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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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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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