

Sinking fluxes of siliceous phytoplankton in the Northwind Abyssal Plain, Oct. 2010-Sep. 2012

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Time-series sinking fluxes of siliceous phytoplankton (diatom, silicoflagellate, chrysophyte cyst, endoskeletal dinoflagellate *Actiniscus*, and edridian) were studied at Station NAPt in seasonal sea-ice area of the Northwind Abyssal Plain (75N 162W, 1975m water depth) from 4 Oct. 2010 through 18 Sep. 2012. Total of 51 sediment trap samples obtained at 180m water depth were applied in this study. Sinking flux of total mass (mainly composed of lithogenic materials) was relatively high in Nov.-Dec. 2010, July-Aug. 2011, and Nov.-Dec. 2011. However, total mass and siliceous phytoplankton fluxes in summer 2012 were relatively low compared to those in 2011. High diatom flux was observed in early winter (Nov.-Dec.) and Aug.-Sep. 2011. The diatom sinking flora except for Aug.-Sep. 2011 was mainly composed of *Chaetoceros* spp., their resting spores, and *Thalassionema nitzschioides*. This flora is similar to the diatom assemblage in the Canada Basin. The diatom sinking flora in Aug.-Sep. 2011 was mainly composed of *Fossula arctica* and *Fragilariopsis oceanica*. In this period, abundant gelatinous house of Appendicularia was also contained in the samples. The high abundances of *Fossula*, *Fragilariopsis*, and Appendicularia were not observed in summer 2012. Silicoflagellate flux showed maxima in early winter and summer both 2011 and 2012. Based on the comparison of diatom sinking flora around the study area, the absence of diatom flux peak in summer 2012 is probably due to significant influence of Beaufort Gyre waters rather than shelf waters. Chrysophyte cysts and heterotrophic siliceous dinoflagellate genus *Actiniscus* were observed throughout the sampled duration. The sinking flux of edridian *Ebria tripartita*, which is mainly observed in the outer continental shelf of Chukchi Sea, increased in Nov. 2010. The high biogenic flux in early winter did not reflect the high primary production at Station NAPt due to limited light condition in polar night. The large portion of high total mass flux in every early winter is probably explained by lateral particle transportation into the Northwind Abyssal Plain from the Chukchi Sea shelf.

Keywords: diatom, phytoplankton, sinking particle flux, sediment trap, the Northwind Abyssal Plain, the Arctic Ocean

Maintenance Mechanism of the Western Pacific Teleconnection Pattern and Its Impact on Sea Ice

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The Western Pacific teleconnection pattern (WP pattern; Wallace and Gutzler, 1981) that accompanies north-south dipolar anomalies in pressure over the Far East and western North Pacific is often observed in association with a cold outbreak over East Asia. It is known that during a prominent positive event of the WP pattern, whose northern center of action is anticyclonic anomaly, sea ice concentration tends to decrease in the Sea of Okhotsk and in the western Bering Sea, while it tends to increase in the eastern Bering Sea. Although the WP pattern has substantial influence on climate over the Far East, its maintenance mechanism has not yet been clarified.

We evaluated kinetic and available potential energy (KE and APE) conversions of the positive WP pattern to investigate maintenance mechanism of the WP pattern. The evaluation is based on a composite map of 32 strong positive monthly events in winter (DJF) for the period of 1948 - 2010. We found that baroclinic energy conversion (i.e., APE conversion from climatological-mean fields to anomalies of the WP pattern) works most efficiently to the maintenance of the WP pattern, and barotropic conversion (i.e. KE conversion from climatological-mean fields to anomalies) and feedback forcing of transient eddies through their momentum transport work less. Most of previous works have paid attention to the latter, but not to the former. This is because teleconnection patterns over the ocean have been considered to have equivalent barotropic structure, thus the barotropic conversion and feedback forcing of transient eddies have only been focused. In contrast to other teleconnection patterns, we have revealed that the composited monthly anomalies of the WP pattern exhibit baroclinic structure with their phase lines tilting southward or southwestward with height at the lower troposphere. The baroclinic structure of the positive WP pattern accompanies westward heat flux from the warmer Pacific ocean to the colder Eurasian continent around its northern center of action, which brings efficient baroclinic conversion. Anomalous heat exchange with the underlying ocean and release of latent heat by precipitation due to anomalous storm track dissipate APE of the WP pattern. Even if these dissipating processes being included, KE and APE conversions from climatological-mean field and barotropic feedback by transient eddies maintain and reinforce the anomalous field of the WP pattern.

Keywords: Teleconnection Pattern, Western Pacific Pattern, Sea of Okhotsk, Bering Sea, Baroclinic Energy Conversion

An Intense Arctic Cyclone in August 2012: A Transition Mechanism to Arctic Cyclone

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An intense arctic cyclone in August 2012 is investigated in this study. Especially, we analyzed i) three dimensional structures and ii) mechanisms of the development focused on a transition process to arctic cyclone from extratropical cyclone.

The center pressure of the arctic cyclone decreases to 965 hPa, which is an all-time minimum in August arctic cyclones. In the early phase, the arctic cyclone is a shallow baroclinic cyclone originated with an arctic front of 60 degree north. Then the baroclinic cyclone undergoes the transition process of the arctic cyclone due to the merger with a relatively weak (990 hPa) preceding arctic cyclone. The shallow baroclinic cyclone becomes a deeper and wider barotropic cyclone with a couple of stratospheric warm core and tropospheric cold core. Analyses show that the transition to arctic cyclone plays some important role in the development of the arctic cyclone.

Keywords: arctic cyclone, extratropical cyclone, transition process

The contribution of sub-grid snow distributions to climate change and polar amplification in a quadrupled CO₂ world.

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Snow cover evolution is an important factor in snow albedo feedback processes and thus "Polar amplification" within future climate projections simulated using general circulation models (GCMs). In the present study, we introduce a sub-grid snow distribution submodel (SSNOWD; Liston 2004) into the Minimal Advanced Treatments of Surface Interaction and RunOff (MAT-SIRO; Takata et al. 2003, Nitta et al. in preparation) land surface scheme, which is coupled interactively with a GCM known as the Model for Interdisciplinary Research on Climate (MIROC; Watanabe et al. 2010).

By using this new version of MIROC GCM with SSNOWD, we compare and evaluate the warming in a quadrupled CO₂ experiment with a pre-industrial control experiment. We also compared a quadrupled CO₂ experiment with a control using the original version of MIROC which assumes a simple empirical relation between snow amount and snow cover in a grid-cell. We finally estimate how the introduction of the sub-grid snow distribution representation contributes to the large-scale climate change and the polar amplification in the quadrupled CO₂ world.

Keywords: snow cover, GCM

Relative contribution of feedback processes to Arctic amplification of temperature change in MIROC GCM

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The finding that surface warming over the Arctic exceeds that over the rest of the world under global warming is a robust feature among general circulation models (GCMs). While various mechanisms have been proposed, quantifying their relative contributions is an important task in order to understand model behavior and operating mechanisms. Here we apply a recently proposed feedback analysis technique to a GCM under different external forcings including elevated and lowered CO₂ concentrations, and increased solar irradiance. First, the contribution of feedbacks to Arctic temperature change is investigated. Surface air temperature response in the Arctic is amplified by albedo, water vapor, and large-scale condensation feedbacks from that without a feedback although a part of it is suppressed by evaporative cooling feedback. Second, the contribution of feedbacks to Arctic amplification (AA) relative to global average is investigated. Under the positive radiative forcings, the albedo feedback contributes to AA predominantly through warming the Arctic more than the low latitudes while the evaporative cooling feedback contributes to AA predominantly by cooling the low latitudes more than the Arctic. Their relative effects vary with the applied forcing, however, and the latter dominates over the former in the increased solar irradiance and lowered CO₂ experiments. The large-scale condensation plus evaporative cooling feedback and the dynamical feedback contribute positively and negatively to AA, respectively. These results are consistent with an increase and a decrease of latent heat and dry-static energy transport, respectively, into the Arctic under the positive radiative forcings. An important contribution is thus made via changes in hydrological cycle and not via the 'dry' heat transport process. A larger response near the surface than aloft in the Arctic is maintained by the albedo, water vapor, and dynamical feedbacks, in which the albedo and water vapor feedbacks contribute through warming the surface more than aloft, and the dynamical feedback contributes by cooling aloft more than the surface. In our experiments, ocean and sea ice dynamics play a secondary role. It is shown that a different magnitude of CO₂ increase introduces a latitudinal and seasonal difference into the feedbacks.

Keywords: Arctic amplification, global climate model

Arctic Amplification and Arctic Oscillation

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Recent rapid Arctic warming is regarded as a research frontier in the study of global warming. Arctic amplification in the context of global warming has been a common feature in climate model predictions and in observational facts in 21st century. Arctic sea ice is melting drastically in 2007 and 2012, exceeding IPCC projections. Although ice-albedo feedback plays an important role in the Arctic amplification, it must be just an amplifier of certain warming processes in the Arctic. Enhanced northward heat transport by the atmosphere and ocean may be a response to the anthropogenic global warming. Long-term natural (internal) variability of the climate system may be another candidate of the Arctic amplification. It is difficult to quantitatively evaluate the internal variability from the long-term integration of climate models. When models are fully coupled with all climate subsystems such as ocean, cryosphere, and ecosystem, the internal variability is expected to become larger. Significant negative trend of Arctic Oscillation (AO) index in the recent years is a manifestation of the internal variability associated with the warming in the Arctic Ocean. North Atlantic warming and the increase in the Atlantic water temperature to the Arctic basin are responsible for melting of a significant portion of arctic sea ice. It may be important to realize that such an Arctic amplification is the most efficient cooling mechanism of the earth in response to the anthropogenic global warming. Moreover, the Arctic amplification results in the AO negative, causing warm Arctic and cold mid-latitudes to cool the entire earth system to decelerate the global warming. We need to aware the fact that the global warming is decelerated in conjunction with the enhanced Arctic amplification and AO negative trend in recent years.

Keywords: Arctic, Arctic Oscillation, Global Change, Arctic Amplification, Ice-Albedo Feedback, Heat Transport

Darkening glaciers and ice caps in Greenland by cryoconite

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

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

Keywords: greenland, glacier, icesheet, microbes, albedo

Possible effects of snow grain size and snow impurity concentration on the albedo measured at SIGMA-A in Greenland

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Snow and ice in the Arctic are presently undergoing drastic changes. The snow surface albedo strongly depends on snow grain size and mass concentration of light absorbing impurities. To clarify the contributions of light absorbing snow impurities to recent abrupt melting of snow/ice in Greenland, intensive observations of meteorological and snow parameters have carried out at the site SIGMA-A (78°03'N, 67°38'W, 1,490 m a.s.l.) on northwestern Greenland ice sheet during the intensive observation period (IOP) from June 26 to July 16, 2012. We installed automatic weather station to measure the meteorological elements, radiation budget, snow temperatures, and relative snow height. We have also performed snow pit work and snow samplings for light absorbing snow impurities. During the IOP no precipitation was observed in the first two weeks and a large amount of rainfall with remarkable lowering of snow surface was observed in the middle of July, when a melting event of surface snow/ice over 97% of Greenland ice sheet occurred. Snow grain shapes observed from snow pit work for snow layer of about 80 cm (annual accumulation) changed from melt forms for upper layer and depth hoar beneath that to melt forms for all layers during the IOP. Light absorbing snow impurities found from snow samples were black carbon (BC) and mineral dust, whose concentrations at surface were both increased from 0.9 ppbw to 4.9 ppbw and from 102 ppbw to 1327 ppbw during the IOP, respectively. We calculated the possible albedo reduction by the measured snow impurity concentrations using a physically based snow albedo model. The maximum albedo reduction due even to EC of 4.9 ppbw is less than 0.01 for typical grain size of melt forms, while it could be enhanced by the effect of dust of 1327 ppbw. BC equivalent total impurity concentration is estimated to be about 15 ppbw (albedo reduction -0.015). This result was consistent with the albedos measured during the IOP. The particle size of mineral dust found in surface snow during the latter half period of IOP was larger than 5 micrometers. This indicates a possible transport of mineral dust onto ice sheet surface. Mineral dust is important as nutrient salt for glacial microbial activities, which reduce the albedo in ablation area and could accelerate the melting of ice sheet.

Keywords: Greenland, albedo, snow grain size, light absorbing snow impurities, black carbon, dust

Assessing the extreme surface melt at SIGMA-A, northwestern Greenland during 2012 summer using a physical snowpack model

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It is reported that extreme surface (or near surface) melt occurred on the Greenland Ice Sheet (GrIS) across 98.6 % of its entire extent on around 12 July 2012. At the site SIGMA-A (78°03'N, 67°38'W, 1,490 m a.s.l.), which locates on northwest part of GrIS, we also observed near-surface melt, and accompanying rapid surface lowering especially during the latter half of our intensive field observation carried out from 26 June to 16 July. In this study we focus extreme near-surface melt occurred during 10 to 13 July at SIGMA-A. During the period average air temperature rose noticeably compared to the first half of the expedition period (30 June to 9 July) by about 1.6 °C, and we encountered heavy rain on snow event. Furthermore, near-surface mass concentrations of snow impurities (black carbon and dust) slightly increased to about 4.9 ppbw and 1327 ppbw, respectively.

In order to understand the detailed mechanism of the extreme near-surface melt, we employed a physically based 1-D snowpack model named Snow Metamorphism and Albedo Process (SMAP) forced by in-situ meteorological and snow data, and performed numerical sensitivity tests to assess relative contributions of temperature rise (Test-I), rain fall (Test-II), and snow impurities (Test-III), which can heat near-surface snowpack. SMAP with the default setting (CTL) was already tested using these data and we obtained reasonable results (root mean square errors for shortwave albedo and snow surface temperature were 0.024 and 0.373 °C, respectively) during 30 June to 14 July. In the Test-I input air temperature was reduced by 1.6 °C and downward longwave radiant flux was also modulated accordingly. For the Test-II we input no precipitation. Finally, in the Test-III we performed "pure snow" run where no snow impurities were input to drive SMAP.

Comparing each result by these sensitivity tests (Test-I, Test-II, Test-III) against that by CTL, and found average reductions in shortwave albedo (0.000, -0.003, and -0.013) and average increases in snow surface temperature (0.106 °C, 0.000 °C, and 0.002 °C) due to temperature rise, precipitation, and snow impurities, respectively during 10 to 13 July at SIGMA-A. These results indicate that albedo reduction is mainly caused by snow impurities, however, its extent is not sufficiently large to modulate surface energy balance dramatically. Instead, temperature rise increases net longwave radiant flux and sensible heat flux at the snow surface and heat the surface significantly, suggesting that temperature rise played an important role in the extreme surface melt at SIGMA-A during 10 to 13 July.

Keywords: Greenland, extreme melt event, snowpack model, snow albedo, snow surface temperature

Crustal rebound in Greenland inferred from ice sheet history derived from three-dimensional ice sheet modelling

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It is very important to determine the temporal variation of meltwater volume and the spatial extent of ice sheets in late Quaternary for studying past and future climate changes and for constraining mantle rheology. Most of the melting histories of ice sheets from Last Glacial Maximum have been inferred on the basis of geophysical and geological constraints (e.g., Peltier, 2004) using the glacial isostatic adjustment (GIA) modelling. However, such reconstructions have ice thickness that is unconstrained in regions from which the required geophysical data are unavailable and furthermore insufficient constraint that might support them to be glaciologically self-consistent. And also there are some difficulties in the geophysical reconstructions that are the ambiguity between ice load magnitude and the timing of ice load removal.

On the other hand, three-dimensional ice-sheet modelling (e.g., Abe-Ouchi et al. 2007) produces physically self-consistent ice sheet which further constrains the history and spatial variations of the load, but have difficulties due to their high sensitivity to the various climate forcing as well as from uncertainties associated with basal processes. However, it is clear that the combination of these two approaches would be expected to lead to a much more highly constrained reconstruction of ice sheet history.

In this study, we try to combine the two methodologies based on the three-dimensional thermo-mechanically coupled ice-sheet model and the bedrock deformation derived from GIA model. As a first step, we evaluate the crustal deformation in Greenland based on the ice models deduced by ICIES (Ice sheet model for Integrated Earth system Studies: Abe-Ouchi et al., 2007). Crustal deformation includes vertical uplift and subsidence, geoid height variations, and regional sea level variations along the coasts of Greenland. We compare the sensitivity of the adoption of ice sheet histories. In particular, we clarify the effect of Laurentide ice sheet on crustal deformation in Greenland.

Keywords: Greenland Ice Sheet, ice sheet modelling, isostasy, crustal deformation, sea level change

Weather Conditions for Large Scale Forest Fire Occurrence in Alaska

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Under a rapid climate change in recent years, a frequent occurrence tendency of a large-scale forest fire is seen in Alaska. Behind this tendency, it is thought that there is an influence of the increased number of lightning flashes under the global warming trend. In the present study, the fire data from 1956 and the thunder data from about 2000 provided by Alaska fire service (AFS) were analyzed, the occurrence characteristic of a fire of Alaska was clarified, and then the weather condition for large-scale fire occurrence was discussed.

Although Alaska is located at around 60 degree north in latitude, maximum air temperature in summer exceeds 30 degree C. and lightning occurs. There is a day when number of lightning flashes exceeds 10,000 or more in a day and a fire in the boreal forest caused by lightning could occur. Actually, the area of 26,700km² burnt in the most disastrous fire year for Alaska in 2004 due to large-scale lightning caused fires. The nine large-scale fires that exceed burnt area of 1,000 km² occurred under a record-high temperature and a strong drought.

Total burn area in 2004 was the largest since record-keeping began in Alaska in 1956. Combined with an additional 19,000km² burned in 2005, the area accounted for 10% of Alaska's boreal forests in just two years.

To clarify weather condition of active fire year, past fires during about half a century from 1956 to 2012 were analyzed. The number of active fire years that exceed burnt area of 5,000km² was 11 years in above-mentioned 2004, 2005, etc. It became clear from the fire occurrence tendency of these years that the large-scale fire has mainly started from June in Alaska. In addition, other conditions between fire and weather condition of 11 large-scale years were examined in detail.

Keywords: Forest Fire, Lightning, Alaska

Sensitivity of backscatter intensity of ALOS/PALSAR to biophysical parameters of boreal forests in Alaska

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We investigated the sensitivity of ALOS/PALSAR backscatter intensity for estimating the above-ground biomass (AGB) and other biophysical parameters (tree height, diameter at breast height (DBH), and tree stand density) in the boreal forest of Alaska. In July 2007, forest surveys were conducted along a south-north transect (150W) to profile the ecotone from boreal forest to tundra in Alaska. In situ parameters were measured in 29 forests by a combination of the Bitterlich angle-count sampling method and the sampled-tree measuring method. These in situ values were compared with the backscatter intensity of ALOS/PALSAR. A strong positive logarithmic correlation was found between the backscatter intensity and the forest AGB, with the correlation being stronger in the HV than in the HH polarization mode. No obvious saturation was found in the sensitivity of the HV mode backscatter intensity to the forest AGB up to 120.7 Mg ha⁻¹. Similarly, a robust sensitivity was found in the HV backscatter intensity to both tree height and DBH, but weak sensitivity was observed for tree density. The regression curve of HV backscatter intensity to the forest AGB appeared to be intensified by the uneven forest floor, particularly for forests with small AGB. The geographical distribution of the forest AGB was mapped, demonstrating a generally south-rich and north-poor forest AGB gradient.

Keywords: ecotone, black spruce forest, forest above-ground biomass, synthetic aperture radar, Bitterlich method

Estimation of biomass change by multi-temporal airborne laser profiling along S-N 750 km transect in northwestern Canada

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Multi-temporal airborne laser profiling missions over S-N 750 km transect along the Dempster highway from Dawson (64.0 degrees N, 138.8 degrees W), Yukon Territory to Inuvik (68.3 degrees N, 133.5 degrees W), Northwest Territories in Canada were conducted in summer of 2003 and 2011 for estimating terrestrial biomass change and monitoring how northern plants respond to possible global warming. By processing original surface profiles of the term-head and end missions, vegetation profiles were obtained as a difference between surface and ground profiles. Then standing stock, and aboveground biomass every 100 m along transect at the term-head and end were obtained by applying equation those vital indices measured at 80 sample plots on ground against average laser vegetation height. Average vegetation height, standing stock and biomass entire 750 km transect were increased from 0.51 m, 15 m³/ha and 9.0 ton d.m./ha in 2003 to 0.81 m, 23 m³/ha and 14.0 ton d.m./ha in 2011 as average annual increment of 0.037 m, 1.1 m³/ha and 0.64 ton d.m./ha. Biomass increment was much larger in forest dominated section (0-70 km from Dawson; nearly 2 ton d.m./ha/year) than tundra dominated section (450-550 km from Dawson; 0.1 ton d.m./ha/year). Air temperature and warmth index in recent 25 years have been rising 0.34 degrees and 1.2 degrees-month (more than 0 degrees Celsius in mean monthly temperature) in Dawson, 0.63 and 0.3 in Eagle plains (the middle point of transect), and 0.78 and 1.9 in Inuvik respectively and which supports soil temperature should have also been rising in this area. Both the air and soil temperature rising causes the releasing growth limitation of plants in this region. However, biomass carbon loss from forest fire seems not significant at least along the laser transect from year 2003 to 2011 from the combination of analysis of multi-temporal airborne laser profiling data set, fire history map from Yukon Territory, and observation from the air and ground.

Keywords: Canadian boreal forest, circumpolar, global warming, biomass change, airborne laser altimetry, multi-temporal measurement

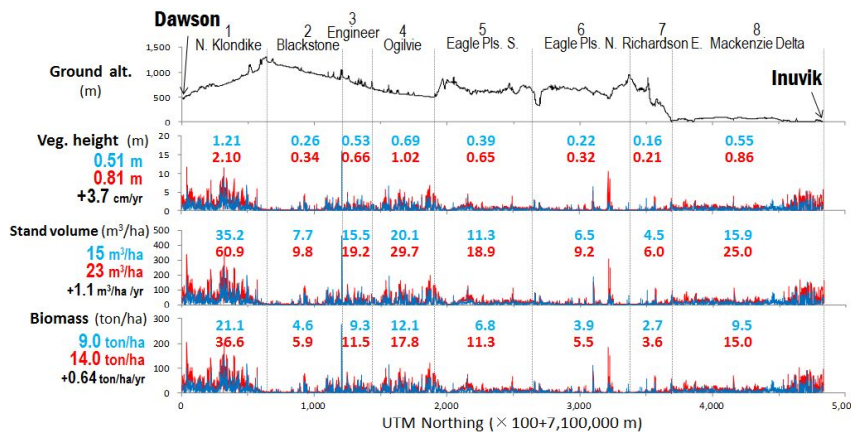


Figure Vegetation height, stand volume, and aboveground biomass in 2003 and in 2011

Changes in the Lena River discharge and net precipitation over the basin during 2005-2008

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River discharge from the Lena River in eastern Siberia is one of the large sources of freshwater in the Arctic Ocean, which plays important roles for sea ice formation and the ocean conveyor belt. It accounts for about 7% of the total freshwater inflow to the Arctic Ocean including total river discharge, net precipitation (P-E) over the ocean and ocean current. In the middle part of the Lena River basin, precipitation was high during 2005-2008 and associated several drastic changes in terrestrial water cycle were observed: extended flood, deepening of active layer and so on. On the other hand the Lena River discharge at the mouth and net precipitation over the basin were also high level during the same period. In this study, we attempt to reveal relationship between the local and basin-wide changes, and those causes associated with moisture transport and large-scale atmospheric circulation.

Annual mean river discharge and net precipitation of the Lena River show strong positive correlation during the past three decades, while they have a time lag of about three months. The discharge and precipitation over the basin also show strong positive correlation during the past seven decades. These results indicate that the interannual variation of the Lena River discharge is controlled by that of the precipitation, while effects of changes in evapotranspiration and land water storage are minor.

On the monthly time scale, net precipitation is positively correlated with precipitation and moisture flux convergence over the Lena River basin. In addition, the monthly mean precipitation shows strong positive correlation with number of days (NOD) in heavy precipitation category. During 2005-2008, the precipitation was high in several months that is consistent with observed results in/around Yakutsk. The NOD was lower in 2005 and 2006 and higher in 2007 compared to the other years. This suggests that the processes associated with the high precipitation were different in each year and in each month.

In August 2005 and August 2006, both of the precipitation and moisture flux convergence are high and heavy precipitation was frequent. However contributions of moisture flux components were different in the two periods. Stationary flux convergence dominates the total flux convergence in August 2005, while transient flux convergence contributes largely to the total flux convergence in August 2006. These results indicate that the moisture transport associated with cyclone activity affects the heavy precipitation in August 2005, while the moisture transport associated with the mean flow of large-scale atmospheric circulation affects the heavy precipitation in August 2006.

In the next step, we will analyze relationships among cyclone activity, heavy precipitation and transient moisture flux (convergence). In addition, the other events of high precipitation during 2005-2008 will be our future work.

Keywords: Eastern Siberia, Recent Change, River Discharge, Net Precipitation, Cyclone Activity

Ecological changes and their influences of wild reindeer populations in eastern Siberia

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Reindeer *Rangifer tarandus*, known for large-scale seasonal migration, is widely distributed in the Arctic and sub-Arctic regions, and the northern indigenous peoples have been living with them. Though reindeer may be influenced by changes in hydrological cycle and vegetation with global warming, there is little information about the present status of wild reindeer in eastern Siberia. In our preliminary survey (interviews to local people) in the Sakha republic, each local population has changed in its number and distribution by plural factors originated in the climate change. Therefore, we started tracking 15 wild reindeer (7 males and 8 females) in their summer range of the upper Olenek area by using the ARGOS satellite positioning system from August 2010. We found that this summer range is used by at least two populations; a northbound migration group (NMG) and a southbound migration group (SMG). Their migrating distances and their wintering landscapes are quite contrastive; forested area (tyga) 500km far from the capturing points for SMG, and open land (tundra) about 1000 km for about NMG. The wintering range of SMG is forested area which has been thought as that of other subspecies, forest reindeer *R. t. fennicus*. We should analyze their genetic status (tundra, forest, or crossing), because there is a "conservation dilemma" in the overlap area of these 2 subspecies. And also the genetic analysis should be needed between these 2 migration groups and semi-domestic reindeer, because large scale abductions of semi-domesticated reindeer by the wild may occur along these unknown new migrating routes. Each reindeer population used different habitat and different route every year, and showed frequent wandering behavior in small number. These ecological changes of reindeer populations are introducing their low growth rate, local high foraging pressure on vegetation, strong competition with musk ox, high-cost reindeer hunting, expansion of wild wolf range, and high predation pressure on domestic reindeer and horses. Thus, we need more complex conservation policies, with ecosystem-level management and rights protection of northern minorities.

Keywords: eastern Siberia, wild reindeer, migration, global warming, northern indigenous peoples, vegetation

CRYOSPHERIC STUDY IN THE GRENE-ARCTIC PROJECT

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During the first intensive observing period in 2012, glacier research in Siberia and ice sheet research in Greenland are carried out. Snow cover research and local weather research groups set the instruments in the various research fields, in Scandinavia, Alaska and Siberia. This study tries to overview the regional variations of cryospheric conditions from the Arctic climate system. Regional cryospheric reports and circum-Arctic weather conditions in 2012 summer indicates a trans-Arctic cryosphere-weather conditions, connecting Greenland melting, Siberian dry and hot summer, and instabilities of Siberian coast, northern Greenland and Japanese monsoonal weather. Alternative temperature patterns and over Arctic regions causes regional warm/cool area and temperature gradient zones.

Keywords: Arctic, Cryosphere, snow, glacier, ice sheet