Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

ACG033-P01 Room:Convention Hall Time:May 25 10:30-13:00

Northern Hemisphere atmospheric blocking in 228-year ensemble simulation with the MRI-AGCM3.2

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In this study, we conducted 228-year ensemble integration using a 60-km-mesh MRI-AGCM (TL319L64). Model integration was conducted for the period 1872-2099 using observed and prescribed, interannually varying SSTs as lower boundary conditions. The prescribed SST was estimated by the CMIP3 multi-model ensemble mean to which the detrended interannual variations in HadISST have been added. The IPCC SRES A1B scenario was assumed for future emissions of greenhouse gases. We focused on Euro-Atlantic (EA) and Pacific (PA) atmospheric blockings in winter (November-February) and summer (May-August).

The TL319L64 AGCM performs well in simulating the blocking frequency and duration throughout the year, compared with the NCEP/NCAR reanalysis data for the period 1950-2005. It is known that there are significant relationships between PA blocking and the El Nino(EL)/La Nina(LA) conditions: wintertime western PA blocking is observed more frequently during the LA condition than during the EL condition, whereas wintertime eastern PA and summertime PA blockings are observed more frequently during the EL condition than during the LA conditions. The relationships between the PA blocking and the EL/LA conditions are well simulated for the period 1950-2005. No apparent relationships between EA blocking and the EL/LA conditions are observed and simulated for the period 1950-2005.

In terms of the timeseries of simulated areal-mean blocking frequency for the period 1872-2099, the wintertime EA blocking frequencies show the most remarkable decreasing trend, whereas the summertime EA blocking frequencies show a decrease trend mainly in the 21st Century. Given that EL condition is predicted to be preferable in the future climate and that there are no possible relationships between the EA blocking and the EL/LA conditions, the reduction in the EA blocking frequency might result from other possible reasons. On the other hand, the wintertime western and eastern PA blocking frequencies show decreasing and increasing trends for the period 1872-2099, respectively. The trends in the PA blocking frequency might be related to preferable EL condition in the future climate, unlike that in the EA blocking frequency.

Keywords: high-resolution climate model, atmospheric blocking, extreme events, long-term variation

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Estimation of global warming trend without the contributions from decadal variability of the Arctic Oscillation

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Climate change associated with recent global warming is most prominent in the Arctic and subarctic. The Arctic Oscillation (AO) is a dominant atmospheric phenomenon in the Northern Hemisphere characterized as opposing atmospheric pressure patterns between the middle and high latitudes. Decadal variability of surface temperature associated with the Arctic Oscillation Index (AOI) shows high correlation with recent global warming trend.

In this study, recent global warming trend is separated in contributions from increasing anthropogenic greenhouse gas and decadal variabilities by the AO.

It is found that the AO is an atmospheric eigenmode with zero eigenvalue, excited mostly by internal nonlinear dynamics. AO may thus be regarded as a natural variability which is basically unpredictable. According to our analysis, the global mean temperature decreased during 1940-1970 associated with the negative AOI. The global warming pattern in the Northern Hemisphere shows that the rapid warming during 1970-1990 contains a large fraction of natural variability due to the AO. Conversely, the period 1990-2010 indicates a clear negative trend AOI. The global warming seems to have ceased in response to the recent negative trend of the AOI. There is a considerable decadal variability of the global mean temperature associated with the natural variability due to the AO.

However, it is found in this study that the AO has large amplitude in local as EOF-1, but the AO is almost dynamically orthogonal to the global warming component for the global mean. The AO can be related to the decadal variability of the global mean temperature only through the feedback by climate sub-systems.

Keywords: Arctic Oscillation, Global warming, Decadal variability

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Cimate - ice-sheet - vegetation system in the Arctic region during the mid-Pliocene warm period

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The most prominent climate change is appeared in the Arctic region under the global warming through the atmosphere-ocean-sea ice-land interaction. Paleoclimatic studies about the Arctic climate variability during the past warm/cold periods (e.g., mid-Holocene, last glacial maximum, last interglaciation) could help for the future warming projection (e.g., Otto-Bliesner et al. 2006). The warmer climate sustained for long time during the mid-Pliocene warm period (MPWP) when the atmospheric CO2 concentration is higher (360˜425ppmv) and the global-mean surface temperature is higher (˜+3K) than the pre-industrial value. The efforts for simulating the climate in this interval are expected to make substantial contributions to advanced validation of climate models predicting future climate change (e.g., Jansen et al. 2007). The reconstruction of the sea surface temperature during MPWP by the deep sea sediments (Haywood et al. 2010) revealed extremely warmer environment particularly around the northern North Atlantic Ocean. The integrated study about the paleobotanical proxy data showed relatively small ice sheet and poleward shift of the boundaries between temperate forest, boreal forest, and tundra during MPWP (Salzmann et al. 2008) which means the significantly warm climate in the high latitude region.

Although the proxy records are not enough for the sea-ice reconstruction during MPWP for the reasons of the restriction of the geological data, the estimation for the amount of the perennial sea ice by use of the benthic foraminifera accumulation rate and the reconstructed sea surface temperature. Robinson (2009) revealed the possibility about the extremely warmer sea surface (˜+18K) than the present day and the seasonal ice-free condition during MPWP estimated from Ocean Drilling Program Sites in the Nordic Seas and the Arctic Ocean based on the ratio of magnesium to calcium in foraminifera and the alkenone unsaturation indices. These new data imply a major reduction of sea ice during MPWP similar to what has been observed in recent summers.

The climate system during MPWP is an example for the equilibrium system under the higher atmospheric CO2 concentration containing the ”slow feedback of the vegetation and ice sheet” (Lunt et al. 2010). Further studies about the Arctic climate during MPWP would help for the development of the knowledge about the climate-vegetation-sea ice interaction system which emphasizes the earth system under the CO2 forcing.

Keywords: paleoclimate, mid-Pliocene warm period, climate change, atmosphere-sea ice interaction, atmosphere-land interaction

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Modification of the Baroclinic Instability associated with AO Index: A Theoretical Proof of the Positive Feedback

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The modification of the baroclinic instability associated with positive and negative Arctic Oscillation Index (AOI) is theoretically investigated using a linearized 3D spectral primitive equation model.

According to the observational analysis, the AOI tends to be positive due to the enhanced northward eddy momentum flux by the transient baroclinic waves which intensify the polar jet in high latitudes and weaken the subtropical jet. Conversely, the AOI tends to be negative when the eddy momentum flux becomes southward in high latitudes causing weaker polar jet and stronger subtropical jet.

In this study the baroclinic instability problem is solved for zonal mean basic states for AOI positive and negative cases by adding and subtracting AO patterns of the zonal mean winds onto the normal basic state. The linear instability analysis shows that the most unstable Charney mode M_C changes its structure to intensify or weaken the polar jet by the eddy momentum flux associated with the positive or negative AOI. More importantly, the meridionally dipole Charney mode M_2 is modified into the monopole Charney mode M_1 (see Tanaka and Tokinaga 2002) to transport eddy momentum flux northward under the positive AOI condition. It is found that this modification is essential to intensify the polar jet during the AOI positive phase. Hence, we have theoretically confirmed that there are positive feedbacks between the baroclinic instability waves and the Arctic Oscillation characterized by the intensity of the polar jet.

Keywords: Arctic Oscillation, Baroclinic Instability, 3 dimensional normal mode

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ACG033-P05 Room:Convention Hall Time:May 25 10:30-13:00

Response of Greenland ice sheet to global warming simulated by a high-resolution ice sheet model

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We present numerical experiments of Greenland ice sheet to global warming using Ice sheet model for Integrated Earth system Studies (IcIES). A high resolution (until around 5km horizontally) is chosen in order to better resolve locally high velocity regions of ice-stream. The ice sheet model is forced by the results of global warming experiments simulated by climate models. Effect of ice-sheet dynamics on changes in the ice sheet volume will be compared with that of that of climate condition such as changes in melting and accumulation due to the global warming. Uncertainties in the model result due to the horizontal resolution are also compared with those to several factors such as parameterization schemes in the model.

Keywords: ice sheet, global warming

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ACG033-P06 Room:Convention Hall Time:May 25 10:30-13:00

Evaluation of distribution of surface albedo and temporal variation in the bare ice area of the western parts of the Gre

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The Greenland ice sheet has recently been reported to be significantly shrinked, especially, in the western ablation area (at latitude 65-71 north and longitude 49 west). In this area, visibly dark-colored ice surface, called dark region, has been found. Such a dark ice surface must affect the melting of ice because of its low albedo. Therefore, it is important to understand the present spatial distribution and formation process of the dark region on the ice sheet to evaluate its mass balance. This study aims to describe the spatial distribution and temporal variation of the dark region in the bare ice area of the Greenland ice sheet using MODIS and Landsat-7/ETM+ satellite images.

The dark regions, defined by the albedo between 0.15 and 0.30, were generally found in the ablation ice area from north to south of the western side of the ice sheet (at latitude 61-83 north). The dark regions were located at the margin of the ice sheet in the northern and southern areas while they were located at the area 50 ? 100 km away from the margin in the middle area. Temporal variations in the dark regions show that their areas generally increased and their mean albedo decreased from 2001 to 2010. In particular, the expansion of the dark region in the middle area was significant after 2005. Spectral reflectances of the dark regions indicate that their low albedo is due to surface impurities.

Landsat images revealed that the dark region in the middle area has the stripe features of blue and black ices. Comparison between 2000 and 2010 images revealed the increase of the black ice area of the stripe feature, suggesting that mineral particles supplied from the ice body accumulated at the surface. Furthermore, the band 2-3 ratio, which is indicative to amounts of red algal snow on the ice surface, showed the significant increase of the area of red snow. This suggests that snow algal production increased in this area. Therefore, it can be concluded that the expansions of the dark region is caused by accumulations of mineral particles from outcropping ice layers that contains a large amount of dusts and of organic matter derived from photosynthetic snow algae.

Keywords: albedo, dark region, temporal variation, impurities

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Roles of Mountain Ranges on Water Field in Eastern Siberia

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In Eastern Siberia, 40% of precipitation is maintained by water supply from ocean. Water vapor transport is affected by mountain range and it also affects to precipitation distribution. There were a few previous studies focusing on precipitation distribution and factors that decides distribution. To make clear water field in Eastern Siberia, we conducted forest survey at first because it was thought tree size was affected by precipitation amount. Then, we investigated precipitation distribution and water vapor transport. At last, roles of three mountain ranges (Verkhoyansk, Dzhudgzhur and Stanovoy mountain range) in Eastern Siberia are analyzed using three-dimensional atmospheric model.

Starting point of this study was forest survey in Elgeeii site (relatively south in Lena basin) and its comparison with Spasskaya Pad site (350km northwest from Elgeeii). Averaged tree height and maximum tree height took larger value in Elgeeii site, thus it was thought that southern Siberia was favorable environment for tree growth, such as much precipitation. According to routine station data, much precipitation in southern Siberia was found not only relation between Elgeeii and Spasskaya Pad but also overall Eastern Siberia.

Precipitation and water vapor flux have strong relationship each other, thus water vapor flux budget was investigated for Eastern Siberia. Taking budget box encircled with line of 59-71N and 116-138E, mainstream of vertical integrated water vapor flux was inflow through west-side and outflow through east-side. This trend became different when net flux separated into incoming and outgoing component; incoming and outgoing water vapor flux through south-side was large as much as water vapor flux through west-side. There is Stanovoy mountain range in just south of the budget box, therefore water vapor flux and precipitation may be affected by the mountain range. Not only Stanovoy mountain range but also other two mountain ranges, Verkhoyansk and Dzhugdzhur mountain ranges, are located in Eastern Siberia. Therefore sensitivity experiment of mountain range disappearance was conducted to make clear roles of mountain ranges in Eastern Siberia.

Averaging from 110-140E, it was found that Verkhoyansk mountain range had little effect on precipitation. Precipitation decrease was 0.2 mm day-1 with 200-400 m topography excavation, it was around half of other two mountain ranges. This small precipitation change was caused by lower specific humidity. However, when we focused on 133E cross-section, relatively higher specific humidity could not keep in Lena basin without Verkhoyansk mountain range.

Dzhugdzhur mountain range had larger precipitation decrease than Verkhoyansk mountain range with its disappearance. Precipitation decreased area was good agreement with elevation decrease area, therefore precipitation over Dzhugdzhur mountain range was maintained by orographical effect.

Stanovoy mountain range had similar precipitation decrease with its disappearance. Both eastern and western edges of precipitation decrease area had corresponded to elevation decrease area, however, precipitation of saddle part did not decrease even if the saddle part had been removed. In control run, there were two precipitation patterns associated with Stanovoy mountain range: low pressure pattern and frontal precipitation pattern. Low pressure pattern passed over the saddle part in control run, however, it did not disappear in no Stanovoy mountain range run. Thus eastern and western part of Stanovoy mountain range is orographical effect precipitation area and the saddle part is non-orographical precipitation area such as low pressure pattern.

Keywords: Eastern Siberia, Mountain Range, Precipitation

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Observation of frozen road along the 700km transect, Northern Alaska

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This study introduces snow survey and road freezing conditions realized over 700km along the Dalton Highway. This survey covers from inland forest and Brooks Range and Tundra in the North Slope. Satellite observations indicate spatial and temporal change of melting area. These data indicates rapid change of load condition in the snow melting season.

Keywords: Alaska, snow melting, freezing, Road

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Recent environmental changes in a tundra area in northern Siberia

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Recent climatic change in the Arctic is beyond the prediction. For example, the minimum sea ice extent of the Arctic Ocean in 2007 was unable to be predicted by any GCMs. Those changes in the Arctic have influences the environment over land and appear as increase in summer precipitation, increase in active layer soil temperature, discharge increase of northern rivers, and so on (Iijima et al. 2010). The influence of the sea ice extent reduction in Arctic Ocean could be appeared over surrounding land, such as tundra area, however, not so many reports based on observation were made so far. In the presentation, analyzing the observed meteorological and of active layer data, the recent changes over tundra area along the coast of Arctic Ocean in northern Siberia are reported.

Keywords: tundra, active layer, terrestrial change, Arctic Ocean

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Stable isotope ratios of water in permafrost and river

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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 Yakutsk and Chokurdakh, Russia. Lena and Indigirka rivers and ground water at Yakutsk city were also sampled, in order to know the hydrological processes in both areas.

Lena river water and groundwater (well water) showed the same variation during the period from 2003-2005, whereas they showed the different trend in 2006 and 2007. This may be caused by the heavy rainfall in the summer of 2006. This means that runoff from this occurred during winter after heavy rainfall, although runoff from this area is not significant usually because of dry climate and permafrost condition.

Chokurdakha is a boundary area between taiga and tundra. Surface water and ice in hallow layer of permafrost showed evaporative isotope signature depending on the surface vegetation. Our observational results showed tight relationship among hydrologic regime, vegetation, and greenhouse emission.

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Photosynthetic characteristics of vascular plants under primary succession stages in a High Arctic glacier foreland

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Photosynthetic characteristics of vascular plants were investigated to know initial colonization and establishment after deglaciation in High Arctic. The study area was located in the deglaciated area of Austre Broggerbreen, Ny-Alesund in Kongsfjorden, Svalbard, Norway. Two sites that represented different stages of succession after glacier retreat in this area were selected: transient stage and late stage. These sites were separated by a floodplain. Leaf photosynthetic characteristics were measured for the four vascular plants (*Salix polaris, Saxifraga oppositifolia, Silene uralensis, and Cerastium arcticum*) at the two sites corresponding to different stages of succession in mid-July 2010. *Salix polaris* and *Saxifraga oppositifolia* are common pioneers in the transient stage of succession, on the other hand, *Silene uralensis* and *Cerastium arcticum* are rare in the transient stage but common in the late stage. All of the measurements were performed at the peak bloom period of the each plant because the photosynthetic rate varies depending on the leaf age (Muraoka et al. 2002). Light - rETR (relative electron transport rate) curves were determined using a PAM fluorometer (PAM-2100), Walz) with control and analysis software under seven stepwise actinic light intensities and saturating pulse. The photosynthetic rate was expressed as the rETR, and rETRmax (maximum rETR) was calculated by the fitting equations as described by Eilers & Peeters (1988).

The maximum yield of PSII (photosystem II; PSII yields under no actinic light) indicated that the four vascular plants were in the healthy non-stressed condition in both the transient and late stages of succession. However, rETRmax obtained by the measurements of light-photosynthesis curve were different between the common pioneer plants (*Salix polaris, Saxifraga oppositifolia*) and otherwise (*Silene uralensis, Cerastium arcticum*) depending on the stages of succession. The common pioneer plants were measured at the almost same rETRmax in the both transient and late stages, but the value of the other two plants were lower in the transient stage than in the late stage.

Keywords: photosynthesis, primary succession, glacier foreland, arctic, tundra ecosystem, vascular plant

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Effect of tar spot disease on photosynthetic production of Salix polaris in the Norwegian High Arctic

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In accordance with GCM predictions, average Arctic temperatures have increased rapidly, at almost twice the global average rate in the past 100 years. It has been predicted that the climate change will influence not only plant but plant pathogen. However, little is known about ecophysiological characteristics of plant pathogen and effect of pathogen on plant in the Arctic terrestrial ecosystem. In this study, we aimed to clarify the effect of plant disease on net production of vascular plant in the Arctic ecosystem.

Study site was situated in polar semi desert in Ny-Alesund, Spitsbergen Island, Norway. In summer of 2009 and 2010, distribution, incidence, growth rate of a pathogen (tar spot disease) and ecophysiological characteristics of a vascular plant (Salix polaris) were investigated. In order to know effect of the disease on net production of S. polaris, we estimated the net production of the infected and uninfected leaves using a model.

Distribution of tar spot was widespread but the incidence was very low. Tar spot symptom emerged after the leaves attained full size. The symptom extended its area for a month and finally covered 16-58% (average 25%) of a leaf. There was no significant difference between the photosynthetic activity of infected leaf and uninfected leaf. Tar spot covered area in itself had no photosynthetic activity. In contrast, photosynthetic activity of green part of infected leaf was similar level with the activity of uninfected leaf. It was calculated that net production per leaf decreased about 5-13% (average 7%) by infection of tar spot disease.

In leaf level, it was estimated that small but significant effect of the disease on the net production of S. polaris. However, in community level, the effect would be negligible because of low incidence of the disease.

Keywords: Arctic, plant pathogen, net primary production, Salix polaris, tar spot disease

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Observations on photosynthesis and C and N stable isotopes of arctic ecosystem in Eastern Siberia

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North Eastern Eurasia is covered by permafrost which is the largest and the deepest in the world, and taiga forest (deciduous conifer larch) exists on it. It is expected that northern edge of taiga (taiga-tundra boundary) is greatly affected by global warming, and change in vegetation may cause greenhouse gas emission. Northward expansion of taiga forest ecosystem or expansion of tundra ecosystem may affect greenhouse emission opposite direction. Therefore, it is very important to know the vegetation change and its controlling factors.

Field observation on photosynthesis of larch and C and N isotope ratios of plants were carried out in taiga-tundra boundary ecosystem at Chokurdakh in 2008, 2009 and 2010 to investigate the response of the photosynthesis on various environmental factors. Observed rate of photosynthesis changed with PAR, and decreased when the chamber temperature was more than 20 centigrade. N content and N and C isotope ratios of larch needles varied among years and also among the sites. Needle delta C-13 was higher in 2009 than in 2008 and 2010, and needles N content was negatively consistent with delta C-13. No significant difference in larch needle delta N-15 was found between 2009 and 2010. Larch trees are generally found on tree mound which consists of sphagnum, however several trees were found growing at wet area where landscape was similar to wetland. Larch needle delta C-13 at wet area was lower than the trees at the other sites, so were the needle delta N-15 and N content. Needle delta C-13 value would usually increase with N content among the larch trees growing sites, however, needle delta C-13 value decreased with N content changed from 2008 to 2010 within the same growing site. Needle delta N-15 value would usually increase with N content among the larch trees growing sites. Within the same growing site, delta N-15 usually did not change with N content observed from 2008 to 2010. To compare morphological difference of the larch trees growing at tree mound area and wet area, the needle length showed that the average needle length was significantly shorter at tree wet area than in mound area.