mechanism of precipitation amount in Alaska with chemical analysis of ice core and meteorological data.

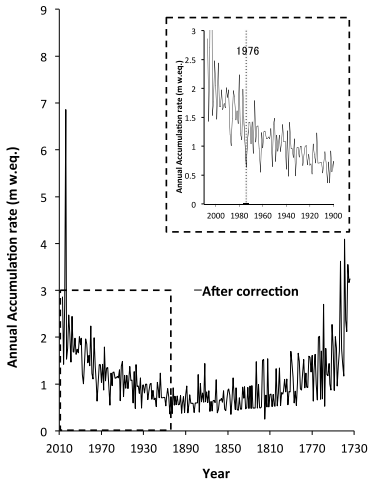

Fig. 1 Annual accumulation rate corrected by the Dansgaard-Johnsen model.

50-YEARS GLACIAL ENVIRONMENTAL CHANGE IN BENNETT ISLAND, SIBERIAN ARCTIC

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Rapid environmental change is seen in DeLong Archipelago, Siberian Arctic which is one of the most warming areas on the Earth. However, only one report described about the area based on the observation in 1980s.To quantitate glaciological change, the data of mass balance and ELA of Toll glacier in Bennett Island were analyzed as well as climate data at the vicinity. Most of mass balance of Toll glacier during 1967-2010 was negative and its cumulative mass balance is ca. -20m w.e., which is one of the largest changes in the arctic. ELA of Toll glacier may reach at 380m, which is the top of the ice cap, in 2020s. The negative mass balance trend is corresponding to warming trend in the arctic. The warming trend is correlated with both mass balance decreases of glaciers and sea ice distribution in the Siberian Arctic.

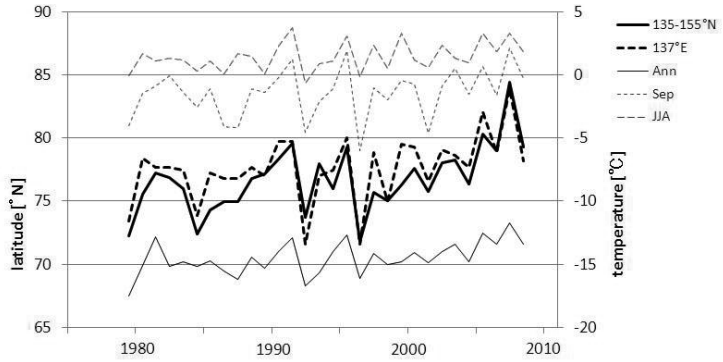

Figure 1.
Air temperature, southern end of sea ice in September and maximum SST at 76.4N, 148.9E.

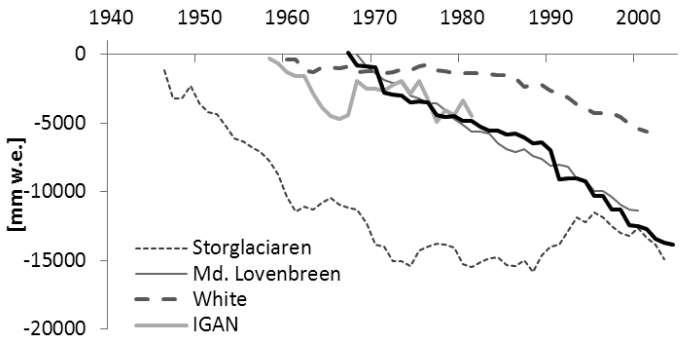

Figure 2.
Cumulative mass balance of Arctic glaciers

DNA ANALYSIS FOR SECTION IDENTIFICATION OF A PINE POLLEN GRAIN FROM THE BELUKHA GLACIER, ALTAI MOUNTAINS, RUSSIA

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Pollen taxon in sediment samples can be identified by analyzing pollen morphology. Identification of related species based on pollen morphology is difficult and is limited primarily to genus or family. Because many pollen grains in mid- and low-latitude glaciers contain protoplasm, genetic information of pollen grains should enable identification of plant taxa below the genus level. Such capability would be extremely useful for reconstructing information on past vegetation, climate, and environments in ice core studies. However, no studies have attempted detailed identification using DNA sequences obtained from pollen found in glaciers. As a preliminary step, the present study attempted to analyze the DNA of pine (*Pinus*) pollen grains extracted from surface snow collected from the Belukha glacier in the Altai Mountains of Russia in the summer of 2003. A 150-bp *rpoB* fragment from the chloroplast genome in each *Pinus* pollen grain was amplified by polymerase chain reaction, and DNA products were sequenced to identify them at the section level. A total of 105 pollen grains were used for the test, and sequences were obtained from eight grains. *Pinus* is a taxon with approximately 111 recognized species in two subgenera, four sections and 17 subsections. From the sequences obtained, the pollen grains were identified as belonging to section *Quinquefoliae*. Trees of the extant species *Pinus sibirica* in section *Quinquefoliae* are currently found surrounding the glacier. The consistency of results for this section suggests that the pollen in the glacier originated from the same *Pinus* trees found in the immediate surroundings.

NUMERICAL STUDY OF AEROSOL EFFECTS IN ARCTIC MIXED-PHASE CLOUDS VIA THE LIQUID PHASE

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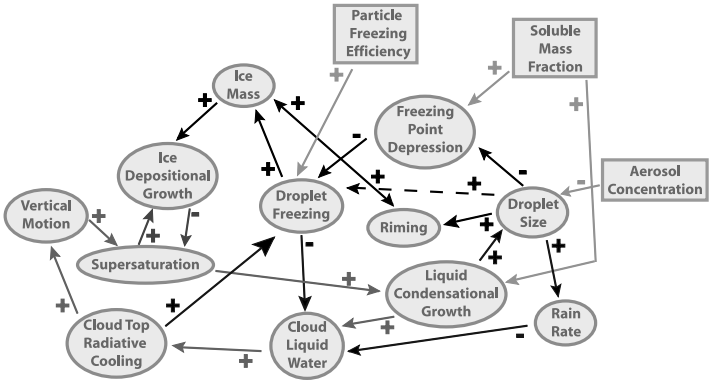
Mixed-phase stratiform clouds are commonly observed at high latitudes (e.g. Shupe 2011) and have significant impacts on the near-surface atmospheric energy budget. Observational and modeling studies (e.g. Harrington et al., 1999; Shupe et al., 2008) demonstrate strong connections between ice amount and cloud liquid lifetime. Active ice formation mechanisms in given atmospheric conditions are sensitive to aerosol properties. Arctic aerosol observations often reveal mixed particles containing both soluble and insoluble mass (Leaitch et al., 1984). Particle soluble mass fractions have been shown to be as high as 60-80% and are often made up of sulfates (Zhou et al., 2001; Bigg and Leck, 2001).

In this work, we present a model study focusing on aerosol impacts on liquid-dependent processes (e.g. droplet size distribution, droplet freezing, drizzle formation) in mixed-phase stratiform clouds. High-resolution simulations are based on a 12-hour period from the Surface Heat Budget of the Arctic (SHEBA) campaign. This time period was the focus of a recent GCSS-WMO mixed-phase stratiform cloud model intercomparison (Morrison et al., 2011) and simulations are completed using the University of Wisconsin Non-Hydrostatic Modeling System (Tripoli, 1992) in combination with advanced bin microphysics (AMPS, Hashino and Tripoli, 2008). We demonstrate the impact of aerosol properties (e.g. soluble mass fraction, concentration, freezing efficiency) on cloud lifetime, cloud water budget, and provide a general overview of the complex interactions between aerosols and liquid and frozen hydrometeors. Additionally, thoughts on the climatic relevance of these interactions will be discussed.



G7–P2

BJERKNES COMPENSATION AND ITS ROLE IN THE ARCTIC

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A vital component for maintaining Earth's climate is the meridional transport of heat through both the ocean and atmosphere, and understanding the decadal to multi-decadal changes of these transports can provide an insight into the natural variability of the climate system. In 1964, Jacob Bjerknes proposed that the total energy transported by the climate system should remain approximately constant if the ocean heat storage and fluxes at the top-of-the-atmosphere were unchanging. This would mean that large anomalies in the oceanic heat transport should be balanced by opposing variations in the atmospheric heat transport; a process later named Bjerknes Compensation.

Bjerknes compensation has been identified in the 600 year control run of the Bergen Climate Model by examining the anomalies of the implied meridional heat transports in both the ocean and atmosphere (Figure 1). These anomalies show strong anti-correlation ($r = -0.72$, $p \leq 0.05$), and a multi-decadal variability with a period of approximately 70 years. By regressing this Bjerknes Compensation signal onto maps of sea level pressure, we have identified a dipole pattern which results in strong meridional flow into the Arctic over the Greenland Sea. Similar regressions onto maps of sea ice concentrations, surface air temperatures, and ocean surface fluxes highlight part of the mechanism by which the compensation occurs through changes in the sea-ice cover. The anomalies in heat transport are found to be highly correlated ($r = 0.73$, $p \leq 0.05$) to the anomalies in Arctic sea-ice area.

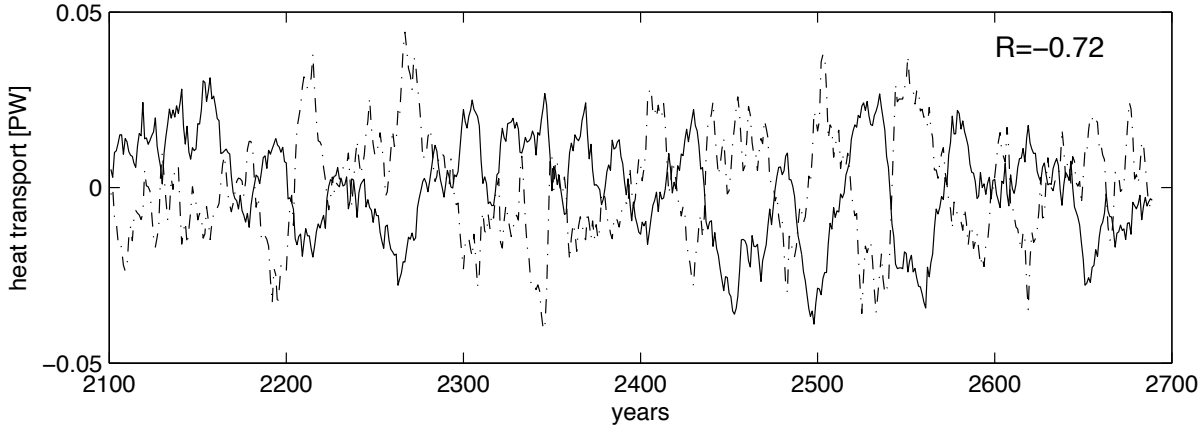

Figure 1: Meridional heat transport anomalies at 67N in the atmosphere (solid) and ocean (dashed), for the 600 year control run of the Bergen Climate Model. An 11-year running mean has been applied to highlight multi-decadal signals. The anomalies have a correlation of $r = -0.72$, $p \leq 0.05$.

G7–P3

The role of atmospheric circulation for sea ice on the Arctic by applying the CMIP3 model

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Recently the decreasing trend of sea ice extent (SIE) on the Arctic was observed and the record-low Arctic SIE was observed in September 2007. Using the NCEP/NCAR reanalysis dataset, Ogi and Wallace [2012] suggested the reason that the record-low Arctic SIE in September 2007 was lower than the SIE in September 2011 is the strong anticyclonic circulation over the Arctic which dominated in September 2007 and it isn't characterized in September 2011.

The purpose of our study is to research the role of atmospheric circulation that relates to the loss of sea ice by CMIP3.

Figure 1 shows the 925-hPa wind anomalies that regress the time series of sea ice area using CMIP3. This result shows the anticyclonic circulation over the Barents Sea and the cyclonic circulation dominating over the Laptev Sea. Furthermore it shows the flow of wind from the Chukchi Sea across the Arctic toward Fram Strait. This result is the similar pattern of atmospheric circulation that data analysis shown in Ogi and Wallace [2012].

We have analyzed that in the event of global warming, anticyclonic circulation influence decreasing the SIE or a rise in temperature by global warming influences anticyclonic circulation. We will also discuss the phenomenon influence to the mid-latitude includes Japan.

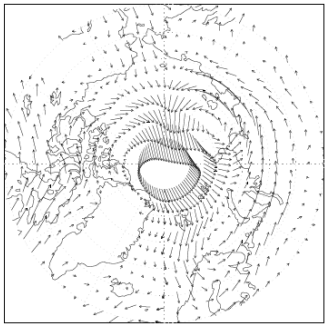

Figure 1: The 925-hPa wind anomalies that regress the time series of sea ice area in September by miroc3_2_medres (1979-2011) of CMIP3.

Influence of retreating sea ice on cloud cover over the Arctic Ocean during recent global warming period

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Sea ice area over the Arctic Ocean has been reducing in recent decades. Coupled atmosphere-ocean general circulation models (GCMs) also have simulated retreat of sea ice in 20th century simulations, although the reduction rate is not consistent with the observations. The Ice-Albedo Feedback is thought to have a main role in the Arctic Amplification (AA). On the other hand, the AA is affected by a feedback of downward longwave radiation at surface enhanced by an increasing cloud over the Arctic region. Observed cloud cover in the Arctic region during cold season (autumn-winter) increased due to the reduction of sea ice (e.g.,Liu*, et al.* 2012). Further, increase in cloud cover over the Arctic Ocean is related to the reduced sea ice in simulations with a GCM (Vavrus*, et al.* 2011). Therefore, understanding a relationship between the reduced sea ice and cloud cover change leads to unraveling a mechanism of the AA in the future. In this study, we investigated the relationship during recent global warming period in simulations with coupled GCM, MIROC5.

Resolution of atmosphere of the MIROC5 is T85L40, and the horizontal resolution of the ocean is approximately 1 degree. The detail of MIROC5 is described in Watanabe*, et al.* (2010). The current study used monthly mean data during 1976-2005 in 20th century simulations, in which reality-based greenhouse gas, aerosol, volcanic eruption and solar variation were prescribed.

In the simulation during 1976-2005, as the Arctic sea ice decreases with global warming, decreasing trends of sea ice area over the Arctic Ocean are found in all months. The maximum reduction of sea ice area occurs in September. On the other hand, the low-level cloud cover averaged over the Arctic Ocean increases during autumn-winter. The maximum occurs in October. In August, although retreat in sea ice appears to be similar to that in September, significant increasing trend in cloud cover is not found. From September, increasing trend of low-level cloud appears over girds with reduced sea ice. During autumn (September-November), surface air temperature increases more largely than the upper air temperature due to the reduced sea ice. Thus, stability of low-level atmosphere is weakened. This effect results in increase in low-level cloud. Also, surface water vapor increases with expanding open water surface. This can contribute to the increased low-level cloud cover.

Reference

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MODELING HIGH WIND EVENTS IN A REGIONAL ARCTIC SYSTEM MODEL

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As climate model resolution increases from the order of 100 km to the order of 10 km the details of high wind events, such as Greenland tip jets, are becoming increasingly well resolved in these models. Observations from these events indicate localized large heat, moisture, and momentum transfer between the atmosphere and underlying ocean or sea ice. To better understand the role of high wind events in forcing ocean and sea ice processes, such as deep ocean convection, a series of uncoupled and coupled model experiments have been designed. The model used for these experiments is the Regional Arctic System Model (RASM), based on the Weather Research and Forecasting (WRF) atmospheric model, the POP ocean model, the CICE sea ice model, the VIC land model, which will include dynamic vegetation, and the CISM ice sheet model.

Initial efforts to characterize the impact of increased resolution on high wind events has focused on several case study simulations of high wind events along the southeast coast of Greenland. In these experiments a stand-alone version of WRF was run with horizontal grid spacing of 100, 50, 25, and 10 km. The 10 km resolution simulations best matched available in-situ observations collected as part of the GFDex field campaign. For the 10 km simulation wind speeds were up to 150% greater, sensible heat fluxes were up to 340% greater, and latent heat fluxes were up to 225% greater than in the 100 km simulation. Multi-year WRF simulations on a large pan-Arctic model domain with horizontal grid spacing of 50 and 10 km have also been performed and the climatology of high wind events across this domain will be presented.

Future work will include stand-alone ocean-ice model simulations forced with ERA-Interim, WRF 50 km, and WRF 10 km atmospheric data. These simulations will be analyzed for differences in mixed layer depth and deep ocean convection occurrence. Finally, fully coupled RASM simulations at 50 and 10 km atmospheric model grid spacing will be performed and analyzed for feedbacks between the atmosphere, ocean, and sea ice during high wind events.

G7–P6

DEVELOPMENT OF AN ENSEMBLE DATA ASSIMILATION SYSTEM WITH WRF FOR THE LAND-ATMOSPHERE INTERACTION IN ARCTIC

Kazuyoshi Suzuki[1], Milija Zupanski[2]

1 RIGC/ JAMSTEC

2 CIRA/ Colorado State University

We are developing an ensemble data assimilation system with regional climate model WRF-ARW. This data assimilation system is focusing to reanalyze atmospheric and land components in Arctic. In this system, we employed the Maximum Likelihood Ensemble Filter (MLEF) (Zupanski, 2005) for the data assimilation method. In this presentation, we show the description of the system and a preliminary result from the developed data assimilation system.

G7–P7

LARGE SCALE VARIATIONS OF THE ENERGY-WATER BALANCE AT THE LAND SURFACE USING A WETNESS INDEX

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The large-scale distribution of energy-water balances at the surface has been examined by indirect measures, such as river discharge or evapotranspiration estimated from the atmospheric water budget. We attempted to examine the large-scale distributions and variations of the energy-water balances at the land surface using a wetness index (WI), calculated as a ratio of precipitation to potential evaporation, on annual basis. A global gridded precipitation data (GPCC) and a reanalysis data (NNRP), to calculate the potential evaporation from the energy-water balance equation, were used.

The global distribution of WI climatology from 1951-2010 (Fig. 1) agree well with the climate zones of wet and dry, as indicated in Xu et al. (2005). The interannual changes in WI had strong positive correlation with precipitation in all regions over the globe. It reveals that small changes in precipitation could result in large changes in WI in high latitudes (Fig. 2).

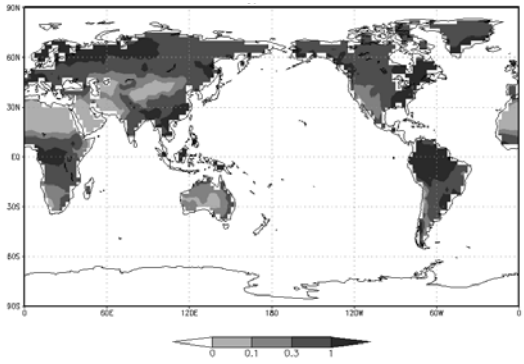

Fig. 1 Climatology of annula WI.

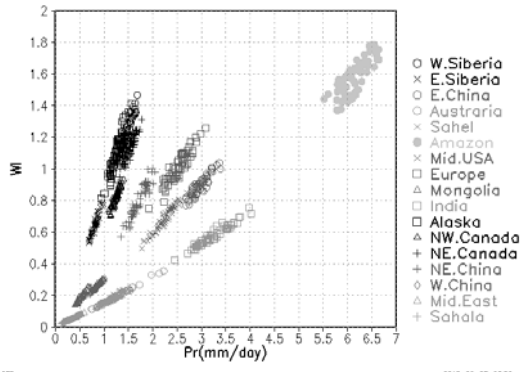

Fig. 2 Correlation between annual WI and precipitation for 1971-2010.

Reference: Xu et al. (2005) Hydrol. Processes, 19,2161-2186.

Acknowledgements: This study is partly supported by the GRENE project for Arctic Climate Change.

SEA ICE VARIABILITY IN THE BARENTS SEA BRINGS ARCTIC WARMTH AND CONTINENTAL COLD

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Warm Arctic and cold Siberia conditions are often observed in pairs in recent winters, and a linkage to global warming has been received increasing attention. In this study, we focused on the wintertime cyclonic activity in the Barents Sea, where the Arctic warming is the most evident, and investigated changes in cyclone tracks in response to the sea-ice variability, as well as their effects on the Arctic warming and Siberian cold. The results showed that cyclone tracks tend to shift northward from Siberian coast toward the Arctic Ocean under the reduced sea-ice extent in the Barents Sea in winter. The resultant distribution of SLP facilitates warm advection over the Arctic Ocean; whereas over Siberia and the Norwegian coast, it creates conditions inducing cold anomalies (Fig. 1). This warm-Arctic cold-Siberian (WACS) anomaly could be one of causes for severe winter in the downstream region.

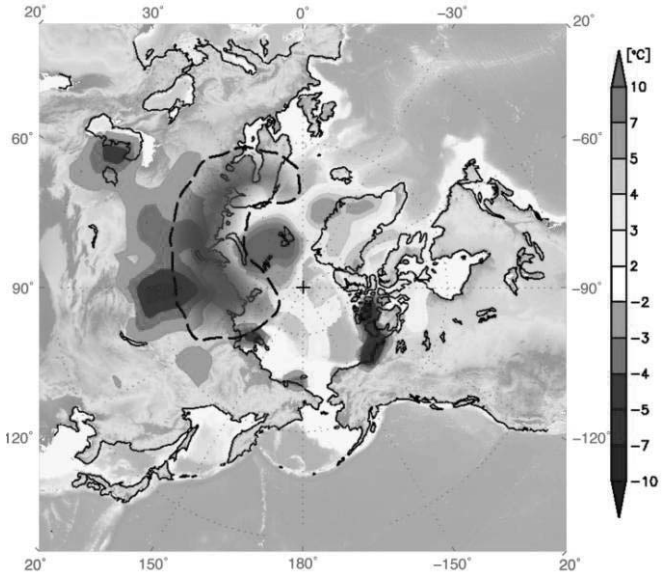

Figure 1: Surface air temperature in relation to the WACS anomaly (shading). The area enclosed by the dashed line indicates anomalously high pressure (hPa).

* Inoue, J., M. E. Hori, and K. Takaya (2012), The role of Barents Sea ice in the wintertime cyclone track and emergence of a warm-Arctic cold-Siberian anomaly, *J. Climate*, 25, 2561-2568. !

S1–P2

CONTRIBUTION OF FROZEN HILLOCKS TO METHANE EMISSION FROM WEST SIBERIAN TUNDRA MIRES

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Methane is the most important greenhouse gases after water vapor and carbon dioxide. Mires are the largest natural source of methane. West Siberia tundra zone gains the especial importance in this regard as the greatly paludified region with the mires covering 29% of this territory. Nevertheless, our knowledge about methane fluxes from tundra frozen hillocks is still incomplete. For this purpose detailed investigation of methane emission from frozen hillocks in tundra zone was organized. Totally about 350 methane fluxes varied from -0.18 to 8.90 mgC-$CH_4 \cdot m^{-2} \cdot h^{-1}$ were measured by a static chamber method during 2010-2011 summer periods.

Statistical characteristics of methane emission probability distributions obtained for each microlandscape type are given in Table. It was revealed that frozen hillocks (Palsa) have the lowest methane fluxes. Obtained data were generalized into the spatial emission model (the model is based upon a fractional area coverage map of mire micro-landscapes, methane flux probability distributions for each micro-landscape type and methane emission period). Version Bc9 of the model estimates total methane flux from West Siberia tundra mires at 109.7 kTC-$CH_4 \cdot yr^{-1}$ that accounts for about 4% of the total methane emission from West Siberia mires. Fens were revealed as the most significant methane source from tundra bogs contributing for about 98% of the regional flux from this territory.

Table. Statistical characteristics of methane emission probability distributions (mgC-$CH_4 \cdot m^{-2} \cdot h^{-1}$) in different West Siberia tundra microlandscapes

Microlandscape type	*Mean*	*Standard deviation*	*Median*	*1st quartile*	*3rd quartile*
Open bogs	0.16	0.26	0.03	-0.01	0.28
Poor fens	1.99	1.78	1.42	0.41	3.38
Fens	1.30	1.12	0.96	0.76	1.53
Palsa	0.13	0.29	0.06	-0.01	0.17
Peat mats	2.21	1.40	2.42	0.99	3.24
Wetland lakes	0.52	0.54	0.27	0.15	0.57

We compared flux data from the most wide spread microlandscapes as frozen hillocks and fens with data obtained by other authors over the whole Eurasian tundra. Comparison showed that differences in methane emission rates are insignificant and can be caused by the interannual variability and different ecological and climatic conditions. Evaluation of different variability types including spatial and temporal variability showed that the uncertainty of obtained flux is close to the theoretically expected rate.

Acknowledgements. Authors thank all participants of field expeditions: Dr. A.G. Bashchuk, B.V. Baharev, V.S. Kazantsev, P.A.Nikitich and T.V.Raudina. Authors express their gratitude to Prof. A.V. Naumov for scientific discussion and help in gas sample analysis.

S1–P3

THE RELATIONSHIP BETWEEN ARCTIC OSCILLATION AND ARCTIC WARMING IN RECENT DECADES

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Climate change associated with recent global warming is most prominent in the Arctic and subarctic. Nagato and Tanaka (2012) calculated the EOF of surface air temperature (SAT) in winter (DJF) and showed that the AO pattern appeared in EOF-1 and Arctic warming patter appeared in EOF-2. In this study, we explore statistically the association between EOF components and climate systems (e.g. sea ice, snow cover, and water vapor).

The linear trend of SAT is positive over Arctic Ocean and negative over north Siberia in recent 20 years. The positive trend over Arctic Ocean has peaks around Greenland and Barents Sea. We consider that warming around Greenland and cooling over north Siberia are characterized by the negative AO index trend in this period. Meanwhile, the positive trend over Barents Sea is caused by sea ice reduction in summer and delay of sea ice recovery in winter (Screen and Simmonds 2010, GRL).

Figure 1 shows the spatial distribution of sea ice cover in September regressed with AO index. This pattern appears when AO index indicate +1σ. This

pattern shows that sea ice over Barents Sea, Svalbard, and Greenland Sea in September increase during recent 20 years because the AO index indicates negative trend. We will explore association between other climate systems and EOF components, and present at the symposium.

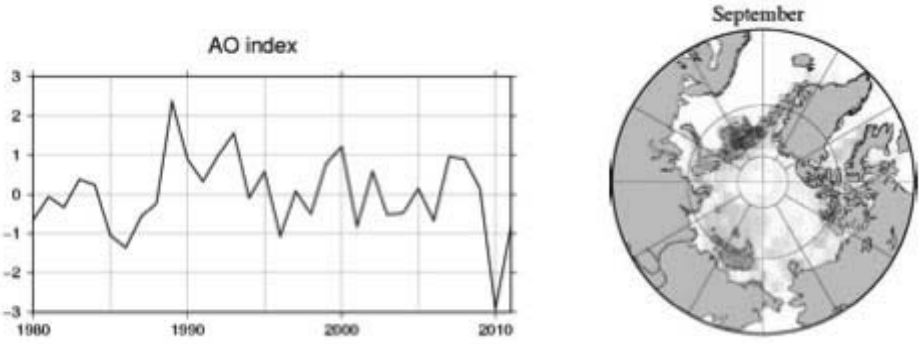

Figure 1. The DJF mean AO index during 1980-2011 (left) and sea ice cover in Septempber regressed with AO index (right). Solid lines show increase zone and dashed lines show decrease zone in right figure.

S1–P4

Abrupt Climate Changes and Emerging Ice-Ocean Processes in the Pacific Arctic Region and the Bering Sea

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The purpose of this study is to reveal several emerging physical ice-ocean processes associated with the unprecedented sea ice retreat in the Pacific Arctic region (PAR). These processes are closely interconnected under the scenario of diminishing sea ice, resulting in many detectable changes from physical environment to ecosystems. Some of these changes are unprecedented and have drawn the attention of both scientific and societal communities. More importantly, some mechanisms responsible for the diminishing sea ice cannot be explained by the leading Arctic Oscillation (AO), which has been used to interpret most of the changes in the Arctic for the last several decades. The new challenging questions are: (1) What is the major forcing? (2) Is the AO, the DA, or their combination, contributing to the sea ice minima in recent years? How do we use models to investigate the recent changes in the PAR. Is the heat transport through the Bering Strait associated with the DA? What processes accelerate sea ice melting in the PAR?

S4–P1

USING BIG DATA, SCENARIOS DEVELOPMENT, AND GAME THEORY TO MONITOR, UNDERSTAND AND ADAPT TO CLIMATE CHANGE IN THE CIRCUMPOLAR ARCTIC

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Adaptation to climate change in the circumpolar Arctic requires strategic and innovative approaches. One of the major adaptation challenges in the circumpolar Arctic is engagement and making effective societal decisions to adapt to climate and other global changes at local and regional scales. Complexity and uncertainty around climate and other changes make existing analysis and governance approaches inadequate. Hierarchical and simplistic decision making will not be successful, given the expanding and exponential nature of change and information, and increasing expectations of participation. The Nordic Centre of Excellence for Strategic Adaptation Research, along with the Arctic Institute of North America , is exploring the use of big data analytics, scenarios development approaches, and games theory to engage the local residents, industry, government and the external stakeholders in monitoring, understanding and adapting to climate change throughout the circumpolar Arctic. As the amount of data and information increases, how that data is analyzed and informs and supports decision making becomes increasingly important. Scenarios are stories that describe a possible future, and building and using scenarios allows an exploration what the future may look like, and preparation for change. Games theory is the study of strategic decision making, and games provide alternative means of sharing information and knowledge and participating in decision making. The research compares and contrast specific examples of big data analytics, scenarios development approaches, and games to evaluate their successes in engaging all these actors in monitoring, understanding and adapting to climate change. Based on the research and these examples, recommendations are made for future uses of big data, scenarios and games theory.

S6–P1

RADIOCESIUM IN THE SEDIMENTS OF THE RUSSIAN ARCTIC SEAS

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Various areas of Russian Arctic seas such as Novaya Zemlya, Yenisei Gulf and Ob Gulf were exposed to significant emission of radioactive nuclides. The purpose of this research study is to identify the characteristics of marine sediments, which determine the accumulation of radiocesium as result of statistical analyses. The study was based on the material collected by different international expeditions from 1993 to 2009 year.

Since 1950 the concentration of radiocesium originating from nuclear weapon tests in atmosphere and under water, and also due to the Chernobyl accident, have undergone radioactive decay and decline of its activity. Local anomalies in sediments are found only in bays and near the mouth of nuclear fleet, and in the estuaries of the Siberian rivers. They are radioactive discharge effluents.

In our study we tried to find out what factors affect the spatial distribution of radiocesium in the shelf zone of the Arctic seas of Russia. Hydrological and hydrochemical characteristics of bottom water, grain and componentwise composition of sediments were examined. During the multiple stepwise non-linear regression analysis, the following factors were founded: average diameter of sediment particles (median), mm; the content of gallium in the pelitic fraction of sediments, ppm; content of feldspar in sediments, %. The influence of median on the content of radiocesium may be explained by the fact that with decreasing size of soil particles increases the specific absorption surface. With respect to the other two parameters further research is necessary. The only difference is that the content of feldspar suggests the following. The content of this mineral determines the structure of bottom sediments, which is indirectly manifested in their absorptive capacity. Gallium is a rare-earth metals, its distribution in marine sediments may indicate a general migration process elements. In the suspended matter of rivers carries up to 99% Ga.

KOLYMA WATER BALANCE STATION – UNIQUE RESEARCH STATION IN THE ZONE OF CONTINUOUS PERMAFROST: HALF CENTURY HISTORY AND FUTURE PERSPECTIVES

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The Kolyma Water Balance Station (KWBS), 21.2 km2, was found in 1948 in the upper Kolyma River basin in the zone of continuous permafrost with mountainous relief. Soil thaw depth varies from 20 cm in bogged lowlands to more than 3 m at south-oriented rocky slopes. Landscape conditions and runoff regime of the KWBS are representative for vast territories of the North-Eastern Russia.

The measurements of runoff, water-balance components, evaporation from soil, water and snow surfaces, ground freezing and thawing depths at different landscapes were conducted. There were more than 30 ground thawing observational sites, 26 precipitation gauges, seven discharge gauges, two water balance plots. The data of long-term measurements was supported by detailed description of natural conditions enabling to study the interactions of particular hydrological processes with landscape components.

Since 1997 the research watershed doesn't exist as previously. Only discharge and standard meteorological observations have been conducted.

Collected for more than 50 years data are invaluable for building and testing the models of different types: runoff formation, climatic, environmental, vegetation dynamics. There is an urgent need to restart the studies at the Kolyma station due to increased interest to natural processes of the Arctic. The KWBS data if prolonged could become effective indicator of climate changes and the basis for the study of their impact on state of permafrost and hydrological regime.

The attention of international scientific community to unique research station with long and rich history could help to rebuild it and continue the mission of science.

Visible Remote Sensing Information for Snow Monitoring

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The launch of advanced instruments onboard of new operational and research satellites greatly improves the potential of mapping and monitoring snow cover. Increasing spectral coverage of the data and frequency of observations allows for more accurate snow cover detection and timely identification of changes in the snow pack properties. A higher spatial resolution of satellite observations provides better opportunity for a much more detailed characterization of the snow cover distribution needed for various applications. As a result of the advancement in remote sensing, the information on snow cover from satellites is being increasingly used not only in global and continental-scale studies but also in regional and local scale investigations. Snow monitoring to a great degree depends on using visible channels even though such data of satellite observations could have significant gaps.

The advance in snow remote sensing is accompanied by increasing requirements to snow products – resolution finer than 1 km, snow fraction in addition to snow extent, a wider range of snow properties. To meet those growing requirements, improved retrieval algorithms and snow models should be developed for visible spectral bands.

A promising direction to create automatic snow retrievals of improved quality is developed by the author of the presentation and implemented in several algorithms. The algorithms were accepted to retrieve all the Visible Infrared Radiometer Suite (VIIRS) snow products in NOAA and have been successfully used to routinely generate daily global maps of snow cover fraction from the Moderate Resolution Imaging Spectroradiometer (MODIS) at GSFC/NASA.

Proper validation is a critically important means to develop snow cover retrieval. Daily snow depth data acquired from more than 1000 World Meteorological Organization (WMO) stations and approximately 1500 US Cooperative stations are currently used to estimate the accuracy of snow derivation from daily VIIRS observations. Another method implemented to analyze the performance of snow algorithms utilizes high-resolution observations as an effective source of ground truth information for snow fraction.

To further improve processing of satellite observations on snow, the strategy characterized by the following distinguishing features is currently under development. Creating snow algorithms, first of all, it is proposed to derive scene-specific (or even pixel-specific) parameters characterizing local properties of snow and non-snow endmembers. The application of such approach requires adjustment of algorithms to varying regional conditions.

Another opportunity to improve snow retrieval is related to the use of snow BRDF models. It has been demonstrated that the means of geometric optics could reliably describe angular dependencies related to bidirectional snow reflectance, and a simple asymptotic analytical model could be used to calculate bidirectional reflectance. Possible applications of the asymptotic analytical BRDF model for remote sensing include sensor calibration, calculating snow albedo, normalizing reflectances, and retrieval of snow grain size needed, in particular, for microwave observations on snow.

The combination of scene-specific algorithms with analytical BRDF model and synergy of remote sensing retrieval algorithms with conventional observations will help create unbiased and consistent information on snow cover.

S4-O13

THE INTIERNATIONAL STUDY OF ARCTIC CHANGE: PROVIDING TIMELY, RELEVANT AND ACCESSIBLE SCIENTIFIC INFORMATION FOR RESPONDING TO ARCTIC CHANGE

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The International Study of Arctic Change is an internationally supported program of arctic environmental change research with the overall objective of providing timely, relevant and accessible information for responding to rapid arctic change. ISAC works to enable the research community to transcend national limitations and to enhance arctic research within an international framework. Recent and continuing changes across all components of the Arctic System are having significant impacts on the natural, the human, and the built environment; and these changes are influencing domestic policies and international relations. Future system states are uncertain and the lack of predictability hinders efforts to develop strategies for adapting to and managing a changing Arctic. ISAC provides an overarching framework to integrate diverse programs and projects with the common goals of observing, understanding and responding to arctic environmental change. The ISAC Science Plan provides a vision for integrating research among diverse fields and varied users and stakeholders. This paper focusses the implementation of ISAC, including responding to change initiatives and the inaugural 2013 Arctic Observing Summit, which aims to provide community-driven, science-based guidance for the design, implementation, coordination and sustained long-term (decades) operation of an international network of arctic observing systems within the framework of the Sustaining Arctic Observing Networks (SAON) initiative.

G7-P8

Toward Hierarchical Modeling and Prediction of the Arctic Climate System

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Arctic sea ice is a key indicator of the state of global climate because of both its sensitivity to warming and its role in amplifying climate change.
Accelerated melting of the perennial sea ice cover has occurred since the late 1990s, which is important to the pan-Arctic region, through effects on atmospheric and oceanic circulations, the Greenland ice sheet, snow cover, permafrost, and vegetation as well as it affects the global surface energy and moisture budgets, atmospheric and geosphere-biosphere feedbacks.

We evaluate available results from CMIP5 models against limited observations for their skill in representing recent decadal variability of Arctic sea ice area, thickness, drift and export. We also intercompare results from CMIP5 models with selected CMIP3 models and a hierarchy of regional ice-ocean and fully coupled climate models to demonstrate possible gains or outstanding limitations in representing physical processes of potential importance to past and present climate variability in the Arctic. We argue that the limited ability of global models to realistically reproduce some of the critical processes affecting recent warming and sea ice melt in the Arctic Ocean distorts predictability of EaSMs and limits the accuracy of their future arctic and global climate predictions. To better understand the past and present states and estimate future trajectories of Arctic sea ice and climate, we argue that it is critical to advance hierarchical arctic regional climate modeling and coordinate it with the design of an integrated Arctic observing system to constrain models.

Organized by

National Committee of IASC, Subcommittee for International Affairs,
Committee on Earth and Planetary Sciences, Science Council of Japan
Japan Consortium for Arctic Environmental Research (JCAR)