Japan Geoscience Union Meeting 2013
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ACG38-P01 Room:Convention Hall Time:May 21 18:15-19:30

The variation of the Siberian cryosphere in the Last Millennium experiment using MIROC-ESM

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In this study, we analyze the result of Last Millennium (LM) Experiment using GCM and ESM, to verify the response of the cryosphere to the hundereds-year-scale climate change. In addition to the sensitivity analysis between the forcing conditions, comparison with existing climate/paleoclimate data. The period of the LM experiment covers the Little Ice Age and Medieval Climate Anomaly, and responses of the cryosphere during those periods are of interest.

The models used in this study are the Atmosphere-Land-Ocean General Circulation Model MIROC and the Earth System Model MIROC-ESM. Resolution of atmosphere/land components are T42 (ca 2.8?) in horizontal, 80 layers in vertical. Ocean component has a resolution of 1.4? (longitude) by variable 0.56?1.4? (latitude) in the horizontal and 44 levels in the vertical. As an ESM, MIROC-ESM has a carbon-cycle components for the land and ocean ecosystems. Setup of the experiments follow the protocol of model inter-comparison CMIP5/PMIP3.

As preliminary results, temporal variations in surface air temperature, snow amount, and snow/rain ratio for Siberia region was analyzed. Winter warming during 20th century is clear. Signatures are shown in rise of February Temperarure, decrease in snow amount, increase in runoff during spring. Ratio of Snow fall / Precipitation is sensitive to the temperature, which may caused the above-mentioned trends in snow.

Keywords: Earth System Model, Last Millennium, climate change, cryosphere

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Vegetation distribution along environmental gradient at taiga-tundra boundary ecosystem in eastern Siberia

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Climate change is expected to cause extensive vegetation change in the Arctic. The studies from high latitude region, Alaska or northern Europe region, reveals impact of climate warming on vegetation change. However, not many studies have been done in northeastern Siberia region. We observed vegetation and species composition along the 50m transect then analyzed relation among vegetation-soil moisture-topographical level. We measured leaf delta 13C and delta 15N, leaf area index (LAI), and dry weight of above ground biomass in 10 plots along transect. Vegetation was categorized into 4 types of plant communities: driest Tree mound(Larix , Orthilia etc.), Shrub(Betula etc.), Sphagnum(Petasites etc.), wettest Hollow (Carex etc.). Isotope ratio showed species specific or taxonomic group specific character. Delta 13C of Salix, herbaceous eudicots and bryophytes increased with soil moisture. N content of eudicots plants and bryophytes were low in mid-wet area (Shrub and Sphagnum area). We suggested that recalcitrance of sphagnum litter provide low N condition, and make lower N content of leaves.

Keywords: arctic vegetation, C / N isotope, Larch forest, environmental gradient, ecosystem change, peatland

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Tree growth and tree-ring delta-13C over the past 150 years at two larch forests in eastern Siberia

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Global climate change scenarios predict an increase in average global precipitation in the present century and this change will be most pronounced in high latitudes [IPCC, 2007]. Previous studies reported that decrease in precipitation with global warming cause quite severe drought stress and consequently significant reduction of tree growth [e.g. Barber et al., 2000; Sarris et al., 2007]. However, it is not clear whether increase in precipitation causes better tree growth even under global warming, especially in dry region like as eastern Siberia. Here, we report an analysis of larch tree-ring width and delta-13C over the past 150 years in eastern Siberian.

Radial growth and delta-13C of larch tree rings were measured at two larch dominated forests; Yakutsk (YK; 62N, 129E) and Elgeeii (EG; 60N, 133E) in eastern Siberia.

Negative responses of larch tree growth to summer temperature were observed in YK for the past 100 years, which may be explained as temperature-induced drought stress [Barber et al., 2000]. On the other hand, larch trees in EG had shown no negative response to summer temperature probably due to large summer precipitation until 1990. However, the negative response with rapid temperature rise was observed after 1990 even in EG. Since 1990, higher tree ring delta-13C reveled iWUE (intrinsic water-use efficiency) improvements at both two sites sharply. These results indicate that higher temperature after 1990 cause more severe drought resulting in great improvement of iWUE and reduction of tree growth, suggesting that the improvement of iWUE seem to be insufficient to compensate for the negative effects of the increasing water limitation on growth.

Therefore, even if precipitation increases, reduction of larch tree growth and in consequence the fall of the carbon assimilation of a forest in eastern Siberia under global warming might is expected.

Keywords: Taiga forest, Larch, Tree ring, Carbon isotope ratio, Global warming, Drought

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Carbon dioxide exchange of larch forest at eastern Siberia - effect of canopy structure and soil environment

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To improve our understanding of CO_2 exchange over eastern Siberia boreal forest, two observation sites at a larch dominated forest were compared. The dominant species in the forest is larch composing the upper canopy, mixed with mainly birch and willow, although distribution ratio differs at each forest. The difference in atmospheric environment was small at 2 sites, but soil properties such as soil thawing ratio and soil water content was different. There was difference in 1.5 times between the CO_2 uptake fluxes in 2 sites, although a difference was not found in ability for photosynthesis of the unit leaf scale. The difference in canopy scale response to environmental condition such as solar radiation, air temperature, and humidity between the sites, which might reflect the dominant species and canopy structure in each forest, was observed. Environmental factors to explain a temporal variability of CO_2 uptake flux extracted by a multiple regression analysis, was different for each sites. Variability including difference in sites was explained mainly by soil water and ground temperature.

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Observations on stable water isotopes in permafrost and surface water in taiga-tundra boundary ecosystem of northeastern

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Eastern Siberia is covered by permafrost which is the largest and the deepest in the world, and permafrost plays an important role for hydrologic cycles in the area. Degradation of permafrost system, therefore, may have a great impact on the hydrologic regime, consequently, on the material cycling including greenhouse gas emission, through vegetation changes. Isotopic composition of water is powerful tool for investigation of hydrological processes.

Observations on the water isotope ratios of soil moisture and permafrost ice were conducted near Chokurdakh, Russia. Indigirka river water and precipitation were also sampled, in order to know the hydrological processes in the area.

Landscape of the Observational site consists of various types of wetlands (wet area) and hummocks which includes micro ridge growing larches (tree mound). At an intensive observation site (site K), 15m or 30m transect including different vegetation types were set and obtained permafrost cores down to 1m.

The isotope ratios of Indigirka river water showed the clear seasonal variation; decrease was found in spring with a runoff of snow melt water. The isotope ratios of Indigirka tributary showed year to year variation. In 2010 and 2012, it was higher than that of mainstream, while it showed the same values as that of mainstream in 2011, when the river water level was unusually high. This result shows water from mainstream flowed into the tributary.

The water contents of permafrost soil depended on the surface vegetation. Ice rich layers were found below the tree mounds. The ice rich soil layer showed higher delta value than the layers above and below. This may be caused by an isotopic fractionation during freezing. Ice rich or pure ice layers at the top of the permafrost or the bottom of active layer showed low delta values, suggesting snow melt water infiltration and freeze on the top of permafrost layer.

Keywords: eastern Siberia, Indigirka river, stable water isotopes, permafrost

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Spatial scale-dependent characteristics of the fraction of absorbed photosynthetically active radiation

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The fraction of absorbed photosynthetically active radiation (FAPAR) is a ratio of absorbed PAR to incident PAR in plant canopies and is an important vegetation parameter and is widely used for the gross primary production estimation. The absorbed PAR and incident PAR are both spheradiances (actinic fluxes). The FAPAR definition that ignores the horizontally incident PAR component (FAPAR1d) results in unrealistic FAPAR estimates in heterogeneous forest when looking at high spatial resolution. We investigated the spatial-scale dependence of the relationship between FAPAR1d and the normalized difference vegetation index (NDVI) in highly heterogeneous Alaskan black spruce forest. We collected most of the necessary forest structural datasets used for three-dimensional radiative transfer simulation. At high spatial resolutions (0.1 m), FAPAR1d reaches 6. As the pixels are merged, it converges on the domain-average values. To estimate a domain-average FAPAR from satellite data, 5-meter or coarser resolution is required in sparse forests, depending on the canopy structural conditions and solar geometry.

Keywords: remote sensing, polar region, radiative transfer

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Ground-truthing for phenological observations by using satellite remote sensing in terrestrial ecosystem in Alaska

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Satellite remote-sensing is an useful tool to detect seasonal and interannual variations in sub- and Arctic terrestrial ecosystems with a high spatio-temporal resolution. However, from the *in situ* ecological research view point, the satellite remote-sensing approach has not been sufficiently tested and validated by ground-truthing. We examined the relationships between seasonal patterns of camera-based canopy surface indices, eddy-covariance-based gross primarily productivity (GPP) and satellite-observed vegetation indices at a daily time step by performing field studies in an open canopy black spruce (*Picea mariana*) forest in Alaska. The ratio of the green digital number to the total digital number, green-excess index, hue (in the hue, saturation, and intensity colour model), GPP, satellite-observed normalized difference vegetation index (NDVI), enhanced vegetation index (EVI) and green-red vegetation index (GRVI) showed bell-shaped seasonal patterns (increasing in spring and decreasing in autumn) and their correlations were detected. Although the upper layer of forest is fully covered by evergreen black spruce, canopy surface images mainly detected seasonal changes in forest-floor vegetation (*Sphagnum* moss and shrubs) and snow cover on the forest floor. These facts suggest the importance of the seasonal patterns of forest canopy and floor status for the observations of satellite-remote sensing in sparse boreal forest in Alaska. Further consideration of parameters such as the degree of canopy openness and the seasonal changes in forest-floor vegetation will therefore be required to accurately detect the intra- and interannual phenological changes in sub- and Arctic ecosystems by using the satellite remote-sensing approach.

Keywords: satellite remote sensing, ground-truthing, phenology, Alaska

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Interannual and regional variations of GRENE Arctic observation sites by Satellite

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GRENE Arctic climate research project has started in 2011, and snow and ice condition has been monitored. This study observes snow and ice conditions at the GRENE Arctic field site and trys to analyze interannual variations and regional differences. The observation area is distributed in Alaska, Greenland, Siberia.This study extracted daily microwave data for ten years period from the observation sites and descried snow conditions. As the snow condition affects many other researches through hydrological process and atmospheric boundary conditions, the seasonal cycle of snow condition is substantial for initiating project. Snow cover and melting periods are indicated and regional and interannual changes are summarized. Melting area and tendencies are investigated in Greenland ice sheet. This study overviews snow and related ground conditions at all major observation sites of GRENE Arctic project by using the satellite microwave data.

Keywords: Arctic, snow, satellite observation, GRENE Arctic project

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Large-scale analysis on long-term changes in the energy-water balance in the Arctic

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The long-term changes in the surface energy-water balance were analyzed at large-scale in the Arctic, using the global datasets of NCEP reanalysis (NNRP) and GPCC precipitation. The Wetness index (WI, Kondo and Xu, 1997) was calculated as the ratio of precipitation (Pr) to potential evaporation (Ep) that is estimated from the energy balance equation at the surface. The trends of WI, Pr and Ep were calculated as linear regression for 1951-2010. In northern Europe, the trend of WI was not significant because the positive trend of Pr is compensated by the positive trend of Ep. In Eastern Siberia, the negative trend of WI was attributed to the positive trend of Ep since the trend of Pr was not significant.

Keywords: surface energy-water balance, long-term changes, Arctic regions, large-scale analysis

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Diagnostic analysis of temperature changes in the Arctic region

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The Arctic region is experiencing one of the greatest warming on Earth and is expected to continue doing so in the near future. Because of the specificities of its climate, especially in terms of snow and sea-ice cover, the mechanisms associated with this warming are partly different from the ones of other regions in the world. One obvious contribution comes from albedo effect due to sea-ice retreat, but other specific mechanisms are possibly linked with this specific thermal response, e.g. in terms of cloud cover changes.

In this study, we decompose the surface energetic fluxes locally in order to consider the different factors influencing the temperature changes at the surface. The relative role of the different factors is considered for the Arctic region and for the whole globe separately in order to highlight the specificities of the Arctic warming.

Keywords: Arctic, Surface energetics, climate warming, temperature change

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

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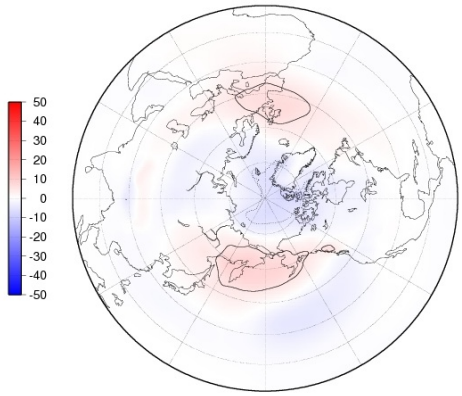
Since 1980s the sea ice extent in the Arctic Ocean has been decreasing. It is important for the climatology in the Arctic whether the sea ice exists or not. The purpose of this study is to investigate the differences of the influences to the atmosphere due to the different conditions in sea ice concentration and sea surface temperature with global atmospheric model NICAM (Nonhydrostatic ICosahedral Atmospheric Model).

Two experiments will be carried out. One is that the monthly climatology of the sea ice concentration and sea surface temperature is used as the boundary condition (normal year), and the other is that the monthly data of them in 2007 is used (less sea ice year). The time integration will be conducted for 50 years for each experiment. The sea ice concentration, sea ice mass and sea surface temperature are fixed within each month during the integration. The horizontal resolution is 112 km (glevel-6) and 40 points are taken for the vertical grid. The experiment is now in progress.

Surface air temperature over the Arctic Ocean on 2007 Experiment is much higher than that on climatological experiment especially in winter. The difference in horizontal distribution of the surface air temperature in summer season is very small compared to in winter season. The maximum difference locates where the sea ice does not exist on September but on January. The strong warming over the Arctic Ocean occurs, the difference is more than 10 degree Celsius. It is found that differences of the sea level pressure in September and January between 2007 experiment and climatological experiment shows positive AO (Arctic Oscillation) distribution, which indicates positive anomaly in mid-latitudes and negative anomaly in Arctic region.

Keywords: Polar amplification, Arctic Oscillation, NICAM, Sea ice



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Freshwater and nutrient distribution of the western Arctic Ocean

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In recent years, reduction of sea ice extent in the Arctic Ocean is remarkable and updated the smallest record in 2012. A marine environmental big change is concerned because heat and material become active after sea ice disappears. It is important to understand marine environment in summer as it influences sea ice formation in winter.

In this study, we investigated fresh water distribution which controls the sea ice formation/melting. We also investigated the nutrients distribution to evaluate the contribution of nutrient from porewater to the water column. Hydrographic observations and sampling were carried out in the western Arctic Ocean in 2000 and 2012 for sediment samples and 2004 and 2012 for water samples during R/V Mirai Cruise. Water temperature, salinity, dissolved oxygen, nitrients and oxygen isotope ratios (precision: 0.04 permille) were used as chemical tracers.

Water temperature was 2 degC higher in 2012 than that in 2004 whereas the difference of salinity was not obvious. Pycnocline by the low salinity water were found on the shelf between Bering Strait and Canada basin of the longtitude 168 degree west section . It was remarkable in September in 2012. As a result of calculation of mixing ratio of freshwater and Pacific water in shallower than pycnocline, 15˜30% and 10% of river water flew into the Chukchi Sea through Bering Strait in September and October, 2012 but less than 10 % in 2004. Low dissolved oxygen water was found near the bottom in 2012. It suggests that this low DO water were formed by the pycnocline with the large freshwater input in 2012.

The dissolved nitrogen to phosphate (DIN DIP ratio), salinity less than 33 and DIP $<$ 1umol/kg, increased 11.8 to 14.2 from the Bering Strait to the basin. It suggests that the water flowing from the Bering Strait should mix with nitrogen rich water as moving toward the north. In 2012, 29.3-1241umol/kg of DIN and 0.9-7.17umol/kg DIP were observed in porewater of the surface sediment. They were obviously higher than 16.1-49umol/kg of DIN and 1.04-3.3umol/kg of the bottom water (1m from the seafloor). These results indicate that addition of DIN is likely from the sediment on the continental shelf in Chukchi Sea.

Keywords: Western Arctic Ocean, freshwater distribution, nutrient, oxygen isotope ratio

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Sumilations of interannual variations in Arctic sea ice thickness with a one-dimensional vertical thermodynamic model

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Recently, Arctic sea-ice in summer decreases and the rate of decrease increases. The decrease of Arctic sea-ice affects on the climate not only in Arctic region but also in mid-latitudes, such as Japan. We have investigated the factors affecting on the interannual variations in sea ice thickness around Arctic sea ice by means of numerical experiments with a one-dimensional vertical thermodynamic model, introduced by Bitz and Lipscomb (1999). The model needs four surface flux inputs to calculate the temporal variations of sea ice thickness: downward shortwave radiation, downward longwave radiation, sensible heat, and latent heat. These four inputs are generated from the daily Japanese 25-year Reanalysis (JRA-25) and JMA Climate Data Assimilation System (JCDAS) from 1979 to the present, averaging over the area of 75-90N and 135-225E. The influences of each surface flux input on the interannual variations in sea ice thickness have been examined by conducting numerical experiments with some inputs for some seasons replaced by their 33-year daily climatology. The interannual variability and trend of the sea ice thickness in the control experiment, with all four inputs having interannual variability in all times, are in reasonable correspondence with those of the observed sea ice extent in the area. It is found that this correspondence is mainly attributed to the interannual variations in summertime longwave radiation, and that the interannual variations in summertime shortwave radiation play a role in suppressing the influences of longwave radiation. The recent decrease in sea ice extent brings the increase in upward sensible and latent heat flux from the ocean, and promotes the formation of thick sea ice in cold seasons. However, the promotion is almost canceled by the simultaneous increase in downward longwave radiation, presumably owing to the increase in air temperature and water vapor content. The results obtained with the model exhibits a strong sensitivity of the interannual variations in sea ice thickness to summertime (June and July) downward radiations.

Keywords: one-dimensional vertical model, sea ice thickness, heat balance, interannual variability

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Recent temporal change of Greenland ice sheet surface temperature and reflectance derived from MODIS data

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Rapid Arctic climate changes are reported in recent decades. Greenland ice sheet holds approximately 10% of the fresh water on earth. If it melts all, sea level rises about 7.2meter. It is reported that mass of Greenland ice sheet is decreasing with temperature rising of climate change. However many climate models aren't able to simulate the recent melting of snow and ice in the Arctic including Greenland. One of the possible causes is albedo reduction of snow and ice surface by light absorbing snow impurities such as black carbon and dust and by glacial microorganisms. In addition, there are reports that the dark region darkened with glacial microorganisms has emerged in the southwestern part of Greenland (Wientjes and Oerleman., 2010). However there are few researches for effect of glacial microorganisms in wide area. So it is important to clarify the impact of glacial microorganisms in wide area.

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

In this paper, we show the temporal change of monthly average ice sheet surface temperature derived from MODIS/Aqua July in recent years, from 2002 to 2010.

We use MODIS LST Product as ice sheet surface temperature. It estimates land surface temperature using Land Surface Temperature Algorithm based on split window method (Wan et al., 1996). We analyzed surface temperature on dark region (68.45N, 49W), downstream of dark region (68.45N, 50W) and upstream of dark region (68.45N, 48W).

Monthly average ice sheet surface temperature is falling in recent years around dark region. The rate of temperature change on downstream is -0.08 degree Celsius per year and the rate of temperature change on upstream is -0.07 degree Celsius per year. The rate of temperature change on dark region is -0.007 degree Celsius per year, it shows less change than the other area. It is considered that low surface reflectance advances solar radiation absorption caused by glacial microorganism. Cooling on the other area seems to be caused by appearance of low temperature ice body under the snow cover especially downstream of dark region. Low temperature ice body controls glacial microorganism growth. Cooling trend on downstream of dark region is caused by suppression of glacial microorganism.

In the future, in order to clarify the relationship between temperature change and glacial microorganism, we will develop product to determine the quantity of glacial microorganism by satellite images.

Keywords: Greenland, Surface temperature, Reflectance, Glacial microorganism