Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

ACG37-01 Room:106 Time:May 22 09:00-09:15

START OF NEW ARCTIC CLIMATE RESEARCH PROJECT

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1.ARCTIC CLIMATE RESEARCH

New Japanese Arctic Climate Research Program has started. This program targeted understanding and forecasting ”Rapid Change of the Arctic Climate System and its Global Influences”.This arctic climate research program is realized by the frame of GRENE (GReen Network of Excellence) project of Ministry of Education, Culture and Sports (MEXT). As the network of s universities and institutions in Japan, this 5-years program involves more than 200 scientist from 35 institutions and universities.

2.JAPANESE ARCTIC ENVIRONMENTAL RESEARCH CONSORTIUM (JCAR)

Arctic researches have been carried out by many individual scientist and small groups for long time. Through the discussions on new movement of Arctic science, new functions of scientific community was recommended, then ”Japanese Consortium for Arctic Environmental Research (JCAR)” was established in May 2011. Almost 300 members joined this consortium and started new discussions on the Arctic science.

For more details, please visit

Arctic Climate Research Project: http://www.nipr.ac.jp/grene/

JCAR: http://www-arctic.nipr.ac.jp/web_HKKC/HKKC_top/index.html

Keywords: Arctic, Climate, Project, onsortium

Japan Geoscience Union Meeting 2012
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ACG37-02 Room:106 Time:May 22 09:15-09:30

International promotion of Arctic Environmental Research

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This presentation will discuss about the recent conditions of research plans and international promotion of Arctic Environmental Research.

Keywords: Arctic Environmental Research, International promotion

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ACG37-03 Room:106 Time:May 22 09:30-09:45

Arctic Data archive System(ADS)

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

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

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

Keywords: Arctic, Environment, Global Warming

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ACG37-04 Room:106 Time:May 22 09:45-10:00

Arctic Satellite Remote Sensing Real-Time and Archived Data for Environmental and Climate Research and Operations

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The Geographic Information Network of Alaska (GINA) at the University of Alaska Fairbanks' (UAF) International Arctic Research Center receives, archives, and distributes in near-real-time satellite data for the Arctic region. The millions of images and data products stored at GINA provide an important tool for long-term environmental studies and as a baseline for climate change detection. GINA operates its own X-band receiving station for MODIS data and the newly launched US NOAA Suomi NPP satellite. MODIS and NPP VIIRS sensor data are processed and delivered in near-real-time and provide valuable support for wildfire, volcanic eruption, sea ice, and ship operations. GINA partners with the NOAA/NESDIS Fairbanks Command and Data Acquisition Station to receive MODIS, AVHRR, DMSP, Landsat, and other satellite data. Landsat 8 and GOES-R data will be captured and processed in the future under this partnership, as well. This presentation will describe environmental and imagery satellite data sets available from the University of Alaska GINA program. The presentation will also highlight ongoing wildfire, sea ice, volcano, and hydrology research outcomes using this data that have been achieved by Japanese and American researchers working together at the UAF International Arctic Research Center.

Keywords: arctic, remote sensing, Alaska, near-real-time data, environmental research, climate research

Japan Geoscience Union Meeting 2012
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ACG37-05 Room:106 Time:May 22 10:00-10:15

The Arctic: A New Frontier

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The Arctic is a new frontier in science, transportation, natural resources, and international politics. In particular, the Arctic is a treasure house of natural science. There are many fascinating phenomena that need intense, explorative research, such as the aurora, noctilucent clouds, the ozone hole, Arctic oscillation, sea ice, glaciers, tundra, and permafrost.
The Arctic is sensitive to climate change and environmental changes, presenting an ideal region for examining future changes.

As the Arctic sea ice seems to be receding, the Northeast Passage sea route may become operable in the future, and the exploration of oil and natural gas may begin soon. Unlike the Antarctic continent, there is so far no international treaty on territorial and resource claims yet, though many countries aside Japan are active on this issue.

Keywords: Arctic, Frontier

Japan Geoscience Union Meeting 2012
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ACG37-06 Room:106 Time:May 22 10:45-11:00

Spectral albedos of glacier surfaces covered with glacial microbes in northwestern Greenland

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Snow and ice in the Arctic are presently undergoing drastic changes. The mass balance loss from the Greenland Ice Sheet increased significantly after the mid-1990s. One of the possible reasons of snow/ice surface melting is due to the increases of light absorbing impurities in snow/ice and snow grain size. This is because the surface albedo of snow (ice) is strongly controlled by mass concentration of light absorbing impurities including glacial microbes and snow (ice) grain size. To clarify this we carried out the spectral albedo measurements on ablation area in Qaanaaq Glacier in northwestern Greenland in July 2011. The almost glacier surfaces in the ablation area were covered with cryoconite (biogenic dust) on ice grain layer with the size of 1 to 2 centimeters and the several-centimeter depth above bare ice. There were also cryoconite holes (a water filled cylindrical melt-holes with cryoconite on the bottom), red snow (snow algae) and rivulets in some parts of the glacier surfaces. We measured the spectral albedos of the glacier surfaces using a spectrometer FieldSpecr3 (ASD Inc., USA) for a spectral range from 350 to 2500 nm. The target surface conditions are comparatively homogeneous cryoconite, bare ice, and red snow. The measured spectral albedos had a remarkable contrast between red snow surface and ice surface covered with cryoconite mainly for the ultraviolet to visible regions (350-750 nm), where red snow albedo increased rapidly with the wavelength, while cryoconite surface albedo was relatively flat. The spectral albedos of cryoconite surface in the spectral domain from 1000 to 1400 nm were higher than that for the underlying bare ice. This is due to light scattering by ice grains, on which the cryoconite covers, above the bare ice. We also simulated the spectral albedos of cryoconite surface and red snow surface with a radiative transfer model for the atmosphere-snow system. The snow grains are assumed to be spherical particles with the size of several millimeters and the ice grains are non-spherical particles with the size of several tens millimeters. Those grain sizes are based on in-situ measured values. For the effects of snow impurities of cryoconite and snow algae (red snow), we simply assumed the optical properties of mineral dust of in-situ measured mass concentrations with external mixtures. The theoretically calculated albedos were higher than the measurements for the spectral region less than 750 nm for both cases of cryoconite and red snow. The differences would be the effects of glacial microbes.

Keywords: albedo, glacial microbes, Greenland, snow grain size, cryoconite, radiative transfer model

Japan Geoscience Union Meeting 2012
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ACG37-07 Room:106 Time:May 22 11:00-11:15

Results of the SeaRISE numerical experiments with the model SICOPOLIS for the Greenland ice sheet

GREVE, Ralf[1*]

[1]Hokkaido University

SeaRISE (Sea-level Response to Ice Sheet Evolution) is a multi-model community effort to predict the likely range of the contribution of the Greenland and Antarctic ice sheets to sea level rise over the next few hundred years under global warming conditions. The Japanese ice sheet modelling community is contributing to SeaRISE with three large-scale, dynamic/thermodynamic models: SICOPOLIS, IcIES and Elmer/Ice. Here, results for the Greenland ice sheet obtained with SICOPOLIS are discussed under the forcings (surface temperature and precipitation scenarios) defined by the SeaRISE effort. A crucial point for meaningful simulations into the future is to obtain initial conditions that are close to the observed state of the present-day ice sheet. This is achieved by proper tuning during model spin-up from the last glacial/interglacial cycle to today. Experiments over 500 years into the future investigate the sensitivity of the ice sheet to changed conditions at the ice surface (future climate warming), the base (increased basal sliding) and the margin (increased melting of marine ice fronts).

Keywords: Greenland, Ice sheet, Climate change, Sea level rise, Modelling

Japan Geoscience Union Meeting 2012
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ACG37-08 Room:106 Time:May 22 11:15-11:30

Simulations of the Greenland ice sheet 200 years into the future with the full Stokes model Elmer/Ice

SEDDIK, Hakime[1*], GREVE, Ralf[1], Thomas Zwinger[2], Fabien Gillet-Chaulet[3], Olivier Gagliardini[3]

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The full Stokes thermo-mechanically coupled model Elmer/Ice is applied to the Greenland ice sheet. Elmer/Ice employs the finite element method to solve the full Stokes equations, the temperature evolution equation and the evolution equation of the free surface. The general framework of this modeling effort is a contribution to the Sea-level Response to Ice Sheet Evolution (SeaRISE) assessment project, a community-organized effort to estimate the likely range of ice sheet contributions to sea level rise over the next few hundred years (http://tinyurl.com/srise-lanl, http://tinyurl.com/srise-umt).

The present geometry (surface and basal topographies) is derived from data where the basal topography was created with the preservation of the troughs at the Jakobshavn Ice Stream, Helheim, Kangerdlussuaq and Petermann glaciers. A mesh of the computational domain is created using an initial footprint which contains elements of 5 km horizontal resolution and to limit the number elements on the footprint while maximizing the spatial resolution, an anisotropic mesh adaptation scheme is employed based on the Hessian matrix of the observed surface velocities. The adaptation is carried out with the tool YAMS and the final footprint is vertically extruded to form a 3D mesh of 320880 elements with 17 equidistant, terrain-following layers.

The numerical solution of the Stokes and the heat transfer equations employs direct solvers with stabilization procedures. The boundary conditions are such that the temperature at the surface uses the present-day mean annual air temperature given by a parameterization or directly from the available data, the geothermal heat flux at the bedrock is given by data and the lateral sides are open boundaries. A non-linear Weertman law is used for the basal sliding.

Results for the SeaRISE 2011 sensitivity experiments are presented so that seven different experiments have been conducted, grouped in three sets. The Set C (three experiments) applies a change to the surface precipitation and temperature, the set S (three experiments) applies an amplification factor to change the basal sliding velocity and the Set T (one experiment) combines the forcings. The experiments are compared to a constant climate control run beginning at present (epoch 2004-1-1 0:0:0) and running up to 200 years holding the climate constant to its present state.

Relative to the control run, the experiments with the changes to the surface precipitation and temperature (Set C) show a contribution to sea level rise of ˜5 cm SLE when a factor 1x is applied to the temperature and precipitation anomalies. A factor 1.5x produces a sea level rise of ˜10 cm SLE and a factor 2x produces a sea level rise of ˜20 cm SLE. The experiments with the amplification factor applied to the basal sliding velocity (Set S) show higher sensitivities. The scenario with an amplification factor of 3x produces a Greenland contribution to sea level rise of ˜70 cm SLE. An amplification factor of 2.5x produces a contribution of ˜46 cm SLE and an amplification factor 2x produces a contribution of ˜26 cm SLE. The combo run (factor 1x applied to the temperature and precipitation anomalies in combination with the doubling of the basal sliding) produces a contribution of 31 cm SLE.

Keywords: ice sheet, modeling, Greenland, SeaRISE

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ACG37-09 Room:106 Time:May 22 11:30-11:45

Factors of variation of glacier equilibrium line in mountainous area of Eastern Siberia

TAKAHASHI, Shuhei[1*]

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Around Suntar-Khayata region in eastern Siberia, about 180 glaciers distributed in mountainous area. In tihis ara, temerature change by global warmin is large and the glaciers are good index of global warming. Factors of glacier formation (temperature, precipitation, solar radiation, wind-speed/dorection, drifting snow and so on) were examined for the response on glacier equlibriumu line altitude ELA).

Keywords: Siberia, glacier, Equlibrium Line Altitude

Japan Geoscience Union Meeting 2012
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ACG37-10 Room:106 Time:May 22 11:45-12:00

Intra-annual variabilities of a subarctic river flux by monitoring: the Yuokon River, Alaska

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The monitoring of discharge,sediment load, POC flux and PON flux was conducted at the lowest USGS gauging station of the Yukon River, Alaska for more than three years. The breakup of the covered ice has ever made it difficult to monitor such river fluxes. However, our monitoring allowed us to estimate the contribution of snowmelt runoff to annual discharge, sediment load, POC flux and PON flux. As a result, the snowmelt runoff for about 40 days accounts for 20 - 25 % of annual discharge, sediment load, POC flux and PON flux of the Yukon.

Keywords: Yukon River, Glacier-melt, Rainfall runoff, Permafrost, Snowmwlt runoff

Japan Geoscience Union Meeting 2012
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ACG37-11 Room:106 Time:May 22 13:45-14:00

Changes of permafrost thawing determined from long-term streamflow measurements of the Lena River, Eastern Siberia

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Permafrost has been reported to be degrading at increasing rates over wide areas in northern regions of Eurasia and North America; the evidence has come mainly from in situ observations in the soil profile, which have limited spatial and invariably limited temporal coverage. Herein two types of methods are proposed to relate low river flows (or baseflows) during the open water season with the rate of increase of the active groundwater layer thickness resulting from permafrost thawing at the scale of the upstream river basin. The methods are tested with data from four gaging stations within the Lena River basin in Eastern Siberia, one in the Upper Lena basin, and three in two of its tributaries, namely the Olyokma and the Aldan basins. The different results are mutually consistent and suggest, that over the 1950-2008 period the active layer depth has been increasing at average rates roughly of the order of 0.3 to 1 cm a^{-1} in the areas with discontinuous permafrost and at average rates about half as large in colder more eastern areas with continuous permafrost. These rates have not been steady but have been increasing; thus it appears that in the earlier years over the period 1950-1970, some large regions have not been undergoing permafrost thawing and probaly even accretion, whereas from the 1990's onward large areas have experienced average thawing rates as large as 2 cm a^{-1} and some, especially those with continuous permafrost, even larger.

Keywords: Permafrost, thawing, Eastern Siberia, Lena River

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ACG37-12 Room:106 Time:May 22 14:00-14:15

Changes in the growth-climate relationship of larch trees in eastern Siberian taiga over the past 100 years

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Dendrochronological studies in high-latitude region focused on the positive growth of trees to warmth (D'Arrigo and Jacoby, 1993). From these results, it had been expected that warming would lead to more tree growth, better survival of individuals and ultimately expansion of trees in tundra. However, from middle of 20th century positive sensitivity of trees growing in northern high-latitude to temperature has declined (Briffa et al., 1998) and temperature induced drought stress may limit radial growth of trees (Barber et al., 2000). That is, trees growing in high-latitude region like as east Siberian taiga are on water stress and moisture condition is likely to be limiting factor for tree growth (Kagawa et al., 2003). Here, we report an analysis of tree ring and climate data including soil moisture reconstructed form delta-13C of tree ring to explore the tree growth-climate relationship and a change in this relationship over the past 100 years in eastern Siberia.

Larch trees (Larix cajanderi) collected in Yakutsk (62N, 129E) 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. Soil moisture for the past 100 years was reconstructed form the delta-13C of tree ring (Tei et al., in preparation). Reconstructed soil moisture from the delta-13C of tree ring was compared with the regional climate record (precipitation), the amount of water input into the soil and a calculated results by one dimensional land surface model (2LM), and seems to be reasonable.

Tree ring width showed positive and negative correlation with soil moisture reconstructed form delta-13C of tree ring ($r=0.56$, $P<0.001$) and July-August temperature ($r=-0.20$, $P<0.05$) in previous year over the past 100 years, respectively. However, these correlations were not stable and the correlation coefficients changed over time. Moving-interval correlation analysis, using 31 years window showed that the relationship between tree growth and late summer soil moisture and temperature in previous year became gradually stronger. These results show that water stress during the late summer in the previous year caused a reduction of tree growth.

In this presentation, we will also show the tree ring width and delta-13C chronology of dead trees and compare with that of living trees to explore the records of stress which larch trees in high-latitude region had experienced.

Keywords: eastern Siberia, tree ring, carbon isotope, soil moisture

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ACG37-13 Room:106 Time:May 22 14:15-14:30

Phytosociological characterization of the High Arctic Region of Canada

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Vegetation of the High Arctic Canada is physiognomically characterized by an extensive barren tundra composed of dwarf shrubs, herbaceous plants, bryophytes and lichens, of extremely low vegetative cover. Such landscapes are often called ”polar desert”. The first attempt of phytosociological classification of vegetation of the High Arctic Canada was made by Barrett (1972) in Devon Island, who recognized 9 associations which were hierarchically grouped into 7 alliances and 7 orders. After then, some more studies were made including Sheard & Geale (1983), Bergeron & Svoboda (1989), Kojima (1991, 1999), and Batten & Svoboda (1994). Based on those preceding studies, this paper provides an integrated summary of the phytosociological classification and hierarchy of the High Arctic vegetation of Canada, presenting four alliance (1.Papaverion lapponici, 2.Dryado-Salicion arcticae, 3.Cassiopion tetragonae, 4.Caricion stantis). These alliances were grouped to higher units, i.e. Saxifragetalia oppositifoliae and Caricetalia stantis, and the highest unit, i.e., Salicetea arcticae.

Keywords: Canada, High Arctic Region, vegetation classification, vegetation types and environment, Salicetea arcticae

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ACG37-14 Room:106 Time:May 22 14:30-14:45

Studies on boreal forest in Alaska by satellite remote sensing and in-situ surveys

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Vegetation, a major component of the global ecosystem, drives the carbon cycle between the atmosphere and the land surface through photosynthesis and respiration. Since the carbon cycle dominates the concentration of atmospheric CO_2, the most essential greenhouse gas, the investigation of vegetation photosynthetic activity over extensive geographical regions is important for climate change studies. Moreover, because vegetation stores carbon as biomass, the monitoring of vegetation biomass is significant for the study of food and fuel resources in addition to the climate change study. Based on the use of satellite remote sensing and field surveys in boreal forests in Alaska, our study focuses on the two vegetation functions: photosynthetic activity (i.e., productivity) and the carbon stock as biomass. The studies introduced here were conducted under the framework of JAMSTEC-IARC Collaboration Study (JICS).

As for the study on the vegetation productivity of boreal forest Alaska, we conduct three investigations at Poker Flat Research Range (PFRR), University of Alaska Fairbanks.

(1) Observation of bidirectional reflectance distribution function (BRDF) of the black spruce forest. The reflected irradiance from the black spruce forest was measured from the top of 17m observation tower in PFRR by the spectroradiometer, being changed the viewing angle from 20 to 70 degrees in the principal plane and the orthogonal (cross) plane in July, 2010 (no-snow season) and March, 2011 (snow season). The BRDF in the principal plane in the no-snow season showed a kind of bowl-shape distribution and the back scatter was generally larger than the forward scatter. By contrast in the snow season, forward scatter was generally larger than the back scatter, that is, reverse of that of the no-snow season. This result can be applied to the 3D forest radiative transfer model for estimating the leaf area index (LAI), an index of photosynthetic potential, based on the satellite remote sensing data.

(2) Monitoring of the forest landscape seasonal change. We installed a fisheye-lens interval camera on the top of the 17m observation tower, and monitored the daily change of the forest landscape by taking photographs. Those photographs tell us that the seasonal change of the vegetation index derived from satellite observations is considerably influenced by the seasonal change of the forest floor vegetation. Such new understanding will be used for the determination of the growing (productive) season of the forest ecosystem by satellite remote sensing data.

(3) Survey of the forest gap. The forest gap was measured by LAI-2000 in autumn of 2011 in PFRR. We are developing the estimation algorithm of the forest LAI by using 3D forest radiative transfer model based on the forest gap data.

As for the study of the carbon stock of the boreal forest, an attempt to estimate the geographical distribution of the forest above-ground d biomass (FAGB) by ALOS-PALSAR has been carried out. The in-situ FAGBs at 29 forests in the south-north transect from Fairbanks to the Brooks Range along the Trans-Alaska Pipeline were measured in July 2007, and based on them, an estimation algorithm for FAGB by ALOS-PALSAR was developed. Consequently, it was revealed that the forest biomass distribute from 5 to 100 Mg/ha (dried matter) and showed south-large north-small gradient in the transect, while the terrain effect contaminates the FAGB estimation that should be reduced.

Keywords: black spruce forest, forest biomass, 3D forest radiative transfer model, leaf area index, BRDF

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ACG37-15 Room:106 Time:May 22 14:45-15:00

Ecosystem modeling of ice and ocean carbon production in the Arctic

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In the Arctic Ocean, both phytoplankton and sea ice algae are important contributors to the primary production and the arctic food web. A coupled ice algal and ocean phytoplankton ecosystem was developed within the global sea ice and ocean climate model POP-CICE (Parallel Ocean Program- Los Alamos Sea Ice Model). The model results were validated with various observations of Chl and primary production. The model results compared well with the following observations and observed trends: 1) an increase of ocean primary production from 2003 to 2007 in the arctic open water areas as derived from remote sensing data; 2) regional annual ice and ocean primary production measured in the Bering and Chukchi seas, and Canadian Basin; 3) primary production rate with phytoplankton size composition and Chl-a concentration along an arctic cruise track in the Chukchi Sea and Canadian Basin from August 2 to September 7, 2008; 4) observed decadal changes of ocean primary production from the 1990s to 2007 due to rising temperature and increasing open-ocean area in the western Arctic. The changes were shown as a trend of a northward shift of production with a decrease in the Bering Sea and an increase in the arctic shelf.

Keywords: ecosystem modeling, Arctic, ocean, sea ice, climate change

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ACG37-16 Room:106 Time:May 22 15:30-15:45

Relationship between the Arctic Amplification and the Arctic Oscillation

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Recent observed Arctic warming may be caused mostly by the increasing anthropogenic greenhouse gases, but the part of the warming may be caused by Arctic Oscillation (AO) which is considered as natural variability of the atmospheric general circulation. During 1990 to 2010 the AO Index has shifted to negative values, which may explain the recent rapid warming over the Arctic Ocean and Greenland. The AMAP project under the Arctic Council (AC) recently announced that the sea level would rise up to 1.6 m by the end of this Century if the Greenland ice sheet continues to melt by this speed. This prediction of the sea level rise is far larger than the value of 0.5 m projected by the Forth Assessment Report (AR4) of the IPCC. However, we must predict the future sea level raise carefully by taking account of the natural variability due to the Arctic Oscillation.

In this study, the recent warming over the Arctic Ocean and Greenland is decomposed in contributions from the natural variability due to the AO and the anthropogenic global warming due to the increased greenhouse gases. The 3D structures of various meteorological variables regressed with the AO Index are analyzed quantitatively, and the results are compared with the observed trends during 1990 to 2010. According to the results of this study, the recent rapid warming over the Arctic Ocean and Greenland can be explained mostly by the features of the AO. Considering the oscillating characteristics of the natural variability by the AO, it is suggested that the prediction of the sea level raise of 1.6 m by the end of this Century is likely to overestimate the reality of the future sea level raise.

Keywords: Arctic Oscillation, Arctic Amplification, Global Warming, Greenland, Natural Variability, Ice Albedo Feedback

Japan Geoscience Union Meeting 2012
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ACG37-17 Room:106 Time:May 22 15:45-16:00

Polar amplification: is signal from lower latitudes important?

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Surface albedo feedback is widely believed to be the principle contributor to polar amplification. However, a number of studies have shown that coupled ocean-atmosphere models without ice albedo feedbacks still produce significant polar amplification in 2xCO2 runs due to atmospheric heat transports and their interaction with surface conditions. The relative importance of atmospheric heat transport and surface albedo is assessed using a conceptual energy balance model. Running the model with prescribed ice area - and, therefore, no surface albedo feedback - always produces a significant polar amplification although smaller than that of the full model. Running the model with prescribed atmospheric heat transport and active surface albedo mechanism produces polar amplification similar to the one obtained in the full model. This could lead to the conclusion that atmospheric heat transport does not participate in forming the polar-amplified global warming response especially when the sea ice feedback plays a significant role. We identify several scenarios in which the equilibrium response to uniform forcing by the model with fixed atmospheric heat transport is identical to that of the full model. However, a detailed analysis suggests that although the temperature responses may be the same, the trajectories of reaching the final equilibrium as well as the underlying physics are quite different.

Keywords: climate dynamics, atmospheric transport, albedo feedback

Japan Geoscience Union Meeting 2012
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ACG37-18 Room:106 Time:May 22 16:00-16:15

Predictability of Arctic Temperatures from Observational Data and Model Simulations

WALSH, John[1*]

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Low-frequency variations and secular trends offer the potential for predictability of Arctic temperatures over timescales from months to decades. Here we consider the effects of natural variability and trends together by asking the question ”What is the probability that the next N-year period will be warmer than the preceding N-year period?”. We compute the probabilities as a function of N based on observational data from particular Arctic stations and corresponding climate model grid cells, as well as from areal averages derived from observational data and model output. The model output is from the Community Climate System Model, Version 4 (CCSM4). The probability generally increases from about 50% for N=1 to 60-90% for N˜20-30 in both the observational data and the model results, implying a greater predictability of longer-term averages. The North Atlantic subarctic shows less predictability of this kind than do other sectors of the Arctic. However, the increase with N is smaller in observational data than in the corresponding model output, and smaller for local temperatures than for areal averages. The implication is that the natural variability is smaller relative to the trend in the model output. All ensemble members of the 20th-Century simulations by CCSM4 show this behavior. Similar results based on sea level pressures indicate that the atmospheric circulation, through its advective driving of temperature variations, is the reason for the discrepancy in temperature predictability. Not surprisingly, sea ice variations show similar increases of predictability with N as the effect of the trend eventually outweighs the effect of natural variability. However, even over decadal timescales, there are substantial probabilities that sea ice extent will increase, as shown by similar examinations of sea ice output from CCSM4 in other studies.

Keywords: Arctic climate, predictability, Arctic temperatures, climate change

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ACG37-19 Room:106 Time:May 22 16:15-16:30

A Diagnosis of Contributing Processes in Maintaining Arctic Amplification in MIROC GCM

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Both observational and model studies show enhanced warming in the Arctic compared to lower latitudes in response to increasing level of greenhouse gases. There have been many proposed mechanisms that contribute to this "Arctic amplification". In order to understand the mechanisms of Arctic amplification and verify each process represented in models, it is essential to first identify and quantify the relative importance of individual processes. While the traditional feedback analysis evaluates radiative effect of processes relevant to radiation at the top of the atmosphere, it does not provide other important information such as the effect of meridional heat transport change. CFRAM, recently proposed diagnostic by Lu and Cai (2009, Clim. Dyn., 32, 873-885), does provide a more complete picture of contributing processes for temperature change. Here we apply this relatively new method to a general circulation model MIROC with partially utilizing the information from the traditional radiative feedback analysis (PRP), and examine the important processes that determine the temperature response in the Arctic to different levels of atmospheric carbon dioxide concentration. We emphasize how processes other than albedo feedback is important in creating the temperature response contrast between Arctic and lower latitudes.

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ACG37-20 Room:106 Time:May 22 16:30-16:45

Studies of coupling processes between upper and lower atmospheres in the arctic region from observations and simulations

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The polar upper atmosphere shows significant variations due to the energy inputs from the solar X-ray and EUV radiation and from the magnetosphere. In addition, recent observational and simulation studies have revealed spatial-temporal variations in the upper atmosphere caused by the lower atmospheric variability. For example, decrease and increase in temperature were observed in the mesosphere and lower-thermosphere, respectively, during the sudden stratospheric warming (SSW) event in 2009. Moreover, the peak height of warming region descends with time, and the coupling process between the troposphere and stratosphere is seen after the 2009 SSW.

The problem of the global warming is one of the main interests in the 21st century. The temperature in the middle and upper atmosphere seems to show decreasing trend during several decades, suggesting the global cooling in the region. For example, some people reported visually-apparent noctilucent clouds in the mid-latitude region for several years. Some observational and theoretical studies suggest that this global cooling in the middle and upper atmosphere affects the general circulation of the lower atmosphere through the coupling process between upper and lower atmospheres. The sciences of the coupling process will enable us to open up the area for the atmospheric science and to take a broad view of the Earth's environment.

We present an overview of our research activities in the arctic region. Some research projects using radars and optical instruments, which have been developed for several decades, and numerical models are shown in this presentation. Moreover, studies of the coupling process between upper and lower atmospheres in the arctic region are discussed.

Keywords: atmospheric coupling process, observations in the arctic region, numerical modeling, climate change

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ACG37-P01 Room:Convention Hall Time:May 22 17:15-18:30

Preliminary analysis of interannual variation in snow physical parameters retrieved from MODIS over northwest Greenland

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Snow and ice in the Arctic have drastically changed in recent decades. The Greenland ice sheet mass loss has rapidly increased from the late 1990s. Possible causes are qualitative change of snow surface conditions including snow grain size and impurities, and the resulting change of snow albedo. An increase in snow grain size reduces the near-infrared albedo and that in light absorbing impurities reduces the visible albedo. The latter effect is larger for large snow grains. Therefore, light absorbing impurities enhance the absorption of solar radiation and speed up grain growth, causing further albedo reduction in a positive feedback. To detect the qualitative change of snow conditions which affect the albedo, we retrieved snow grain size and mass concentration of impurities from Terra/MODIS and preliminary analyzed the interannual variations over the Greenland ice sheet.

The target parameters were snow grain sizes in different snow layers (surface, top and bottom layer) and mass concentrations of light absorbing impurities optically equivalent to soot, which were retrieved from MODIS single scene data over northwest region of Greenland from late July to early August in each year from 2001 to 2011. The snow grain sizes were larger in the coastal region and smaller in the inland area. The wet snow areas where the surface grain size is large were widely varied from year to year, implying that the seasonal variations in snow grain size are greatly different during each year. The surface snow grain size was the smallest, and the top and bottom layer grain sizes are comparable. This result indicates that the snow grain size was almost vertically homogeneous except for the surface. The retrieved grain sizes were roughly within the range of the preliminary validation measurement in August 2011. On the other hand, the soot concentrations were generally under the lower detection limit (0.001ppmw) in the early period, which was consistent with previous ground measurements. However, they exceeded the limit and around 0.01 ppmw in the last several years, which were overestimated compared with the validation measurement in August 2011. This might be possibly caused by a change in the sensitivity of MODIS sensor.

Keywords: snow grain size, light absorbing snow impurities, MODIS, Greenland, interannual variation

Japan Geoscience Union Meeting 2012
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ACG37-P02 Room:Convention Hall Time:May 22 17:15-18:30

Review of previous study and observation plan for mass balance of No. 31 glacier, Siberia

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There are 182 glaciers in Suntar Khayata mountain range, east Siberia. The little ice age was in 1800s in this region. Twice of warm and cold period were seen since 1500 A.D.

Glacier research has done at no. 31 glacier during IGY years in 1957-1959 and profile of mass balance have observed.

We have started glacier research at no.31 glacier in September 2011. The instruments of Automatic Weather Station (AWS), stakes, interval cameras, snow depth sensor, rain gauge were set near and on the glacier. Air temperature, relative humidity, atmospheric pressure, solar radiation, wind speed, wind direction and precipitation are measured at the AWS. Stakes network and meteorological observation network will be expanded next season.

Previous mass balance study has been done by Koreisya (1991) and Ananicheva et al (2010). We have calculated pass mass balance by the method of Koreisya (1911). However, the result did not match to Ananicheva et al (2010). The observation in next year will be used to reconstruct mass balance of no.31.

Keywords: glacier, arctic, Siberia, no.31, mass balance, observation

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(May 20-25 2012 at Makuhari, Chiba, Japan)

ACG37-P03 Room:Convention Hall Time:May 22 17:15-18:30

Glacier environment in DeLong islands, Siberian arctic

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[1]JAMSTEC

There are many glaciers in Russian arctic. De Long Islands in Siberian arctic are composed of three islands and 50 % of the area is covered by glaciers (Kadota et al., in prep). Bennett Island, one of DeLong Islands, is of 30km long and 10km wide. There are three icecaps on the island. The altitude of each icecap is 384m, 426m and 200m, respectively (World Atlas of Snow and Ice Resources). Mass balance of Toll glacier, which is the largest glacier in Bennett Island, in 1986/87 was -0.303 m w.e. (Verkulich et al., 1992) and during 1956-1972 was -0.10 w.e. (Jania and Hagen, 1996). Glacier area shrinkage revealed by satellite images are 20 % in 1951-2010 for Bennett Island and 40-50% for the other two islands in De Long Islands (Yabuki, personal communication).

Meteorological observation is continued at Ostrov Kotelnj (76.0N, 137.9E) in New Siberian Island since 1937. Air temperature in 1960s was lowest since 1930's. The warming in 1990s was rapid and the warming trend is continued after 2000.

Siberian arctic is the area where the largest sea-ice-area change was seen. Although the sea ice came across to the continent even in September until 1996, sea ice in September was apart far from the coast since 2004. In 2007, in which the sea ice was in minimum, most of Siberian arctic was free from sea ice except for a small part. Southern most position of sea ice in September is plotted for the range of 135-155 East during 1979-2010 with SSMI data. The southern-most position was correlated to annual and monthly mean temperature in September.

Keywords: glacier, arctic, ice cap, mass balance, temperature increase, sea ice distribution

Japan Geoscience Union Meeting 2012
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ACG37-P04 Room:Convention Hall Time:May 22 17:15-18:30

Research related to seasonal snow cover in the Arctic Climate Change Project as one of GRENE programs

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The Arctic Climate Change Project as one of Green Network of Excellence (GRENE) programs in collaboration with various research communities has started since 2011.

Seasonal snow cover will be significantly affected by climate change, and changes in seasonal snow cover can affect climate through various feedback mechanisms. Towards a better understanding of the role of seasonal snow cover in the Arctic, research related to seasonal snow cover is mainly dealt with in a research theme entitled ”Role of snow, glacier and ice sheet in the Arctic under global warming” to contribute to GRENE goals such as 1) Elucidation of Polar Amplification mechanism on warming in the Arctic region, and 2) Elucidation of role of the Arctic region in global climate change and its prediction. This presentation will describe the outline and progress of the plan.

Keywords: seasonal snow cover, the Arctic, climate change

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ACG37-P05 Room:Convention Hall Time:May 22 17:15-18:30

Observation of melting signal from Arctic cryosphere

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Melting of glacier, Ice Sheet and snow cover area were analyzed by satellite microwave observations. This study discuss melting timeing and area for field observation sites in the Arctic cryosphere reserach project.

Keywords: Arctic, snow, Akaska, Greenland, melting

Japan Geoscience Union Meeting 2012
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ACG37-P06 Room:Convention Hall Time:May 22 17:15-18:30

Uncertainties in steady-state and short-term responses of Greenland ice sheet simulation

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We present a series of numerical experiments of Greenland ice sheet to global warming and uniform warming using Ice sheet model for Integrated Earth system Studies (IcIES) to describe the model characteristics and its sensitivity.
Various uncertainties in the model result due to several factors such as parameterization schemes (physical aspects) as well as numerical aspects in the model are discussed.

Keywords: Greenland ice sheet, Ice sheet model

Japan Geoscience Union Meeting 2012
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ACG37-P07 Room:Convention Hall Time:May 22 17:15-18:30

The 2010 draining episode of an ice-dammed lake in West Greenland: Further evidence for accelerated melting?

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Furuya and Wahr (2005, GRL) detected unloading deformation signals around Lake Tiningnilik in West Greenland, an ice-dammed lake located ˜40 km to the south of Jakobshavn Isbrae. We associated the signal with a draining episode of the ice-dammed lake in 1993 and 2003, and explained the rate and pattern of the signal, assuming 7.5 meter/year increase in water level over an elastic body.

Previous field-based observation indicate that the draining episode takes place every 10 years (Braithwaite and Thomsen, 1984; Bogglid, personal communication, 2004), and thus we thought the next draining would happen around 2013. However, it turns out that the latest event occurred in 2010, which is 3 years earlier. Recent studies based on InSAR and GRACE indicate an accelerating loss of ice at Greenland. Our very localized observation may be a further evidence for the recent accelerated melting in Greenland.

We also detectged accelerated flow velocities in the nearby glacier. The acceleration was probably caused by the sudden increase of subglacial water flow from the ice-dammed lake.

Keywords: Greenland, ice-dammed lake, Jokulhaups, Synthetic Aperture Radar, glacier flow

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ACG37-P08 Room:Convention Hall Time:May 22 17:15-18:30

The GreenLand Ice Sheet monitoring Network (GLISN)

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The Greenland Ice Sheet and its response to climate change have potentially a great impact upon mankind, both through long-term sea level rise and through modulation of fresh water input to the oceans. Internationally monitoring the dynamic response of the Greenland Ice Sheet to climate change is a fundamental component of long-term observational efforts for monitoring climate change. Glacial earthquakes have been observed along the edges of Greenland with strong seasonality and increasing frequency since 2002 (Ekstrom et al, 2003, 2006) by continuously monitoring data from the Global Seismographic Network (GSN). These glacial earthquakes in the magnitude range 4.6-5.1 may be modeled as a large glacial ice mass sliding downhill several meters on its basal surface over duration of 30 to 60 seconds. The detection, enumeration, and characterization of smaller glacial earthquakes are limited by the propagation distance to globally distributed seismic stations, i.e., the Global Seismographic Network (GSN) with the International Federation of Digital Seismograph Networks (FDSN). Glacial earthquakes have been observed at seismic stations within Greenland (Larsen et al, 2006), but the current coverage is very sparse. In order to define the fine structure and detailed mechanisms of glacial earthquakes within the Greenland Ice Sheet, a broadband, real-time seismic network needs to be installed throughout Greenland's Ice Sheet and perimeter. The International Polar Year 2007-2008 was a good chance to initiate this program with international collaboration. All of the partners are committed to free, unrestricted, open access to all data from The GreenLand Ice Sheet monitoring Network (GLISN) in real-time. In this presentation, seismicity around the Greenland region, including glacial related signals are presented with discussion associated with recent global warming.

Keywords: Greenland, global warming, glacial earthquakes, broadband seismometer, monitoring, global network

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ACG37-P09 Room:Convention Hall Time:May 22 17:15-18:30

SEASONAL CYCLE AND VARIABILITY OF ARCTIC SEA ICE

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Seasonal cycle is a very principal variation of sea ice change and has been studied for basic understanding of sea ice study. Recently many satellite data became available and strong variation has been reported. In the seasonal cycle, Arctic summer sea ice minimum is strong concern. This shows largest interannual variations in the annual cycle. In May and November, Arctic sea ice shows least interannual variations. There are some important turning points of ice conditions in the annual cycle. We tried to summaries resent understanding and unsolved problems, and discussed again the fundamental seasonal cycle.

Keywords: Arctic, sea ice, seasonal cycle

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ACG37-P10 Room:Convention Hall Time:May 22 17:15-18:30

Transfer of momentum from Atmosphere into the ocean via sea ice

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Recent rapid sea ice reduction (SIR) gives us an image that the Arctic climate sub-system is vulnerable to global warming. By the end of this century, IPCC AR4 climate models show that substantial warming in surface temperature occurred in the Arctic Ocean where the sea surface was covered by sea ice in late of last century. This implies the warming in the Arctic Ocean was not only caused by global warming but by some positive feedback mechanism to accelerate SIR in the Arctic climate sub-system. Current numerical models cannot predict the variation of sea ice extent and spatial pattern of sea ice retreat. To understand the fate of the Arctic sea ice will contribute to reduce the uncertainty of future prediction of global climate.

Our scientific goal is to clarify actual mechanism of catastrophic SIR and to suggest the viewpoint to improve the current models from real observational and dynamical research. A quantification of a hypothesis on ”Positive feedback mechanism (Shimada et al., 2006)” that accelerates SIR is our main stream toward the goal. This Positive feedback mechanism hypothesis consists of sequential phenomena just like as domino; (1) activations of sea ice motion (SIM) associated with SIR, (2) strengthening of upper ocean circulation (UOC), (3) upper oceanic warming, (4) less sea ice formation, (5) imbalance between sea ice melt and formation. These phenomena compose a positive feedback loop to induce further SIR. This hypothesis well explains pattern of SIR from Pacific sector, however, the conceptual idea is insufficient to improve the current climate models. Development of the qualitative and conceptual research into more quantitative and practical one is required. Here, we focus (1) and (2) among the feedback system toward quantitative understandings.

(1) Mechanism of increase in SIM associated with changes in sea ice properties; There are large discrepancies of SIM between actual data and model results. In particular, recent activations of SIM do not linearly respond to the surface winds stress. Then, we examine relationships between winds and SIM dependent on sea ice properties. Basically, SIM in the first-year ice area is much faster than that in the multi-year ice area, under almost the same strength of wind stresses. Additionally, in the area of large divergence of SIM, the efficiency of momentum transfer increases regardless of the sea ice type. In both cases, strengthening of SIM is owing to dissipations of internal stresses dependent on changes in sea ice properties and motion. Therefore, the sea ice type and divergence/convergence of SIM are useful parameter to improve parameterizations of momentum exchange between atmosphere and sea ice.

(2) Dynamics of UOC pattern and its inter-annual variation; Strength of UOC has been speculated that it linearly respond to that of Ekman pumping/suction (EP/S) caused by sea surface stresses. However, in some area there is an inconsistency between the spatial distribution of EP/S and depth of main pycnocline that is a kind of proxy of strength of UOC. This inconsistency is found in the region where bottom slope is greater than some critical value. The variation of SIM, that is the main driving force of UOC, has a power spectrum peak near annual time scale. This time scale disturbance is significant to argue the inter-annual variation of UOC. In this timescale, in the region with flat seafloor topography, an induced baroclinic structure cannot propagate due to small value of planetary beta effect. While in the region where the slope is greater than some critical value, baroclinic structures can propagate as topographic Rossby waves and the depression structure is radiated. This basic dynamics is crucial to understand the observed spatial pattern of UOC. In the flat deep Basin, UOC is identified by satellite derived surface data, but in the slope region such surface data is not sufficient to understand the actual pattern.

Keywords: Arctic Ocean, sea ice reduction, climate change, global warming

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Long-term hydrometeorological, ecological and dendrochronological monitoring at larch forests on permafrost of Mongolia

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1. Introduction

The larch forest of Mongolia is located at the southern edge of Siberian Taiga forest. The 80% of forested area of Mongolia is dominated by larch forest (*Larix sibirica*). In Mongolia, the forest is dominant on north-faced slope where the permafrost is located underground while the steppe grassland is dominant on south-faced slope area without permafrost. The disturbances on the forest such as fire, logging and pest out break are important factor for predicting future change of forest. The climate change becomes remarkable such as increase of the air temperature (1.8 degrees in recent 60 years) and change of precipitation (7.5% decrease in summer and 9% increase in winter) in Mongolia. These changes of climate condition and human impacts might affect the ecosystem of Mongolia especially for forest distribution.

The purpose of our study is to investigate the heat, water and carbon exchange process, and dynamics by comprehensive approach. In this paper, we show the observation method, data and preliminary results.

2. Observation method and data

We have started long term monitoring of hydro-meteorological, ecological and dendro-chronological observations at the 25-m height tower and forest around the tower in the Udleg (48 15 43.7 N, 106 50 56.6 E, altitude 1264m) over the larch forest in Research Forest of National University of Mongolia in Udleg village, Batsumber district, Tuv province of northern Mongolia since 2009. As for the hydrometeorlogical observation, we have been observing the air temperature, relative humidity (at 2m and 25m), air pressure (25m), wind speed and direction (25m), precipitation (25m), snow depth, short wave and long wave radiation (5m, 25m), photosynthesis active radiation (PAR; 5m, 25m), soil temperature (0, -0.2, -0.4, -0.8, -1, -2, -3, -4, -6, -8, -10m) and soil moisture (-0.1, -0.3, -0.5, -0.7, -0.9, -1.3, -1.8, -2m) and sensible heat, latent heat, momentum and carbon dioxide fluxes (by eddy-covariance method using sonic-anemometer-thermometer and infrared gas analyzer at 27.5m). As for the ecological observation, we have carried out the growth of diameter at breast height (DBH using dendrometer), sap flow (Granier method), vegetation and surface condition measurements. The dendro-chronological observation has been carried out for the age of each tree, growth rate, drought and fire histories. The average height and DBH of larch tree were 18.3m and 33.2cm, respectively.

3. Results

The annual range of air temperature and annual mean air temperature were about 60 degree C (+25 to 27 degree C in June and July as the annual maximum, and about -30 degree C in January and December as the annual minimum) and -1 degree C, respectively. The annual precipitation was about 250 mm with about 90% of it from May to September. According to the image analysis of in situ camera, 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 on the surface when the surface albedo was about 0.2 to 0.3. In early May the leaf of larch emerged and attained the mature growth in July, and then the leaf senescence occurred in early October. The PAR albedo shows abrupt decrease in early May and abrupt increase in early October that coincides with the image analysis. 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 the 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.

Keywords: Mongolia, Larch forest, Heat, water and carbon balance, Soil moisture, Permafrost

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ACG37-P12 Room:Convention Hall Time:May 22 17:15-18:30

Isotopic composition of atmospheric water vapor and its source and transport in the taiga forest, eastern Siberia

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The boreal forest in eastern Siberia prevails on the continuous permafrost under continental arid climate. Plant transpiration process in the forest plays an important role in the water cycle in eastern Siberia. In this study, the isotopic composition of atmospheric water vapor in a time scale of a few weeks was observed in eastern Siberian taiga in the mid to late summer periods in 2006, 2007, and 2008, with the isotope ratios of precipitation, plant sap water, soil water, and the water in organic layer in order to clarify how the forest transpiration works in the water cycle. The factors controlling the isotopic variation were examined, by comparing the isotope data with meteorological parameters. During these years, soil moisture content was increase and the condition was extremely wet in 2007, because of heavy rainfall and winter snowfall.

The delta-^{18}O values of atmospheric water vapor correlated positively with atmospheric mixing ratio in 2006 and 2008 (R^2 = 0.99 and 0.88, respectively). This was elucidated by two sources of the water vapor: one has high delta-^{18}O from plant transpiration and the other has low delta-^{18}O which was affected by rain events. On the other hand, no significant correlation was observed in 2007 when soil was extremely wet. This indicated that the evaporation from wet land surface was more remarkable than the plant transpiration in 2007.

A region with 500 km x 500 km in size was set around the observational site and horizontal water vapor fluxes at each boundary of the region were calculated using reanalysis data to compare with the isotope data. No significant correlation was observed between directions and delta-^{18}O values. Back trajectory analysis (HYSPLIT4 model) was made to know the source area of water vapor. The water vapor with high delta-^{18}O value was observed in the air advected from forest area where air temperature was relatively high, whereas the water vapor with low delta-^{18}O value was observed in the air advected from the area where air temperature was low and occasionally precipitation occurred. Contribution of two sources, transpired water vapor and water vapor affected by rain events, may control the isotopic variation of atmospheric water vapor.

These results revealed the significant role of the transpired water vapor with relatively high delta values generated from taiga in the water cycle in eastern Siberia. These results are useful for further investigation of water cycle including various model works.

Keywords: stable isotope of atmospheric water vapor, eastern Siberia, taiga, plant transpiration, precipitation

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Recent Large Forest and Tundra Fires in Alaska

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Around 120,000 lightning flashes a year, or 3 times more than average, started around 300 fires in each year of 2004, 2005 and 2007 in Alaska. But each burnt area of these three years differed considerably. Burnt areas in 2004 and 2005 were the largest and third largest burnt area of last 55 years (1956-2010) respectively. But burnt area in 2007 was a little bit smaller than the average even though one largest tundra fire occurred. To explain backgrounds of two large burnt areas in 2004 and 2005, and one small burnt area in 2007, various fire characteristics were considered. Firstly, various fire characteristics such as fire distribution, fire size, fire duration, ignition by lightning, fatal fire day, detected date of fire, and number of live fires, were extracted from fire data by NASA and AFS (Alaska Fire Service). Secondly, an effect of weather condition on lightning and fire activity was examined by comparing hotspot data with daily precipitation, and with air temperature.

Comprehensive understanding for active forest fire occurrences in active lightning years in Alaska were made based on various fire characteristics with the help of statistics. Finally, various fire characteristics used in this paper cleared that after active lightning ignited whole Alaska forest in June and July, most large fires in 2004 and 2005 started and lasted until August. Number of daily live fires in each year reached 100 and many of them lasted until September except 2007. As large number of live fires, more than 80, in 2004 and 2005 could become active under occurrence of drought and high air temperature condition, very large burnt area in 2004 was achieved. In 2005, nevertheless continuous rainfall started from June, large burnt area was also made by a very active forest fire period occurred in August. On the contrarily, burnt area in 2007 was not so large due to lack of lightning occurrence in June, continuous rainfall from the top of June, and small number of live fires, less than 60.

Keywords: live fire, fire duration, hotspot, lightning, drought, precipitation

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Distribution of biogenic volatile organic compounds over the Arctic Ocean

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There are a variety of biogenic volatile organic compounds (BVOCs) in the atmosphere. They are believed to be playing an important role in the global environment through aerosol formation, ozone depletion, etc. We studied spatial/temporal distribution of selected BVOCs in the atmosphere over the Arctic Ocean, and found that their concentrations were likely to be affected by sea-ice type.

Air samples were collected during an Arctic cruise conducted by the R/V Mirai from 30 August to 21 October. Sampling was done with stainless steel canisters on board at the front of the uppermost deck, forward of potential contamination from stack. After transport to the laboratory, the samples were analyzed using a pre-concentration/capillary gas chromatograph - mass spectrometry (GC-MS).

Methyl iodide (CH_3I) is the most abundant organic iodine compound in the atmosphere, which is mostly emitted from the ocean. Methyl chloride (CH_3Cl) is the most abundant chlorine compound in the atmosphere, which is mostly emitted from tropical forests followed by warm ocean and biomass burning on a global scale. Both of them showed gradual decrease with latitude, but they showed quite different variation in the marginal ice zone. CH_3Cl concentration was higher at the sites surrounded by sea ice than at the open sea near the ice edge, while CH_3I concentration decreased over/near the sea ice. This finding would suggest CH_3Cl is absorbed by the cold seawater, but CH_3I is emitted even from the cold water. Among the other BVOCs, methyl bromide (CH_3Br) was similar to CH_3Cl in the relationship to sea ice. Bromoform ($CHBr_3$), which is mainly emitted from macroalgae, showed the third pattern: lowest over thin (new) sea ice and highest over thick (old) sea ice. This would be consistent with that ice-algae usually grow on the old sea ice.

Keywords: volatile organic compounds, Arctic, methyl iodide, methyl chloride, bromoform

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Methane flux and its stable isotope ratios in a taiga-tundra ecotone in East Siberia

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One of the major sources of CH_4 is natural wetland and CH_4 is partly absorbed into forest soil. These CH_4 exchange between soil and the atmosphere is known to be spatially variable to great extent (*Sachs et al., 2010*). Wetland is broadly distributed in the Arctic (*Aselmann & Crutzen, 1989*) and taiga-tundra ecotone (low and high shrub tundra) also covers significant area in the region (*Kaplan & New, 2006*). The vegetation in the taiga-tundra ecotone might be changed by climate change such as enhanced warming in the Arctic (*Walker et al., 2006*) and eventually CH_4 flux as well, which is a strong greenhouse gas. In order to estimate CH_4 emission from a region in the taiga-tundra ecotone, it is necessary to observe CH_4 flux not only at a typical tundra site but also at multiple sites including taiga area. Such observation had been carried out in other region such as West Siberia (*Flessa et al., 2008*), but not yet in East Siberia. The objective of this study is (1) to establish new observation sites in a taiga-tundra ecotone in East Siberia and observe CH_4 flux at each vegetation landscape and (2) to clarify the controls of CH_4 flux in the ecosystem.

We observed CH_4 flux by closed chamber method in Jul 2009-2011 at 4 new sites (separated for tens of km) with different vegetation in the taiga-tundra boundary of Indigirka lowland near Chokurdakh (70N, 148E), Russia. The region has a typical tundra station, where CH_4 flux had been observed since 2004 (*van Huissteden et al., 2005*). We set new sites denoted as V (taiga-like), K (typical boundary), B (tundra-like), where tree mounds with moss cover (*Sphagnum spp.*) and with larch, wet area with sedges (or *Sphagnum*) and frequently with surface water were distributed in a patchy way. We also set site F (floodplain) in 2010. Along with flux observation, we measured oxidation reduction potential (ORP), soil temperature, soil moisture, and thaw depth as potential controls of CH_4 flux. In 2011, we also measured CH_4 concentration in surface water and in soil pore (at ca. 15 cm) in wet areas, and delta-13C and delta-D of these dissolved CH_4 and emitted CH_4 to clarify the production, transport, and oxidation process. GC-FID was used to analyze CH_4 concentration and GC/GC/C(TC)/IRMS for delta-13C and delta-D of CH_4.

The observed CH_4 flux was -0.23~7.0 mgC m^{-2} h^{-1} and different among vegetation types. At tree mounds and river terrace (F site), the soil was drier with relatively higher ORP than wet areas and CH_4 emission wasn't observed. At K wet area (sphagnum/sedge), where dead larch with flat Sphagnum cover on ground could be seen and regarded vegetation succession was taking place, small CH_4 emission was observed (2.1 mgC m^{-2} h^{-1} at maximum). At V, B sedge wet area, the largest emission was observed (0.05~7.0 mgC m^{-2} h^{-1}). CH_4 flux didn't correspond with CH_4 concentration in surface water, but the flux was large when CH_4 concentration in soil pore was high, indicating that the contribution of CH_4 diffusion throughout surface water is small and that CH_4 could be emitted from soil through vascular plants. CH_4 flux was positively correlated with soil temperature at wet areas, as well as CH_4 concentration in soil pore. CH_4 flux at K sedge wet area, however, was almost constant and had no correlation with CH_4 concentration in soil pore. In 2011, when the water level of the river system was remarkably high and the soil was wet, the largest CH_4 flux was observed with low ORP. The observed delta-13C of CH_4 in soil pore was extremely high (-59~-47 per mil), which indicates the delta value was affected by diffusion or oxidation in the soil. Delta-D-delta-13C plot supported the CH_4 transportation by plants. To estimate CH_4 flux of the region, it's necessary to consider not only tree mound and sedge wet area but also vegetation succession. If vegetation changes from tree mound to succession area, or from succession area to sedge wet area, regional CH_4 flux might increase and cause positive feedback on climate.

Keywords: methane, taiga-tundra ecotone, East Siberia, Arctic, carbon isotope ratio, hydrogen isotope ratio

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The intensity distribution of snowfall in the cold regions

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In climate changes, such as global warming, a water cycle also causes a global change. In polar region, when change of snowfall changes a area of snow cover and a period, work of ice-albedo feedback process is affected. In order to study the present condition of the water cycle of polar region, or the influence on the future climate, we have to observe snowfall correctly. However, in the snowfall observation using the raingauge currently performed all over the world, the capture rate is 50% or less in many cases. This is intensively called on for improvement in observation accuracy. According to the low-temperature condition in the polar region, many snowfall events have the little amounts in total and they are frequently constructed with weak intensity, which we have to catch in observation. We have been carried out the observation in Niigata Prefecture and Hokkaido until now using some instruments in order to solve such a problem. Our presentation will clarify the snowfall events from the viewpoint of the intensity based on the domestic snowfall data mainly observed by a snow particle counter. Moreover, we would like to comment also about use of ceilometer observation.

Keywords: snowfall amount observation, polar region, cold region, snow particle counter, ceilometer

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Anthropogenic impact on spring precipitation over Eurasian continent in the late 20th century

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Global warming due to anthropogenic greenhouse gases (GHGs) causes an increase in mean and extreme precipitation. It also causes a decrease in snow cover duration and snow water equivalent (SWE) in mid-latitude and lower altitudinal area, whereas it causes an increase in SWE in high-latitude and high altitudinal area. On the other hand, anthropogenic emissions of aerosols have decreased over European countries, the U.S., Japan, etc., although they are still increasing in China, India, and developing countries. Changes in the anthropogenic aerosols alter the surface radiation fluxes through the scattering and absorbing processes of aerosols. These changes in surface radiation fluxes affect the surface energy budget; that is latent and sensible heat fluxes. Recently, it is pointed out that 'dimming and brightening' associated with aerosol changes affect regional and global climate changes. Decrease in anthropogenic aerosols induces brightening over Europe, which resulting in an increase in evaporation. The increase in evaporation contributed to the increase in precipitation via the water budget relationship.

Here, we investigate the impact of changes in GHGs and aerosols on precipitation over the Eurasian continent in the late 20th century using historical simulations performed by a coupled general circulation model generally known as the medium-resolution version of the Model for Interdisciplinary Research On Climate (MIROC). The atmospheric component of MIROC includes an explicit representation of the first and second kinds of indirect effects induced by soluble aerosols as well as the direct effects of all aerosols. We look into the relative contribution of individual anthropogenic forcing factors by analyzing datasets of several experiments forced with different combinations of external climate forcing factors. We focus on the changes in surface radiation and heat budgets which affect the evaporation and precipitation statically.

The historical simulation by MIROC can simulate the observed precipitation trend over high-latitudinal area in the late 20th century. Significant increase in precipitation was observed and simulated during spring. Moistening trends are significant over the western part of Eurasia (Europe) during all season. The annual drying trend can not be simulated over the eastern parts of Eurasian continent. According to an analysis using an approximated atmospheric moisture budget equation, we find that the increase in precipitation is caused by the increase in evaporation and advection over the western and eastern parts of Eurasian continent, respectively. The change in evaporation is thought to be related to the surface radiation changes, hence, we investigate the changes in surface shortwave and longwave radiation. Change in net surface shortwave radiation (SSR) controlled the changes in net radiation. The net SSR increases over central and western parts of Eurasian continent not only in the all-sky situation but also in the clear-sky situation. The downward SSR shows an increase over Europe. In contrast, the upward SSR shows a decrease, which means the increase in net radiation at the surface, over the central part of Eurasia. According to an analysis of several experiments forced with individual forcing factors, it is speculated the change in downward SSR is associated with the changes in aerosols, while the changes in upward SSR is associated with the snow cover change. The increase in downward SSR over Europe was caused by the decreases in aerosols. The decrease in upward SSR over the central part of Eurasian continent was caused by the increasing concentrations of GHGs; the decrease in upward SSR is strongly associated with the surface albedo reduction which is caused by the decrease in snow cover due to global warming.

Keywords: global warming, anthropogenic, greenhouse gases, aerosols