

Catastrophic reduction of sea-ice in the Arctic Ocean - its impact on the marine ecosystems in the polar region-

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The sea-ice in the Arctic Ocean has dramatically reduced during the past decade. The drastic sea-ice reduction would cause a complicated and difficulty to understand the perspective on marine ecosystem surrounding the Arctic Ocean, because disadvantage phenomena such as ocean acidification and advantage phenomena such as improving light condition for primary producers, respectively, are simultaneously progressing. We have investigated the response of marine organisms caused by catastrophic sea ice reduction in the Chukchi Sea and Northwind abyssal plain at where the sea ice reduction has progressed most seriously in the Arctic Ocean. The aims of our study are No.1 to understand temporal changes in primary production, No.2 to understand the physiological response of marine phyto and zooplanktons having carbonate tests on warming or freshening associated with sea ice melting, No.3 to develop a new model for marine ecosystems in the Arctic Ocean, to reproduce the primary production by using the model and to understand the response of marine ecosystems on the environmental changes caused by rapid sea-ice reduction. In this presentation, we will show an overview of this project composed of three sub-themes, Observation, Culturing, and Modeling. For the observation, we will show a seasonal change in biogenic components flux obtained at the Northwind abyssal plain by a year round time series sediment trap system and seasonal change in dissolution of pteropod tests due to the seasonal change in the ocean acidification. We will also show the potential mechanism of high biogenic fluxes found in the beginning of the sea-ice season using the original Arctic Ocean ecosystem model. For the culture experiment, the physiological response of *Emiliana huxleyi*, coccolithophorid strain on the environmental changes caused by sea-ice melting will be presented.

Keywords: Arctic Ocean, Biogenic particle, Eddy, Ocean acidification, Coccolithophorid

Hindcast simulation of the ice and circulation in the Arctic Ocean for 1978-2012: An application of AO-FVCOM.

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A high-resolution, unstructured-grid, finite-volume ice-ocean fully coupled model system, named AO-FVCOM, has been developed for the Arctic Ocean. The governing equations are cast in a generalized terrain-following coordinate system with spatially variable vertical distribution in the vertical and are discretized using flexible non-overlapped triangular grids in the horizontal. This model system includes a) an unstructured grid version of the Los Alamos sea ice model Community Ice CodE (UG-CICE), b) hydrostatic and non-hydrostatic dynamics (NH-FVCOM); c) an unstructured-grid version of the Simulating Wave Nearshore model (SWAN) (named SWAVE), d) 3-D wet/dry point treatment, which can simulate flooding/drainage processes in estuaries and wetlands; e) 4-D nudging, OI and Kalman Filters data assimilation algorithms; f) the mass conservative nesting module to integrate multi-domain FVCOM domains; and g) the MPI parallelized visualization tool ViSiT, which allows users to monitor model performance during the simulation and post-process the model output data. An updated version of AO-FVCOM is capable of simulating the ice imbedded in the ocean.

AO-FVCOM is a regional model nested with Global-FVCOM. Two version of AO-FVCOM were configured with a finest horizontal resolution of 300 m and 2 km for the Arctic Ocean, respectively. The 2-km version has run for a period of 1978-2012. Without data assimilation, the model was capable of reproducing the seasonal and interannual variability of the ice coverage area in the Arctic and also significant drops of the ice coverage in 2007 and 2012. The 35-year simulation results for the circulation and water transport are being validated with comparison to field measurement data. The influence of the model resolution on water transport through the Canadian Archipelago has been also examined over seasonal and interannual scales, and an example of the water transport through Nares Strait will be presented.

Keywords: Arctic Ocean Modeling, Global-FVCOM, Arctic-FVCOM, Multi-domain nesting, 35 year Arctic simulation, Ice-Current Interaction

Changes in the Western Arctic Biogeochemistry over the Last Three Decades: a Modeling Perspective.

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Over the last three decades, the Western Arctic Ocean (WAO) seasonal and permanent sea ice have experienced significant changes, with the summer sea ice extent still shrinking to record low levels and the permanent ice thickness being greatly reduced. Thus, the WAO circulation (e.g. intensification of the Beaufort Gyre), the oceanic heat content and biogeochemistry are directly impacted. We use the coupled pan-arctic Biology/Ice/Ocean Modeling and Assimilation System (BIOMAS) to investigate changes in the physical system, nutrient fluxes and productivity of the planktonic ecosystem between 1988 and 2011. Model simulations show that an earlier phytoplankton bloom and a slight increase in its biomass in general characterize the WAO. The largest response in the secondary producers is seen as an increase in the magnitude of the microzooplankton biomass as well as in the duration of its growing season. Primary productivity while increasing on average over the WAO shows some decrease in the Beaufort Gyre due to its intensification. Under ice blooms such as the one observed during the ICESCAPE (NASA funded program) in July 2011 are also intensified. This research was done in collaboration with colleagues from University of Washington (Dr M. Steele and Dr. J. Zhang), Woods Hole Oceanographic Institution (Dr. C. Ashjian) and University of Rhode Island (Dr. R. Campbell).

Keywords: Arctic, Modeling, Primary Productivity, Climate Change, Food Web

Relationship of Primary Productivity in Northwind Abyssal Plain with Beaufort Gyre Variation

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The western Arctic marine ecosystem was addressed using a combination year-round mooring observation and multiple numerical models. Our previous studies have revealed eddy-induced biological pump from the Chukchi shelf region to the southern Canada Basin. Whereas this system caused an early-winter peak of sinking flux of Particulate Organic Nitrogen (PON), we then focused on summertime ecological processes. The sediment trap measurements in the Northwind Abyssal Plain (NAP: 75N, 162W) of the western Arctic Ocean captured a maximum diatom flux with dominance of sea ice species in summer 2011. However, the particle fluxes in summer 2012 were considerably suppressed probably due to extension of oligotrophic Beaufort Gyre water to the NAP area. To examine interannual variability in ocean circulation around the target region, the decadal experiment from 1979 to 2012 was performed using the pan-Arctic ice-ocean model COCO. A virtual passive tracer provided inside the Canada Basin certainly suggested that the Beaufort Gyre direction switched southwestward (toward Station NAP) during the early period of 2012. In addition, the three-box lower-trophic model with sea ice species was applied under physical environments at Station NAP to assess an impact of nutrient deficiency on primary production in 2012. Finally, we plan to discuss how to improve existent problems of Arctic marine ecosystem model.

Keywords: Arctic marine ecosystem model, ice algae, oligotrophic water

Estimating potential habitat for chum salmon (*Oncorhynchus keta*) in the Western Arctic using a bioenergetics model coupl

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Chum salmon (*Oncorhynchus keta*) are distributed widely in the Northern Pacific and are an important commercial fisheries resource in North Pacific countries. Chum salmon can be divided into North American and Asian groups, and the Asian groups can be divided further into Japanese and Russian groups, which show different migration routes. Japanese and Russian chum salmon stocks are predominant in the Bering Sea during summer and fall. However, recently, several studies reported different tendency. Higher densities of chum salmon were observed within the vicinity of the Bering Strait and the Chukchi Sea than the eastern Bering Sea on September 2007 and alike Japanese chum salmon migrated to northern areas in the Bering Sea on August 2009. Sea surface temperature in the Arctic marginal seas has increased since the mid-1960s, especially since 2000. We speculated that SST increase affect to salmon northing directly. Therefore, we focused on chum salmon migrating northward to the Western Arctic. We estimated the potential habitat for chum salmon in the Western Arctic using a bioenergetics model coupled with a three-dimensional lower trophic ecosystem model (3-D NEMURO). The model domain contained the entire Chukchi Sea and the southern area of the Canada Basin. The horizontal resolution was about 2.5 km, and there were 25 vertical levels (surface to 4000 m). We assumed chum salmon move to a depth where the growth rate is the maximum within 100 m, because chum salmon migrate vertically to below 100 m depth for controlling their body temperature and searching for prey. The model was run for nine months from March to November 2003, thus representing the entire months chum salmon are distributed in the Bering Sea from June to November. In the bioenergetics model, the growth rate of an individual chum salmon was calculated as a function of water temperature, salinity, and prey density, which were obtained from the 3-D NEMURO model results. We calculated the growth rates of chum salmon of 100 gWW to 4000 gWW and defined 'Potential habitat' as 'an area where chum salmon can grow up (i.e., the growth rate is positive)'. The potential habitat reflected the warm and nutrient-rich Pacific water inflowing from the Bering Strait. That was restricted to the southwestern Alaskan coast on June and expanded to the Chukchi Sea and along the Alaskan northwestern coast from July to September and reduced from October. The main limiting factor was the water temperature on June and November and the prey density on July to October. For global warming scenario, we used the modeled monthly water temperature anomaly between 2005 and 2095 under the IPCC SRES-A1B scenario. Under the global warming scenario, the potential habitat for chum salmon increased during early summer and autumn due to the water temperature increase, whereas during summer the potential habitat for smaller chum salmon increased but that for larger chum salmon decreased because the water temperature exceeded the optimal condition, especially in the southern Chukchi Shelf and near the Bering Strait. The water temperature limitation was relaxed with a water temperature increase on June and November, but regionally the water temperature was the main limiting factor during summer.

Keywords: Arctic, marine ecosystem model, Chum salmon

Seasonal changes in zooplankton swimmer and faecal pellets collected using a sediment trap in the western Arctic Ocean

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Most studies on zooplankton community in the Arctic Ocean have been performed on the basis of net-collected samples. However, seasonal sea ice coverage in this area prevents the accurate evaluation of their seasonal changes. To overcome these challenges, analysis on zooplankton swimmers collected using a moored sediment trap is a powerful tool. In the present study, we analysed the seasonal changes in zooplankton swimmers and faecal pellets collected using a sediment trap moored at the Northwind Abyssal Plain in the western Arctic Ocean.

Samples were collected using a sediment trap moored at 184-260 m at St. NAPt (75N, 162W, bottom depth: 1975 m) in 10-15 day intervals from October 4, 2010 to September 18, 2012. The sample cups were filled with 5% buffered formalin seawater. After the trap was retrieved, a total of 52 samples were gently sieved using a 1-mm mesh, and a fine-size fraction (<1 mm) of each sample was filtered using a membrane filter and subsequently weighed. Next, the total mass flux ($\text{mg DM m}^{-2} \text{ day}^{-1}$) was evaluated. Zooplankton faecal pellets were then quantified in an aliquot of the fine-size fraction, according to four morphological types (oval shape, cylinder shape, spherical shape and brown oval shape). On the basis of both the size fraction samples (<1 mm and ≥ 1 mm), species identification and enumeration of zooplankton were performed under a dissecting microscope. Furthermore, cluster analysis by Bray-Curtis similarity using the connected unweighted pair group method and the arithmetic mean was performed on the zooplankton flux data ($\text{ind. m}^{-2} \text{ day}^{-1}$). To identify the species most responsible for the similarity between zooplankton communities, SIMPER analyses were performed on the flux data.

In addition, satellite data were obtained, which revealed the sea ice coverage period (November-June), open water period (August-October), and high chlorophyll a period (August-October). The total mass flux ranged from 0.1-263.3 $\text{mg DM m}^{-2} \text{ day}^{-1}$, and its peaks occurred in November, which corresponded to the onset of sea ice coverage. In the faecal pellets, oval shaped and spherical shaped morphologies were predominant, and resulted in a total pellet number of 60% and 30%, respectively. With regards to the specific characteristics of the faecal pellets, the brown oval shape occurred only in the open water period (July-August) and their maximum composition during this period reached 80%. The zooplankton flux ranged from 35 to 739 $\text{ind. m}^{-2} \text{ day}^{-1}$ and was significantly higher in September-November compared with other periods ($p < 0.0001$, one-way ANOVA). In addition, poecilostomatoid copepods were numerically the most dominant taxa (annual mean $\pm 1\text{sd}$: $69 \pm 18\%$). For seasonal dominant taxa, bivalve larvae were found in October-November (53%), and barnacle larvae were abundant in August 2011 (33%) but were not present in 2012. Cluster analysis on the zooplankton flux identified five zooplankton community groups. The occurrence of each group clearly showed seasonality, and alterations in their timings corresponded with the timing of the onset or offset of ice coverage or seasonal changes in daylight hours.

On-board experiments demonstrated that the brown-oval-shaped faecal pellets might be egested by amphipods. Furthermore, the high brown-oval-shaped faecal pellets found during the open water period (July-August) might reflect the massive feeding activity of amphipods. For zooplankton swimmers, seasonal abundant bivalve and barnacle larvae may be transported from a shallower region (e.g., the Chukchi Sea). The annual change in occurrence of barnacle larvae (present in 2011, but not in 2012) may be caused by the annual changes in water mass formation in the upper layer of the St. NAPt.

Keywords: western Arctic Ocean, sediment trap, zooplankton community, faecal pellets

Volume, heat and freshwater fluxes of Pacific Water through the Barrow Canyon in the Arctic Ocean

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Interest in Pacific Water flowing from the Bering Strait into the Arctic Ocean has increased markedly in recent years, because of warming and increasing of Pacific Water inflow. Barrow Canyon, in the northeast Chukchi Sea, is a major conduit for Pacific Water to enter the interior Arctic basins. Our study focuses on the quantitative estimate of volume, heat and freshwater fluxes through Barrow Canyon by mooring observations with hydrographic surveys. We conducted year-round mooring observations at one station from 2000 to 2001 and at three stations from 2001 to 2013 in the mouth of Barrow Canyon. The annual mean volume, heat and freshwater fluxes through Barrow Canyon were 0.49 Sv, 2.25 TW and 31 mSv, respectively. Annual averaged volume and freshwater fluxes through Barrow Canyon in recent years from 2010 to 2013 were lower than the 2000-2008 averages, mainly due to strong northerly wind. In contrast, heat flux for the period 2010-2013 was higher than the 2000-2008 average. It tended to be three highest maximum in 2007, 2010 and 2012, when summer sea ice extent extraordinary retreats in the Arctic Ocean, mainly because of the warming of Pacific Summer Water. Heat fluxes observed in these years were 3-4 times larger than that observed in summer 1993. It is sufficient to melt 1-m-thick ice over an area of 360,000 km², which is equivalent to the total land area of Japan. The heat possibly contributes to both sea-ice melt in summer and a decrease in sea-ice formation during winter because this water typically subsides just below the surface mixed layer in the Canada Basin.

Keywords: Arctic Ocean, Pacific Water, Heat flux, Sea ice extent

Water masses transporting process from the Bering Sea to the Arctic Ocean revealed from multiple chemical tracers

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The Arctic Ocean is tightly connected to the Pacific Ocean through the only oceanic gateway Bering Strait. Water, heat, nutrients, and other substances inflowing via water masses exchanges affect the marine environment in the Arctic Ocean. In recent decades, the Arctic Ocean has changed dramatically, especially the rapid reduction of sea ice. The changing of water masses through the Bering Strait is thought to be one of the main reasons. Thus, focusing on the process of water masses transporting will contribute to understanding and forecasting the marine environment in the Arctic Ocean. In this research, stable oxygen isotopes, salinity and rare earth elements (REEs) are used to reveal the water masses transporting process from Bering Sea to the Chukchi Sea, which data comes from the Oshoro-Marun C255 cruise during 14 June - 07 August 2013. 182 water samples of $\delta^{18}\text{O}$ from 31 stations were analyzed by IR-MS (Isotope Ratio Mass Spectrometry). The $\delta^{18}\text{O}$ composition and salinity are used to separate the different water sources based that river water is highly depleted in $\delta^{18}\text{O}$ relative to marine waters as well as to sea-ice. Rare earth elements in the sediments from 8 stations were also analyzed by the method of BCR sequential extraction procedure which partitions the elements in sediments among various forms. It aims to trace the material sources, reflecting the water masses transporting process indirectly. The investigations show that in the Bering Sea, $\delta^{18}\text{O}$ value is around -2 ‰ in the surface increasing to -0.8 ‰ in the bottom water, closed to the $\delta^{18}\text{O}$ value of Pacific Ocean water, indicating that the upper layer water is obviously affected by freshwater. In the Bering Strait, $\delta^{18}\text{O}$ value is similar in the whole water column, around -1.3 ‰, consistent with salinity, which means that the water is well mixed in the Bering Strait (East side of Bering Strait). In the Chukchi Sea, $\delta^{18}\text{O}$ value is also affected by sea ice melt water. REEs data shows that different fraction of sediment has different sources, most part of sediments originally come from land, after charged into ocean, they combine with particles or substance under different marine environment.

Keywords: Arctic Ocean, water mass, oxygen isotope, rare earth element

Influence of the Gulf Stream on the Barents Sea ice retreat and Eurasian coldness

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Abnormal winter sea-ice retreat over the Barents Sea has been considered as a leading clue to the recent midlatitude severe winters. Barents Sea is considered as a hot spot for the rapid Arctic climate change due to the intense air-sea interaction induced by the sea-ice decrease; however, the underlying mechanisms remain uncertain, in particular causal relation of sea-ice retreat and atmospheric forcing and response. To understand this causality, we selected typical cases, defined as averaged warm and averaged cold years of December using the NCEP Climate Forecast System Reanalysis (CFSR). The composite analysis, revealed that anticyclonic anomaly is obvious over the northwestern Eurasia. The western Barents Sea and Sbarvard locates at the strong pressure gradient zone, prevailing southerly winds. Over the Barents Sea, the difference in daily mean air temperature between warm and cold winters is more than 10°C, suggesting that warm advection prevails during warm years. Therefore, during warm years, decrease in sea-ice cover is induced by southerly warm advection. The positive anomalies of precipitation from the southeast of Greenland to Barents Sea and negative anomalies of them from Nordic Sea to western Eurasia means the poleward shift of cyclone tracks, suggesting that the moisture transport is also changed poleward. Because the cyclones tend to shift poleward in less sea ice year over the Barents Sea, it is natural that the snow depth over the sea ice near the Fram Strait shows a positive anomaly during warm winters. Here we show that the poleward shift of sea surface temperature over the Gulf Stream, where is situated upstream from the Barents Sea, modifies the horizontal distribution of tropospheric condensational heating resulted from change in convection over the warm current, likely acting as a bridge to the Barents Sea by forcing planetary waves. This remote atmospheric response modifies cyclone tracks poleward, resulting in anomalous warm advection over the Barents Sea sector.

Keywords: Gulf Stream, Arctic, Barents Sea, Eurasian coldness

Study of interannual variability of the atmospheric water cycle in the Arctic circumpolar region

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The thawing depth (active layer depth) in late summer drastically deepened and the soil moisture increased from 2005 to 2008 in the middle of the Lena River Basin. This was partly due to the high rainfall in late summer, as well as the high snowfall in winter. Subsequently, permafrost-forest degradations and waterlogging has been detected in the region. To clarify whether high precipitation occurred in the past in this region, we investigate the atmospheric water cycle and water budget using archived precipitation (PREC/L) and atmospheric re-analysis data (JRA-25, JRA-55). Previous studies revealed a negative correlation in the summer atmospheric circulation pattern between the Lena and Ob River Basins. However, little is known about the atmospheric water cycles in the Arctic circumpolar region, including the Mackenzie River Basin. Hence we analyzed the interannual variability of the atmospheric water cycle in the Arctic circumpolar region, comparing the three large North Eurasian river basins (Lena, Yenisei, and Ob) and the Mackenzie river basin. The analyzed results are as follows.

1) In the highest five-year summer net precipitation in the Lena River basin during the period 1958 to 2012, significant cyclonic deviation was present from the Barents Sea towards the region across from the Yenisei and Lena. The deviation distribution of the height field and the water vapor flux from the west to the Lena river basin were significantly increased, so as to form a positive deviation of net precipitation.

2) A significant enhancement of cyclonic circulation was detected from 2005 to 2008 on the Eurasian side of the Arctic Ocean. However, anticyclones appeared over Mongolia. These probably increased the atmospheric moisture convergence over the Lena River Basin in this period.

3) A significant positive trend in the summer precipitation and the summer net precipitation appeared after 1995 between the Lena and Yenisei River Basins. On the contrary, the negative trends between the Lena and the Ob River Basins became unclear from 1993.

Keywords: summer precipitation, summer net precipitation, Lena River Basin, Arctic cyclone

Evaluation of Large-scale Surface Wetness Variations in Northern High Latitudes During 1980-2010

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Large-scale surface wetness is evaluated by a wetness index (WI), calculated from GPCC precipitation divided by potential evaporation (Ep) using ERA interim data during 1980-2010. The climatological distribution of annual WI agrees with that of surface soil moisture (SSM) in ERA interim. Anomalies of annual WI also have strong relation with that of SSM in each region; the correlation coefficient between SSM and WI is higher than that between SSM and precipitation. Therefore WI corresponds to SSM for climatology and year-to-year variations.

The linear trends of WI, Ep and precipitation are calculated, with an attempt to decompose the factors of WI trend into those of Ep and precipitations. In high latitudes of Eurasia and eastern Canada, the increasing precipitation trends are canceled by the increasing Ep trends, resulting in little WI trends. In central Asia, western North America and Alaska, the decreasing precipitation trends and the increasing Ep trends lead to the decreasing WI trends. The precipitation variations dominate the WI variations in most regions. For example in Alaska, the decreasing precipitation trend contributes 72% to the decreasing WI trend and the increasing Ep trend does 27%. On the other hand, there are some regions where the Ep trend is important for the WI trend. For example in monsoon Asia, the precipitation trend is small and contributes only 3% to the decreasing WI trend, while the increasing Ep trend does 99%.

Consequently, it is shown that WI corresponds to surface soil moisture and indicates surface wet/dry conditions, and that the contributions of precipitation and Ep to its trends are quantified. Further analyses will be applied to the outputs of global climate models (GCMs) to evaluate reproducibilities of the surface energy-water balances in those GCMs.

Keywords: surface wetness, large-scale variations, reanalysis data

Multidisciplinary in situ and satellite observations for accurate detection of phenology in sub- and Arctic ecosystems

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To accurately evaluate the spatio-temporal variability of ecosystem functions and service in sub- and Arctic regions under rapid meteorological and climate changes, global, long-term, and comprehensive phenological observations are required. Towards this aim, satellite remote-sensing is useful to detect the spatio-temporal variability of plant phenology such as the timing of start (SGS) and end of growing season (EGS). However, from the in situ ecological research viewpoint, the satellite remote-sensing has not been sufficiently tested and validated by ground-truthing. Here, (1) we performed daily field observations with time-lapse digital cameras in boreal forests in Alaska and Siberia; (2) we examined the relationship between satellite-observed vegetation indices and plant phenology; and (3) we evaluated the spatio-temporal variability of the timing of SGS and EGS in sub- and Arctic regions by using MODIS Terra and Aqua-observed green-red vegetation index (GRVI). We found that (1) satellite-observed vegetation indices (i.e. NDVI, EVI, and GRVI) mainly detected the plant phenology of forest floor in sparse forests; (2) large year-to-year variability of the timing of SGS was detected in eastern Siberia and western Ural Mountains, while that of EGS was not clearly detected; and (3) in contrast, large year-to-year variability of the timing of EGS was detected in western Alaska, which is mainly covered by tundra vegetation, while that of SGS was not clearly detected.

Keywords: phenology, remote sensing, terrestrial ecosystem, Siberia, Alaska, ground-truthing

Estimate of permafrost organic carbon balance in Alaskan boreal and tundra ecosystems using natural radiocarbon tracer

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The high-latitude regions, where a serious warming is expected, currently store large amounts of soil organic carbon in active-layer soils and permafrost, accounting for nearly half of the global belowground organic carbon pool. Despite the importance of these regions in the present carbon cycle, the soil C fluxes and budget are still only poorly known. Here, we use radiocarbon as the tool for quantifying the C balance of the inputs and decomposition in tundra and boreal soil. We evaluated the C inputs (I) and decomposition rates (k , inverse of turnover time) and net C accumulation (CA), using ¹⁴C approaches.

Tundra and boreal soils show different patterns of depth distribution and C storage. Cumulative organic carbon stocks in boreal forest are 5.3 and 19.2 kgCm⁻², in surface organic layer (0-25 cm), and deep organic and mineral layers (25-70 cm), respectively. Large annual C input (0.25 kgCm⁻² yr⁻¹) and relatively slow decomposition (27 years) lead to rapid CA (0.05 kgCm⁻² yr⁻¹) in surface organic layer in boreal forest. Deep organic and mineral layers including near-surface permafrost show slower rate of input (0.03 kgCm⁻² yr⁻¹) and turnover (617 years) and CA about 20 times slower (0.003 kgCm⁻² yr⁻¹) than surface organic layer. Decomposition organic matter (Rh), which in accord with C losses from both surface and subsurface layers, was 0.23 kgCm⁻²yr⁻¹. This value agreed well with Rh (0.23 kgCm⁻² yr⁻¹) simulated by process-based models that simulate the biogeochemical and hydrologic cycle, where Rh averaged 45% of ecosystem respiration and 59% of soil respiration.

In contrast, large amount of SOC (36.4 kg m⁻²) have accumulated over millennia (turnover time: 4540 yrs) below the thin organic layer in tundra. The CA of mineral layer and permafrost is close to zero (0.003 kgCm⁻² yr⁻¹), and Rh is 0.008 kgCm⁻² yr⁻¹. Our radiocarbon data show that the most SOC in tundra soil was mode of stabilizing OC by permafrost and steady-state SOC stocks under current C balance.

Large-Scale Forest Fires in Alaska: Weather Conditions in 2004 and 2005

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In Alaska, large-scale forest fires mainly occurred in the boreal forest of the Interior (area roughly around 400 x 800 km) in 2004 and 2005. Number of large-scale forest fires (burnt area more than 500km²) were 17 in 2004 and 12 in 2005. These large-scale forest fires boosted up burnt areas 26,000km² in 2004 and 18,800km² in 2005. Their areas were largest and third largest among the past 58 years from 1956 to 2013.

In order to evaluate large-scale forest fires in both years, statistical analysis for the fire data in the past 58 years was carried out. As a result, annual average burnt area was 3,480 km², and the coefficients of standard deviation (sigma) were +4.25 for 2004 and +2.88 for 2005. In the background of these large standard deviation coefficients, only 11-year could show large burnt area of more than 6,000km², and burnt area of other 47-year were less than 5,000km². In addition to this trend, the occurrence of fire year with burnt area more than 6,000 km² was once per decade from the 1950s to the 1980's. But from the 1990's, fire year tended to occur more frequently. That is, they were 1957 (2nd largest), 1969 (6th), 1977 (7th), 1988 (8th), and these frequencies were once per decade. However, from the 1990s, fire years occurred in 1990 (4th largest), 1997 (9th), and 1991 (11th). From the 2000s, four fire years observed in 2004 (largest), 2005 (3rd largest), 2009 (5th), and 2002 (10th). The frequent occurrence trend of such fire year may be suggesting close relationship with the rapid reduction of sea ice in the Arctic Ocean under a rapid climate change.

From the comprehensive analysis in this paper, largest burnt areas in 2004 happened under the condition made by ridge extended from Canada lasted about three month from June to August. The very severe fires observed in August 2005 occurred along with the movement of the high pressure system from the Gulf of Alaska to the Beaufort Sea.

Keywords: Forest Fire, Hotspot, Climate Change, Lightning, Jet Stream, Sea ice

Detection and attribution of changes in arctic ecosystems and atmospheric CO₂

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Atmospheric CO₂ responds to terrestrial ecosystem activity widely from sub-hourly to decadal time scales primarily due to photosynthesis, weather and climate variations. The measurements of CO₂ thus consist of source signals from anthropogenic as well as natural ecosystem activities convolved with atmospheric transport. Since the records of CO₂ concentration in ambient air at monthly or finer time resolution began in the late 1950s, the seasonal ecosystem dynamics has enhanced significantly in the recent years (Graven et al., 2013). We further analyse the relative contributions of fossil fuel emissions and atmospheric transport on the CO₂ at a greater number of surface measurement sites since the 1980s using the CCSR/NIES/FRCGC atmospheric general circulation model (AGCM)-based chemistry transport model (ACTM). Our results suggest the trends in fossil fuel emissions and transport have detectable contribution to the CO₂ seasonal cycle changes at the sites in northern tropics to mid-latitudes, and that the seasonal cycle increase in the arctic region is governed mainly by the terrestrial ecosystem.

To attribute causes for the recent changes in carbon cycle dynamics we have chosen the period of 1999-2011, which is covered by high quality process oriented ecosystem parameters from remote sensing and atmospheric CO₂ measurements at the largest network of sites for flux inversion. Our analysis suggests that the early greening by several days in the Alaskan tundra region closely correlated with the amplitude of CO₂ seasonal cycle at Point Barrow, Alaska. But no clear trend in the greening onset is detectable at semi-arid grasslands near Ulaanbaatar, Mongolia, except for the closely coupled interannual variations in greening onset time and CO₂ seasonal cycle amplitude. We estimated CO₂ fluxes from 84-regions of the globe at monthly time intervals using measurements from about 100 sites. The terrestrial CO₂ fluxes are estimated after removing the effects of fossil fuel emissions and oceanic fluxes in measured CO₂ concentrations. We find the carbon exchange of the Alaska region of our inversion is increased both for the seasonal cycle amplitude and net annual uptake over the period of 2002-2011.

Our results have large implications for developing the future and validating the present earth system models for studying climate-carbon-biosphere interactions.

Keywords: CO₂ seasonal cycle, Ecosystem phenology, Arctic environment

Epoch difference of water cycles in eastern and western Siberia

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Among all the rivers flowing into the Arctic Ocean, the three great Siberian rivers; Lena, Yenisei and Ob, are the three largest in terms of water discharge (R), and they are a large source of freshwater. We examined the relationship of long-term water cycle variability between eastern and western Siberia on the basis of net precipitation ($P-E$) estimated from an atmospheric reanalysis, and R s from observations at the river mouths and from a reconstruction based on tree rings.

The relationship of summer ($P-E$)s between the Lena and Ob Rivers is different in the first half and the second half of the past three decades. During 1980s to mid-90s, the ($P-E$)s have a strong negative correlation. These variations were affected by the east-west seesaw pattern of moisture flux. These results are consistent with Fukutomi et al. (2003). The decomposition analysis revealed that the stationary component of moisture flux dominates the seesaw pattern during the period. After mid-1990s, the correlation of the ($P-E$)s between the Lena and Ob becomes weak. During mid-1990s to 2000s, the $P-E$ over the Lena was affected by cyclonic moisture flux over the basin. In addition to the stationary component, the transient component of moisture flux also affects the $P-E$ variation in this period.

Long-term records revealed that the R s of the Lena and Ob Rivers have moderate or weak positive correlations and strong negative correlations before the 1980s. Interestingly, the correlations tend to be distributed in the negative side. It implies that the east-west seesaw pattern frequently appear over Siberia. In conclusion, the moisture transport processes over Siberia are different in each era and they result in the different variability of the R s and ($P-E$)s of the Lena and Ob Rivers.

Keywords: Siberian rivers, moisture transport process, net precipitation, river discharge, interannual variation, long-term variability

The Structure Change of Arctic Cyclones on Cyclone Phase Space

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In this study, we investigated the structure change of the Arctic cyclone's life cycle on a cyclone phase space.

Keywords: Arctic cyclone, Structure change, Cyclone phase space

A negative phase shift of winter AO/NAO due to the recent Arctic sea ice reduction in late autumn

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Attribution of the long-term changes in the wintertime Arctic Oscillation (AO)/North Atlantic Oscillation (NAO) to the recent Arctic sea ice reduction is studied. Observations using ERA interim reanalysis and Merged Hadley/OI-SST show that small (large) sea ice area in summer to autumn leads the negative (positive) phase of AO in early winter and NAO in late winter. Relationship with winter AO/NAO is the strongest with the sea ice variability in November rather than September. To separate influences of sea ice variability and sea surface temperature (SST) anomalies, sensitivity experiments are performed with atmospheric general circulation model (AGCM for Earth Simulator, AFES4.1), in which observed changes (anomalies of 2005-2009 from 1979-1983) of the sea ice and SST are prescribed. The Arctic ice reduction generates the negative AO/NAO pattern that brings cold winter in mid-latitude continental regions. Both SST anomalies in the tropics and mid-/high-latitudes mask the continental cooling. Model-based analysis reveals that stationary Rossby wave response to the ice reduction in Barents Sea induces anomalous meridional circulation corresponding to the negative AO. The ice reduction increases (decreases) a frequency of the large negative (positive) AO occurrence about a twice (half). The anomalous meridional circulation warms the Arctic and cools the mid-latitudes. This provides additional Arctic heating about 25% of heat release due to the ice reduction. As a response to ice reduction, transient eddy activity over northern Eurasia is reduced and the change in the eddy damps the stationary responses.

Keywords: Arctic sea ice loss, Arctic Oscillation, long-term changes

Cross spectral analysis of the AO index using the AOI equation

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Arctic Oscillation (AO) is explained as an atmospheric dynamical eigenmode. There is an argument, however, that the AO is a statistical illusion by the EOF analysis. Tanaka and Matsueda (2005) showed AO mode as the most unstable standing mode in the barotropic atmosphere. In addition to the zero frequency of the mode, the growth rate becomes also zero for adequate frictional force and interaction with transient eddies. Such a mode can be amplified resonantly by quasi-situational forcing. This idea of the AO is called singular eigenmode theory. For the problem of missing correlation in surface pressure between the Pacific and Atlantic is explained by Suzuki and Tanaka (2007) by analyzing barotropic height instead of the surface pressure. The barotropic height indicates significant correlation between the two regions. The missing correlation is thus explained by the baroclinic component of the atmosphere. We support the singular eigenmode theory, but a further analysis is required by the data analysis of the AO index. In this study we derived an equation called AOI equation from the definition of the AOI differentiated with respect to time, and substituting the primitive equation. According to the analysis result of the NCEP/NCAR reanalysis for 62 years of data, it is found that the AOI time series is proportional to the linear term of the AOI equation. The nonlinear term and external forcing term indicate inverse correlation with the AOI, which tend to damp the AOI to the normal. The fact that the linear term of the primitive equation is proportional to the AO structure, i.e., $L*x = a*x$ implies that the AO is an eigensolution of the dynamical system. The present study supports the singular eigenmode theory from the data analysis using the AOI equation.

Keywords: Arctic Oscillation, Global warming, Low-frequency variability, Singular eigenmode theory, Normal mode, Barotropic instability

Cryospheric studies using satellite data in the GRENE Arctic Project

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GRENE Arctic Climate Research project aims to establish interdisciplinary collaborations of different scientific area. The GRENE project constructed the Arctic Data archive System (ADS) at NIPR to support this researching frame. ADS stores the field data obtained by the project, satellite data by collaboration with JAXA and modelling output from climate models. This presentation introduces activity of data archiving in GRENE Arctic project and ADS for multiple studies.

This study investigates cryospheric change using satellite data stored in the ADS and other satellite programs.

Keywords: Arctic, Cryosphere, Satellite, data archive

Recent changes of satellite-derived snow grain size and glacial microbial activities in Greenland ice sheet

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Snow surface albedo strongly depends on snow grain size and mass concentration of light absorbing impurities. These snow parameters are uncertain factors for the recent drastic snow and ice meltings in the Arctic. Particularly, Greenland ice sheet (GrIS) is presently undergoing drastic changes. In 2012 a record melting event of surface snow/ice occurred over the GrIS. When air temperature increases, snow grain size is also increased by accelerating the snow metamorphism and thus the albedo is reduced (positive albedo feedback). This process is mainly dominant in the accumulation areas. On the other hand, the bare ice area is extended by snow melting on ice associate with air temperature raise in ablation areas. It is recently reported that wide bare-ice areas in GrIS are covered with glacial microbes whose albedos are lower than that of blue ice surface. This albedo reduction effect is also another positive albedo feedback effect by glacial microbes. To examin these feedback effects by snow grain growth and glacial microbial activities in conjunction with air temperature increase, we retrieved snow grain size and glacial microbe concentration from Moderate Resolution Imaging Spectroradiometer (MODIS) data. The employed algorithm is based on a look-up table method for bidirectional reflectance distribution function at the top of the atmosphere as functions of snow grain size, snow impurity (soot) concentration, solar and satellite geometry. The employed satellite channels are 0.46, 0.86, 1.24, and 1.64 μm . Since the snow impurity concentrations in accumulation area are the same or lower level of the detection limit of soot concentration in GrIS, we use this retrieval result as an indicator of microbial activities in bear ice areas. The monthly averages of snow grain size and snow impurity concentration from 2000 to 2013 in GrIS derived from Terra/MODIS revealed the following facts. (1) The areas of large grain size changed year by year. (2) There is no constant increasing trend, but the larger values were observed in recent years (2009-2012) and especially for 2012 the remarkable increase in whole Greenland. (3) Larger snow grain size and high impurity concentration, which indicate the areas of high glacial microbial activities, are distributed in coastal regions of GrIS in June (mainly in southern part), July and August. These parameters in colder summer of 2013 than the recent several years, were almost the same as those in 2000.

Keywords: Greenland, snow grain size, glacial microbe, albedo, satellite remote sensing, MODIS

Acceleration and deceleration of ice thickness variations in Greenland from ICESat laser altimetry (2003-2009)

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The laser altimeter mission ICESat, launched by NASA in January 2003, measures the Earth's surface elevation with a precision of several cm. ICESat has performed campaign observation of about 90 days a year between September 2003 and October 2009. The spatial resolution of the measurement in Greenland is about 20 km in average. In this study, we analyze acceleration/deceleration of ice thickness variations in Greenland from ICESat elevation data. We employ Plane fitting method (e.g. Zwally et al., 2011) to correct topographic effect coming from gaps of repeat-track paths, and fit the time-series of surface elevation variations with a linear combination of linear and quadratic terms by least-squares method at every 700m interval. The quadratic trend signal thus extracted represents accelerated/decelerated variations.

The obtained linear variation suggests significant ice thinning trend in southeastern and western Greenland. Their thinning rates attain to about 1.5-2 m/yr. On the other hands, inland area shows ice thickening trend with a rate of 0.3 m/yr. Assuming the firn density as 700 kg/m³ in ice thinning area and 300 kg/m³ in ice thickening area, we obtain the total ice loss rate of about -200 Gt/yr, which is equivalent to about 0.55 mm/yr sea level rise. This agrees well with GRACE gravimetric estimate.

Next we focus on the quadratic variation. Western Greenland shows significant negative quadratic variations, suggesting acceleration of ice thinning rate. Such trend is particularly noticeable in Jakobshavn glacier and Qaanaaq area. On the other hands, southern Greenland shows different behaviors: negative quadratic variations (accelerated ice thinning) in Helheim glacier and Kangerdlugssuag glacier, and positive quadratic variations (decelerated ice thinning) in other coastal area. We speculate that accelerated ice thinning in the above outlet glaciers reflects recent global warming, while decelerated ice thinning in other coastal area of southern Greenland does anomalous precipitation of Arctic Oscillation with positive phase during the winter of 2007-2008.

Keywords: Greenland, Ice thickness variation, Climate change, Space geodesy, ICESat, GRACE

Sensitivity of Response of Greenland Ice Sheet to Global Warming on Surface Mass Balance and Initialization methods

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We present a series of numerical experiments of Greenland ice sheet under global warming condition using Ice sheet model for Integrated Earth system Studies (IcIES).

In this study, influence on the simulation from the difference in the method to compute the surface mass balance is focused.

Typically, ice sheet simulation is driven by a *reference-anomaly* method, in which the surface temperature and/or the accumulation are decomposed into the reference terms (e.g., observation), the anomaly (e.g., climate scenario from climate models).

Then the surface melting is computed using parameterization such as positive degree-day (PDD) method with the temperature.

These decomposed terms have own uncertainties, which may influence the ice-sheet simulation.

In this study, impact of these properties to the present-day control case, as well as the response under uniform warming condition are discussed, which is thought be a useful and basic information of the property/sensitivity of the Greenland ice sheet.

In addition, several initialization methods (free spin-up, fixed-topography spin-up, etc) are applied to IcIES in order to evaluate the influence of the error in the present-day simulated topography to the short-term response of Greenland ice sheet.

Keywords: Greenland ice sheet, Ice-sheet model

Ice thickness change of Bowdoin Gletscher, northwestern Greenland

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Ice discharge from calving glaciers in the Greenland ice sheet (GrIS) has recently increased through the acceleration of glaciers, and this increase plays an important role in the ice volume change of GrIS and sea level rise. Previous studies have used remote-sensing (RS) data to assess surface lowering of calving glaciers in GrIS. However, because of the remoteness of these glaciers, relatively few field data are available on the surface elevation change. Consequently, RS data have been used without calibration with field data. The accuracy of such studies relies on digital elevation models (DEMs) derived from satellite data.

In this study, surface elevation was measured along longitudinal and three transverse profiles in Bowdoin Gletscher (77°41'18"N, 68°29'47"W) in July 2013. DEMs of Bowdoin Gletscher in August 20, 2007 and September 4, 2010 were generated by Advanced Land Observing Satellite (ALOS) Panchromatic remote-sensing Instrument for Stereo Mapping (PRISM) images with a 50 m grid mesh, and calibrated using field data. Mean surface elevation change along the field survey profiles were -16.3 ± 4.0 m (5.3 m yr^{-1}) in 2007-2010 and -10.8 ± 4.0 m (-3.8 m yr^{-1}) in 2007-2013. Surface elevation change along the lower most transverse profile (800 m from the calving front) was more negative than those along the other profiles in the upper reaches. Surface lowering rate at all profiles has decreased from 2007-2010 to 2010-2013.

Keywords: Calving glacier, Greenland

Estimation of glacier motions at Svalbard, NovayaZemlya with ALOS/PALSAR

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While the Greenland Ice Sheet's mass loss is equivalent to 0.6mm/yr sea level rise, a half of them is attributed to the changes in glacier dynamics (Broeke et al., 2009). Namely, surface velocities of many glaciers in Greenland have increased in the recent decade (Moon et al., 2012). We thus wonder if glacier velocities outside Greenland have also increased or not.

Svalbard and NovayaZemlya are arctic islands located at 78 degrees north and 74 degrees north, respectively, and have many glaciers. Stozzi et al. (2008) estimated glacier motions in these islands with SAR in 1990s. However, there are not any studies with SAR in recent decade.

We examined Duvebreen glacier in Svalbard and Vize Glacier in NovayaZemlya. In this study, we used PALSAR derived by the ALOS satellite launched from Japan. The PALSAR data were acquired 10 times at Duvebreen glacier from July 2007 to October 2010, 13 times at Vize Glacier from February 2007 to December 2010. We compared the result with 1990s velocity in previous study.

Accordingly, two glaciers in Svalbard and NovayaZemlya speeded up from 1990s. This result suggests that velocity of other arctic glaciers increase as Greenland's glaciers.

Keywords: svalbard, novaya zemlya, glacier, alos, duvebreen, vize glacier

Snow impurity concentration and snow grain size measured in Ny-Alesund, Svalbard

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Mass concentration of light absorbing impurities in snow and snow grain size are important parameters controlling snow albedo. An increase in light absorbing impurities such as black carbon (BC) reduces the visible albedo and that in snow grain size reduces the near-infrared albedo. To monitor these snow physical parameters and evaluate those effects on snow albedo in the Arctic, we have measured the snow parameters using a ground-based spectral radiometer system for albedo and flux (GSAF) in Ny-Alesund, Svalbard (78°55'N, 11°55'E). The BC concentration in snow and snow grain sizes in the topmost and subsurface layers were retrieved from spectral albedos measured using the GSAF from March to June, 2013. Furthermore, the retrieved snow parameters were validated by comparing with in-situ measurements based on snow pit work and snow sampling in April, 2013. The collected snow samples were filtrated, and then elemental carbon (EC), organic carbon (OC) and dust concentrations in snow were measured by filter weighing and thermal optical analysis.

The snow depth gradually increased up to 40 cm during the polar night from late October to late February. It maintained around 40 cm until the middle of May, and then rapidly decreased to 0 cm in early June. The BC concentrations retrieved from the GSAF varied little during March to June with about 110 and 40 ppbw for external and internal mixture models employed in the retrieval algorithm, respectively. The in-situ measured EC, OC and dust concentrations were 8-35, 32-190 and 570-3180, respectively. The BC-equivalent concentrations estimated from the light absorbing effects of both EC and dust were 18-43 ppbw, which agreed with the GSAF-derived BC concentrations using the internal mixture model. The topmost layer snow grain radius retrieved from the GSAF were varied within the range 30-300 μm until the middle of May, then increased more than 1000 μm with the snow melting. The snow grain sizes in the subsurface layer were generally larger than those in the topmost layer, which was consistent with the in-situ measurement. We estimated the possible albedo reduction by snow impurities using a physically based snow albedo model with the GSAF-derived snow parameters. The albedo reduction was enhanced to -0.038 during snow melting period after the mid-May, compared with -0.027 before the mid-May, mainly due to the increase in snow grain size.

Keywords: light absorbing snow impurity, black carbon, dust, snow grain size, Ny-Alesund

New developments of Arctic Data archive System(ADS)

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Arctic is the region where the global warming is mostly amplified, 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.

ADS developed the the online visualization system (VISION) of grid data (a satellite and model simulation), which observational researcher was not good. This VISION which can easily visualize special change can become effective for not only the understanding of the phenomenon but also the design of the observation for an observational researcher.

Keywords: Arctic, Environment, Global Warming, ADS, Visualization, VISION

Recent advance in discussions on the Arctic Environmental Studies

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This presentation introduces recent activities of the discussion on Arctic environmental studies. There are many national and international discussions on the Arctic study. Japan Consortium for Arctic Environmental Research (JCAR) has started discussions on the future study plan. IASC and ICARP-III discuss on the enhancement of present and future Arctic research and coordinations.

Keywords: Arctic, Environmental study, planning

Sea ice and ocean primary production and phenology in the Arctic Ocean

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In the Arctic Ocean, both phytoplankton and sea ice algae are important contributors to primary production and the arctic food web. We use a coupled ice algal and pelagic ecosystem model embedded in the global physical model POP-CICE (Parallel Ocean Program- Los Alamos Sea Ice Model) to study the ecosystem response to climate changes. The model results showed a mean seasonal cycle of ice algal production from March to May and subsequent ocean production from May to September in the Arctic. The ice algal production, although smaller than that of the ocean, is of ecological importance as a food source for higher trophic levels during the long arctic winter before ice melt. The simulated mean open-ocean upper 100m primary production within the Arctic Circle was 413 Tg C/yr in the years 1998 to 2006, close to the remote sensing derived estimate of 419 Tg C /yr but with higher interannual variations. The mean sea ice algal production in the Northern Hemisphere from 1998 to 2007 was 21.3 Tg C/yr, which is in the range of multi-observational estimations of 9 to 73 Tg C/yr based on in situ measurements. Arctic organisms are adapted to the strong seasonality of environmental forcing. Climate warming causes shrinking ice coverage and earlier ice retreat in the Arctic, which is likely to change the timing of primary production. Using a synthesis of available satellite observation data and the coupled ice-ocean ecosystem model, we found that, over a large portion of the Arctic marginal seas, the timing variability of ice retreat at a specific location has a strong impact on the timing variability of pelagic phytoplankton peaks but weak or no impact on the timing of ice-algae blooms in those regions. The model predicts latitudinal and regional differences in the timing of ice algae biomass peak (varying from April to May) and the time lags between ice algae and pelagic phytoplankton peaks (varying from 45 to 90 days). The correlation between the time lag and ice retreat is significant in areas where ice retreat has no significant impact on ice-algae peak timing, suggesting that changes in pelagic phytoplankton peak timing control the variability of time lags. Phenological variability of primary production is likely to have consequences for higher trophic levels, particularly for the zooplankton grazers, whose main food source is composed of the dually pulsed algae production of the Arctic.

Keywords: Arctic Ocean, primary production, phenology, sea ice algae, phytoplankton

The effect of meteorological condition on energy and carbon budget on taiga-tundra boundary in North-eastern Siberia

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1. Introduction

In Arctic, temperature has increased almost twice the global average rate in the past 100 years. We aim to clarify the land-atmosphere interaction over the boundary between taiga and tundra in northeastern Siberia, where the climate change effect might be remarkable. We have started the energy, water and carbon fluxes observation as well as hydro-meteorological observation in northeastern Siberia, Sakha Republic, Russia in June 2013.

2. Material and methods

Our observation site is located at Kodack site (70.564 N, 148.267E, altitude 7m) about 100km south from East Siberian Sea in Arctic Ocean near Chokurdakh city in the North-Eastern Siberia, Sakha Republic, Russia. The Kodack site is belong to Indigirka river basin (drainage area: 324,244km²) which flow to the East Siberian Sea. The annual air temperature and precipitation are -13.4 deg. C and 200mm respectively (1979-2008, Baseline Meteorological Data in Siberia (BMDS) Ver.5.0, Yabuki et al., 2011). The surface is covered by snow except July and August and the maximum snow depth is 40cm in April. In this region, the permafrost exists and the active layer depth ranges from 25cm to 40cm (van der Molen et al., 2007). The topography at the site consists of higher mounds and lower wet lands, where the difference of the height are about 50cm. At the higher mound, the shrubs and larches are dominant, while the sphagnum are prevailing at the lower wet land. The meteorological and flux observation has been carried out over the mound area.

The air temperature, relative humidity, wind speed and direction, air pressure, precipitation were observed at 1.5m height. The incoming and outgoing shortwave and longwave radiation were observed by 4-component radiometer at 1.37m height. The soil heat flux was observed by heat flux plate at 0.05m depth. The soil temperature was observed by platinum sensor at depths of 0.025, 0.05, 0.225, 0.425, and 0.625 m. The soil moisture was observed by capacitance sensor and frequency domain reflectometry sensor at depths of 0.035, 0.145, 0.335, and 0.535 m. The energy and carbon fluxes were calculated by the eddy covariance method from the observed values of the sonic anemo-thermometer at 2.55m height.

3. Results

The analysis results from 23 June to 27 October 2013 will be shown. The daily mean air temperature and relative humidity varied from 0.5 to 21.9 deg. C and from 53.9 to 90.0%, respectively. The total precipitation was 29.5 mm, and the maximum daily precipitation was 9 mm?day⁻¹. The daily mean wind speed varied from 1.3 to 6.1 m s⁻¹. There was clear relationship between the daily mean air temperature and wind direction. When the wind direction was northerly (southerly), the air temperature was low (high). The soil temperature (Ts) at surface varied from 2.8 to 10.8 deg. C while Ts at deeper than 0.425 m kept below 0 deg. C, which implies the frozen soil. The Ts at depth of 0.225m increased from -0.4 to 1.8 deg. C. The soil water content (SWC) was higher than 50% in surface layer of wet land while SWC at dry mound was lower than 11%. The net radiation varied from 50 to 200 W m⁻² and soil heat flux varied from 11 to 40 W m⁻². The daily mean latent heat flux (average during analysis period: 39 W m⁻² was little higher than the daily mean sensible heat flux (26 W m⁻²). The daily mean net ecosystem exchange (NEE) on 24 and 26 June was 0.32 and 0.41 g C m⁻² day⁻¹, respectively, which implies the carbon was released from the surface to the atmosphere while the NEE of the other days was negative value which implies the carbon was uptaken from the atmosphere. The accumulated NEE during analysis period was about -64 g C m⁻² day⁻¹, which was smaller uptake than the value observed at tundra (-92g C m⁻² day⁻¹; van der Molen et al., 2007). As our observation was started about half month after the start of growing season (late May), further analysis using the next year observation is necessary.

Keywords: Taiga-Tundra boundary, Siberia, Energy and carbon budget

Year to year variations in larch growth and their controlling factors in taiga-tundra boundary ecosystem, NE Siberia

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Eastern Eurasia is covered by permafrost which is the largest and the deepest in the world. In its arctic region of lowland of Indigirka River, taiga-tundra boundary ecosystem covers the area. For better understanding of this boundary ecosystem, it is important to understand controlling factors on the growth of larch trees which is the dominate tree species of taiga. Larch growth can vary spatially and temporally. In spatial variation, we found that high soil moisture influences mortality of the larch trees and N availability explains differences in trees ability of C assimilation among the sites. To know the controlling factors on temporal variation of larch growth, we conducted field measurements on photosynthesis, needle nitrogen (N) content, needle mass and isotopic ratios in larch needle and stem in every summer from 2009 to 2013 at four sites in the Indigirka River Basin, near Chokurdakh (70°37'N, 147°53'E), northeastern Siberia.

There was no seasonal variation in needle mass during the growing season after needles were fully open, while needle N content showed seasonality. Needle N content in the year positively correlated with July air temperature and stem $\delta^{13}\text{C}$ and following year needle $\delta^{13}\text{C}$. These results indicate that, in the year with higher July air temperature, more N was allocated to needle and larch trees exhibited higher photosynthetic rate and photosynthetic C used for needle production was one year delayed. Higher air temperature in the year possibly indicates higher solar radiation based on positive correlation between July temperature and sun hours. Therefore, it can be said that larch growth shows strong dependence on solar radiation. In terms of temperature itself, we found higher temperature could limit photosynthetic rate. In addition, wet event, occurred at some sites in 2011 and 2012, caused low photosynthetic rate and low needle N content in 2012, and higher needle $\delta^{13}\text{C}$ in 2012 and 2013. These results indicate that high soil moisture could limit larch photosynthesis and reduce N uptake and cause stomata closure as well.

Our observational results indicate that solar radiation is one of the most important controlling factors on larch growth, and high soil moisture and high temperature can limit larch growth.

Keywords: Carbon and nitrogen isotopes, Needle N content, Photosynthesis, Air temperature and solar radiation, Soil moisture, Vegetation change

Spacial distribution of vegetation at taiga-tundra boundary ecosystem in eastern Siberia

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Vegetation types, species compositions were observed with physical environment such as micro topography and soil moisture at taiga-tundra boundary ecosystem in lowland of Indigirka river in north eastern Siberia near Chokurdahk village(70°N,148°E)in July 2012 and 2013. There are 4 types of plant communities: driest Tree mound(*Larix gmelinii* etc.), Shrub(*Betula nana* etc.), Sphagnum(*Sphagnum* sp. etc.), wettest Hollow(*Eriophorum angustifolium* etc.). Large area is also covered by Willow(*Salix udensis* etc.) along the river. Soil moisture is the most important factor controlling vegetation and other biogeochemical cycles, such as methane emission. Thus, it is necessary to make a vegetation map with a classification as a key for estimating methane emission.

The objective of this study is classify land cover vegetation using remote sensing approach on satellite images and photographs. In remote sensing approach we used high resolution satellite multispectral image(GeoEye-1, WorldView-2) and aerial photo by radio-control helicopter. Supervised classification was conducted for spacial distribution of vegetation based on aerial photos. This vegetation map will be used for upscaling of biogeochemical cycle process such as greenhouse gases.

Keywords: Taiga-Tundra boundary, vegetation map, remote sensing, Siberia

Satellite observation of cryospheric change using Arctic Data archive System (ADS)

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Arctic Data archive System (ADS) has been constructed in the GRENE Arctic Climate Research project. ADS is useful for quick look of data and visualizing satellite data in the Arctic. The decline of sea ice area in the Arctic influences on the environment and industrial activities in the coastal region and people's life. Satellite microwave data since 1978 was archived in ADS. They are SMMR, SSM/I, AMSR, AMSR-E and AMSR2. These data sets enable to analyze more than 35-years time series of snow conditions, sea ice conditions in the Arctic.

The data is available for all-weather, even during the polar night season. The data enables climatological analysis for more than 30-years time span. This study demonstrates ADS capabilities for long-time monitoring and snow and ice conditions.

Keywords: Arctic, Cryosphere, Satellite, Data archive

Age of the Pacific Winter Water in the Canada Basin estimated from SF₆

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In the Pacific sector of the Arctic Ocean, Pacific Winter Water (PWW) distributes between 100m and 200m depths. Because the PWW has high nutrient concentrations and low pH, its spreading pathway has implications on primary production and ocean acidification in the Arctic Ocean. In this study, we have observed distribution of SF₆, a transient tracer alternative to CFCs, in order to trace newly formed PWW into the Canada Basin.

Sampling was carried out in summer of 2013 on the CCGS Louis S. St-Laurent. Seawater at the core of PWW (salinity = 33.1) were collected in Niskin bottles and then transferred into custom-made glass bottles. Samples were kept at low temperature and brought back to Japan. Concentrations of SF₆ in seawater samples were determined by an ECD-GC following the method described in Bullister and Wisegarver (2008).

Results show that younger PWW distributes at the periphery of the Beaufort Gyre, a major anticyclonic circulation in Canada Basin. The age of PWW estimated from SF₆ was 13~15 years in the center of the gyre, whereas age was 6~9 years around the gyre. From the distributions of SF₆ age, dissolved oxygen and nutrients, it is suggested that there is a pathway of PWW from the Siberian shelves or slopes into the northeastern Canada Basin.

Keywords: arctic ocean, time transit tracer, SF₆, ocean circulation

Mineralization Rate of Soil Organic Carbon at the Lowland of Indigirka River in North-eastern Siberia

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The Arctic has a large amount of organic carbon accumulated in the soil. If the enhanced warming under the Arctic amplification leads to higher soil temperature or deepening of the active layer, emission of greenhouse gases, i.e. CO₂ and CH₄ can increase. The decomposition rate of organic matter, which is an important factor of CO₂ and CH₄ emission, depends not only on the quantity of organic matter, but also on that quality. In this work, surface soils from the lowland of Indigirka river in Northeastern Siberia were incubated at constant temperatures (5, 10 °C) to evaluate the production rates of CH₄ and CO₂ and to know the degradability of the soil organic matter.

The study site is around Chokurdakh (70.62 N, 147.90 E) located in the continuous permafrost of Eastern Siberia and situated in the boundary of tundra and taiga. Surface soil layers (ca. 10-60 cm deep) were sampled at 7 points of a drier mound with larch trees and of wetter areas with sedges and *Sphagnum spp.*. Besides thawed layers (10, 20, 30 cm deep) sampled in July were incubated at Chokurdakh for 8 days anaerobically, frozen soil layers sampled in the early summer of June (13-62 cm) were incubated in Japan for 34-42 days both anaerobically and aerobically. These soils include the active layer (ca. 20-50 cm) and the top of the permafrost of this region.

CH₄ production was not detected in the mound soils while CO₂ production was, suggesting areas with dry condition have few methanogens and will not produce CH₄ even if they turn into anaerobic condition. On the other hand, soils from wet areas produced CH₄ (0-0.88 μmol (g dry soil)⁻¹ day⁻¹) and the production as well as that of CO₂ was more active at the shallower layers, representing larger amount of labile organic matter. The rate of CH₄ production at 10 °C were found to be 0.9-1.1 times of that at 5 °C in the shallower layers (ca. 10-40 cm), while 1.9-3.3 times in the deeper layers (32-45 cm). It indicates that the temperature dependency of CH₄ production is higher in the middle to the bottom of the active layer than in the top layer.

Keywords: methane, carbon dioxide, incubation experiment, Eastern Siberia, taiga-tundra boundary, stable isotope ratio

Accurate snowfall measurement at Yakutsk, Russia

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In association with global warming, the water cycle in the atmosphere also changes for every climatic region on the globe. In polar regions, change in snowfall turns in change in distribution of snow surface and snow cover period, which will drive the ice-albedo feedback process. In order to know the present condition of the water cycle of polar regions and to study the trajectory of the polar climate systems in future, we have to observe not only air property such as temperature but also hydrological property such as snowfall amount, snow depth and so.

In spite of the development in accurate measurements for air temperature, pressure, wind speed and direction, the accuracy of snowfall measurement is not sufficiently high. While heated raingauge is currently generally deployed all over the world, the capture rate of snow particles falls together with wind speed, e.g., around 0.5 of the rate at 5 m/s. It means we measure only a half of the true value of snowfall amount at 5 m/s. This effect has been known for long time as wind loss. Evaporation loss also is more important in the polar regions than the other regions because many snowfall events have the smaller amounts in the total and lower snowfall rates according to the lower-temperature condition in the polar regions. Now, the accurate measurement of snowfall amount is one of the top issues in polar climate science.

The purpose of this study is to measure the accurate snowfall amount in the Arctic region. Moreover, based upon the results, we intend to correct other data which are measured in other region and in past years and also contribute to improve climate model by provideing accurate snowfall data. This study deploys a disdrometer, which measures diameter and fall velocity for each particle and out put the statistics minutely. It is not affected by wind loss and evaporation loss. This presentation shows a snowfall event observed at Yakutsk in early winter of 2013/14.

Keywords: Yakutsk, Snowfall, Disdrometer

Continuous measurements of the atmospheric O₂/N₂ ratio at Ny-Alesund, Svalbard

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Simultaneous observations of atmospheric O₂ (defined as O₂/N₂ ratio) and CO₂ concentrations provide valuable information about the global carbon cycle. For a better understanding of the global carbon cycle, several laboratories have developed precise measurement systems for the O₂/N₂ ratio and carried out systematic observations since the early 1990s. To elucidate the variations of the atmospheric O₂/N₂ ratio in detail and to contribute to a better understanding of the role of Arctic region on the regional and global carbon cycle, we developed a continuous measurement system using a differential fuel-cell O₂ analyzer, and then initiated systematic observation at Ny-Ålesund, Svalbard in November 2012, which is the first continuous observation in the Arctic region. The system is equipped with NDIR analyzer to measure CO₂ concentration simultaneously. The analytical precisions of O₂/N₂ ratio and CO₂ are estimated to be ±1.4 per meg and ±0.03 ppmv, respectively. Here, we will present observational results of the first year.

The O₂/N₂ ratio observed at Ny-Ålesund shows a clear seasonal cycle with peak-to-peak amplitude of about 120 per meg, which reaches a minimum in late March to early April and a maximum in August. On the other hand, the CO₂ concentration varies seasonally in opposite phase with the O₂/N₂ ratio, showing the amplitude of 16 ppm. Short-term variations on time scales of several hours to several days are also clearly seen. In winter, it is often observed that the O₂/N₂ ratio sharply declines in a short time, accompanied by an increase in the CO₂ concentration, and the low values last for several hours or days. The O₂:CO₂ exchange ratio defined as the slope of a linear regression line between the measured values of O₂/N₂ ratio and CO₂ range between -1.6 and -1.5 ppm/ppm, which are close to the average O₂:CO₂ exchange ratio expected from fossil fuel burning in Europe. The results of backward trajectory analysis indicated that the air masses arrived at Ny-Ålesund during the periods when such short-term variations were observed passed near or over Scandinavian Peninsula. Therefore, such a decline in the O₂/N₂ ratio is ascribed to transport of urban air influenced by human activities in Europe. In spring to summer, irregular fluctuations of O₂/N₂ ratio are often observed. The amplitude of such fluctuations reaches 50-60 per meg (corresponding to about 10-13 ppm). Similar fluctuations of CO₂ are also found in opposite phase with O₂/N₂ ratio. However, their amplitudes are 5 ppmv at most. The comparison of backward trajectories of air parcels with the distributions of marine biotic net primary production suggests that such fluctuations of O₂/N₂ ratio are closely related to O₂ emission due to marine biological activity near Norwegian Sea.

Keywords: atmospheric O₂, carbon cycle, O₂:CO₂ exchange ratio, air-sea O₂ flux

Geographical variations in formation process of cryoconite granules on Arctic glaciers

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The dark colored impurities deposited on the glacier ice are called cryoconite. Cryoconite is consisted of mineral particles, organic matter and microbes, including snow algae, cyanobacteria and bacteria. They usually form small spherical aggregates known as cryoconite granules. The spherical shape is maintained by filamentous cyanobacteria. The satellite images of Greenland ice sheet revealed that the dark colored bare ice surface has expanded recently and may have a big impact on the melting of ice. The darkening may be due to increase of cryoconite on the surface. Therefore, the understanding of the structure and formation process of the cryoconite granules is important for studies of the influence on the glacier ecosystem and mass balance of glaciers. In this study, we analyzed the structure and characteristics of cryoconite granules on Arctic glaciers and we clarified the differences in the formation process with the glaciers.

We analyzed the cryoconite samples collected on the northwestern part of the Greenland ice sheet, the Longyearbreen glacier of the Svalbard, the Suntar-Khayata glacier of the Siberia, the Gulkana glacier of the Alaska. We observed the cryoconite granules using a microscope in order to clarify the characteristic of the composition, the granule size. Furthermore, to observe inner structures, thin sections of cryoconite granules were made.

Microscopy of cryoconite granules revealed that their size and coloration differed among the glaciers. The size of granules was the largest for Svalbard followed by Siberia, Alaska, and Greenland. The coloration of cryoconite granules was brown for Svalbard, black for Siberia, gray for Alaska, and black to brown for Greenland. Cross section of the granules also showed the distinct features. The granules from Greenland had mostly subgranules inside. The granules from Svalbard had some concentric layers of dense organic matter. The granules from Siberia had a large mineral particle inside. The granules from Alaska had no specific inner structure. These differences of cryoconite granules may reflect physical and/or chemical conditions of each glacier.

Development of a Palsa along the Denali Highway, Alaska

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Palsa is a peaty permafrost mound distributing in continuous and discontinuous permafrost zones. Main mechanism of the development the mounds is frost heave by ice segregation of peat or mineral soil material. Upper part of palsa usually consists of peat and lower part of a core of alternating layer of segregated ice and mineral soil material. History of paleo-environment around the period of last glacial retrieve in surrounding area can be inferred from analysis of palsa cores and stratigraphy. Our target palsa was located along the Denali Highway, Alaska, and the mound was truncated during highway construction in 1957. The outcrop of palsa have been eroded away from the highway line about 20m partly exposing the internal structure. This permafrost mound was firstly introduced as palsa by Pewe in 1983, and from dating of basal peat, deglaciation of this area occurred at least about 10500 year BP. History of palsa development and environment change was reconstructed from results of analysis from 6.5m core and ground temperature.

Keywords: Alaska, Denali Highway, Palsa

Sr-Nd isotopic ratios of mineral dust in Arctic snow

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Snow and ice on glaciers contain various atmospheric depositions, such as soot and mineral dusts. These light-absorbing impurities can reduce surface albedo and affect melting of glaciers. Thus, it is important to understand how these impurities were supplied on glaciers.

Stable isotopic ratios of Sr and Nd provide a means of identifying sources of substances and can use for the dusts in snow because it requires low samples for analysis. In this study, we analyzed Sr and Nd isotopic ratio of the mineral dusts collected from snow in several Arctic regions (Mongol, Alaska, and Greenland).

The Sr and Nd isotopic ratios of mineral dusts in Arctic snow showed geographical variations among the sampling sites. The ratios of dust collected from snow in Mongol showed higher Sr and lower Nd values, while those of Greenland were higher Sr and lower Nd values, and were close to the ratios that have been reported in loess, desert sand, soil, or moraine around each region. This result indicates that mineral dusts in snow on the two sampling sites were mainly derived from surrounding regions. On the other hand, the isotopic ratios of dust in snow of Alaska were close to those of deserts in Kazakhstan and Taklamakan Desert, suggesting that the mineral dusts originated from such further deserts were likely to be long-range transported to Alaska.

Keywords: Sr-Nd isotopic ratio, mineral dust in snow, Arctic region

Intercomparison of Arctic atmospheric reanalysis data: Deriving observation-based forcing data for terrestrial models

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The goals of the modeling group in the terrestrial research project of the GRENE Arctic Climate Change Research Project (GRENE-TEA) are to a) feed to the CGCM research project for the possible improvement of the physical and ecological processes for the Arctic terrestrial modeling (excl. glaciers and ice sheets) in the extant terrestrial schemes in the coupled global climate models (CGCMs), and b) lay the foundations of the future-generation Arctic terrestrial model development.

In GTMIP (GRENE-TEA Model Intercomparison Project), we utilize the GRENE-TEA site observations to drive and validate the participating models. However, the observation data are prone to missing or lack of the necessary variables or parameters to drive the model. Therefore, we create continuous forcing data in the following manner: First, we create 30-year hourly time series (version 0; v0) of 7 meteorological components from the closest point data of the reanalysis products (a model-based dataset for the sub-monthly variations, and the observation-based CRU for the monthly). Then, v0 is merged with the observation data to create site-fit continuous data (v1) for each GRENE-TEA site. Use of this v1 expects to reduce the systematic biases in the input data in comparing the model outputs with the site observations, to delineate the variations among the models.

So far several atmospheric reanalysis datasets, for example NCEP-NCAR or JRA-55 are available as model input data. In this study, six atmospheric reanalysis datasets are compared in terms of the climatic reproducibility in the region north of 60°N to select the one to be used for constructing the v0 data. The compared datasets are ERA Interim, JRA-55, MERRA, NCEP/NCAR Reanalysis 1, NCEP-DOE Reanalysis 2, and NCEP-CFSR. The CRU dataset is used as a representative of the ground-level observations. We take air temperature at 2m high and precipitation as the key parameters representing the climate condition.

Keywords: Arctic region, Terrestrial model, Reanalysis dataset

Automatic measurement of gas emission/uptake of Alaskan permafrost soils

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¹NIAES, ²NIES

The release of carbon from the decomposition of organic matters in permafrost soils are very important for the acceleration of global warming. We applied our dynamic system to Alaskan soils and measured temperature dependence of gas (CO₂, CH₄, N₂O, NO, H₂, CO) emission/uptake. The Four core samples were placed on petri-dishes which were put into chambers where temperature was controlled. CO₂ emission from soils showed variations different from sample to sample. Even at -5C, CO₂ emissions were observed. From the time series of CO₂ emission rates, we estimated Q₁₀ values. Q₁₀ values were similar between 5-15C and 15 and 25C. Some soils also temperature-dependently emit NO, CO and N₂O.

Keywords: permafrost soil, Alaska, CO₂, NO, laboratory experiment

Simulating effects of natural fire disturbance on soil carbon storage of boreal forest and tundra ecosystems in Alaska

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Boreal forest and tundra are the major ecosystems in the northern high latitudes and represent one of the largest reservoirs of carbon over terrestrial ecosystems in the world. Most of the carbon is stored in permafrost where frozen organic matter is protected from decomposition due to biotic activity in the underlying soil. The surface humus layers that should work as the protective layers insulate the permafrost soil far away from the effect of climate warming. Hence, the removal of protective layers by natural fire episodes increases the vulnerability of permafrost to thaw, and the carbon stored in permafrost to decomposition under climate warming in the near future. To elucidate effects of fire severity and temperature sensitivity on the soil carbon storage of boreal forest and tundra ecosystems in Alaska, we conducted simulations using the Physical and Biogeochemical Soil organic carbon Dynamics Model (PB-SDM), which consists of meteorologically-relevant land surface model and soil organic carbon dynamics model. The PB-SDM model of fire severity, designed from the analysis of the field observations, describes the effects of fire characteristics in frequency and size on the reduction of the soil organic layer. The simulation captured realistic annual variations in soil organic carbon storage and thickness in boreal forest and tundra ecosystems individually by finding optimal model parameters in terms of the frequency and size of fire events and temperature sensitivity. The result reveals that our model can be used for predicting soil carbon storage in boreal forest and tundra ecosystems at regional scales where fire regimes play a key role in the soil organic carbon storage as affected by climate warming.

Keywords: High-latitude soil, fire severity, Soil organic carbon, boreal forest, tundra

Methane Oxidation Potential of Arctic Wetland Soil of a Taiga-Tundra Ecotone in North-eastern Siberia

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Arctic wetlands are significant sources of atmospheric methane and the observed accelerated warming of the arctic causes increased methane formation in water-saturated tundra soil with deepened permafrost thawing. Methane oxidation is regarded as the key process to regulate methane emission from wetlands. In this study we determined the potential methane oxidation rate of the wetland soils of a Taiga-Tundra transition zone in Northeastern Siberia with special reference of the spatial heterogeneity and response to environmental parameters. The surface peat soil samples (0-10 cm) were collected in the summer of 2012 and 2013 from depressions that were covered with tussocks of sedges and Sphagnum spp. and mounds vegetated with moss and larch trees. The potential methane oxidation rate was estimated by a bottle incubation experiment in which homogenized soil samples were incubated with methane at the initial concentration of 0.5-0.8 %v/v. Soil samples from the mounds showed no detectable methane oxidation, whilst the soils collected from depressions exhibited active methane oxidation with no lag. The potential methane oxidation rates at 15 oC were of 270 and 190 nmol h⁻¹ g⁻¹ dw in the moss- and sedge-dominated zones, respectively. Methane oxidation was active over the depths including the water-saturated anoxic layers, suggesting the resilience of methane oxidizing bacteria. The maximum methane oxidation rate was recorded in the layer above the water-saturated layer: the surface (0-2cm) layer in the sedge-dominated zone and in the middle (4-6 cm) layer in the moss-dominated zone. Temperature-dependent methane oxidation was observed at the range of temperature from 0 to 15 oC. The estimated threshold temperature of methane oxidation was -4 to -11 oC, which suggested methane oxidation at subzero temperatures. Treatment with inorganic nutrients and black carbon did not affect the potential methane oxidation rate.

Keywords: Methane oxidation, tundra, peat

Online visualization tool "VISION" on Arctic Data archive System (ADS)

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We are constructing an online archive system of data about Arctic research that many researchers and institutes have collected, which is named ADS (Arctic Data archive System). We aim at that the many researchers specializing in the various fields of the Arctic research - such as atmosphere, ocean, land, physical and chemical analysis and computer simulation, etc - can become to mutually use their data across their own fields through our data archive. For this purpose, it is necessary for us not only to manage data systematically, but to build the system where researchers can easily grasp the contents of the data archive.

However, it is difficult to exactly understand contents of the data that others made. The researchers try to understand the contents of the data of their own fields and succeed in many cases. But it is not easy for them even to judge the contents of the data out of their fields. Therefore, we developed GUI-based online data visualization application named " VISION " , which all the researchers engaged in the Arctic research can easily operate. It can be expected that " VISION " facilitates an understanding the data of the various fields of the Arctic research among the researchers, then the researchers become also use the data out of their own fields.

We will introduce a structure and function of " VISION " and demonstrate an operation of this system.

Keywords: online visualization, satellite data, SSMI, AMSR

Shrinking glaciers in Suntar Khayata, east Siberia

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Introduction

Since Northern Hemisphere high latitude regions are noticeable trend of global warming and climate change, appearance of its impact is interest. Northeastern Eurasia is area of blank of observational research. One of a few regions studied in the past is Suntar Khayata in east Siberia, where Russian scientists carried out wide range of study during IGY (1957-1959).

Study area

Suntar Khayata region, located in the latitudes between 62 and 63 degree north and in the longitudes between 140.7 and 142 degree east, forms a divide between the Arctic Sea and the Sea of Okhotsk. Oymyakon depression, known as the cold pole in the Northern Hemisphere, is located to the northeast. Glacier inventory of this region was prepared based on the aerial photographs taken in 1944-1947 (Koreisha, 1963). Total number and area of glaciers were 205 and 206.28 km². Three glacierized region are recognized, namely Northern massif, Central massif and Southern massif. The highest elevation of each massif is 2959 m, 2933 m and 2944 m.

Glaciers observed are No. 29 to 33 in Northern massif including No. 31 which was intensively studied during IGY.

Observation

We carried out glaciological observations such as mass balance (stake method), ice thickness measurement (radio-echo soundings), and topographic survey (DGPS) in July/August in 2012 and 2013. Automatic weather stations were also set on/around the glaciers.

Results

Glacier-wide mass balance in 2012/2013 was -1.04 m w.e. for a glacier complex (Glaciers No. 29, 30 and 31). This value shows more negative state than those in 1957-1959.

We generated DEMs of surface and bed of the Glacier No. 31 using ice thicknesses obtained by radio-echo soundings and surface elevations by GPS survey, then we estimated the volume of the glacier to be 0.20 km³ (area: 3.02 km², mean thickness: 62 m). Ice thicknesses in its tongue reduced by 110-60 m (terminus to upstream) since 1957.

Based on multi-temporal aerial and satellite imagery, 18 investigated glaciers reduced in area by approximately 36% from 1945 to 2011.

Concluding remark

Summer (July-August) air temperature observed on the glacier in 2012 and 2013 were higher than those in 1957-1959, which brought about more negative mass balance than those in 1957-1959. Superimposed ice formation was also very limited in 2012/2013. This resulted in disappearance of accumulation area. Reconstruction of long-term mass balance history is present target.

Acknowledgement

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Keywords: glacier, Siberia, Suntar Khayata, shrink

Effect of snow depth on pan-Arctic permafrost thermal regimes

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This study quantitatively evaluated how insulation by snow depth (SND) affected the soil thermal regime and permafrost degradation in the pan-Arctic area, and more generally defined the characteristics of soil temperature (T_{SOIL}) and SND from 1901-2009. This was achieved through experiments performed with the land surface model CHANGE, to assess sensitivity to winter precipitation as well as air temperature. Simulated T_{SOIL} , active layer thickness (ALT), and SND were generally comparable with in-situ or satellite observations at large scales and over long periods. Northernmost regions had snow that remained relatively stable and in a thicker state during the past four decades, generating greater increases in the T_{SOIL} . Changes in SND have led to changes in the thermal state of the underlying soil, which is strongly dependent on both the magnitude and the timing of changes in snowfall. Simulations of the period 2001-2009 revealed significant differences in the extent of near-surface permafrost, ranging from 15.6 to 18.7 million km². This spread was the result of differences in the model's treatment of meteorology. Permafrost loss was greater when SND increased in the autumn rather than in the winter, due to insulation of the soil from the early cooling. Simulations revealed that T_{SOIL} tended to increase over most of the pan-Arctic from 1901-2009, and this increase was significant in northern regions, especially in northeastern Siberia where SND is responsible for 50% or more of the changes in T_{SOIL} at a depth of 3.6 m. In the same region, ALT also increased at a rate of approximately 2.3 cm per decade. The most sensitive response of ALT to changes in SND appeared in the southern boundary regions of permafrost, in contrast to permafrost temperatures within the 60°-80°N region, which were more sensitive to changes in the SND. Finally, the modeling performed in this study suggests that snow cover contributes to the warming of permafrost in northern regions and could play a more important role under conditions of future Arctic warming.

Keywords: active layer thickness, land surface model, permafrost, snow depth, soil temperature

Fixed-point observation of diatom biocoenosis and water mass condition in the northern Chukchi Sea during September 2013

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In order to estimate the relationship between diatom flora and water mass condition in the northern Chukchi Sea, fixed-point ocean observation was conducted at Station 41 (72.45N, 168.24W, 56 m water depth) by R/V Mirai (Cruise MR13-06) in 10-25 September 2013. The optical equipment named "Multi-wave length excitation fluorescence photometer (Multi-Exciter)" was applied with CTD observation for the estimation of chlorophyll concentration in each major phytoplankton groups (diatom, green algae, and blue algae). Chlorophyll concentration gradually increased with the weakening of summer stratification by intensified sea-surface wind. The Multi-Exciter showed the clear increase of diatom in upper water column, which were also suggested by size-fractionated analysis of chlorophyll concentration and microscopic observation by scanning electron microscope and light microscope. However, the increase of diatom cell abundance was minor compared to the increase of total chlorophyll concentration. The dominance of large diatom genus *Proboscia* and the increased chlorophyll concentration in one diatom cell were the main causes on the increase of total chlorophyll concentration. The 3-6 fold increase of chlorophyll concentration within 6 hours was rarely observed around chlorophyll maximum layer during the middle observation period, which is probably explained by not only improved habitat environment for diatom but also movement of water masses such as lateral input of high chlorophyll waters.

Keywords: Arctic Ocean, Chukchi Sea, diatom, excitation fluorescence, chlorophyll concentration

Reconstruction of paleoenvironmental changes in the Chukchi Borderland over the last 15.5kyr

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Knowledge on past variability of sedimentary organic carbon in the Arctic Ocean is important to assess natural carbon cycling and transport processes related to global climate changes. However, the late Pleistocene oceanographic history of the Arctic is still poorly understood. In the present study we show sedimentary records of organic carbon(TOC, $\delta^{13}\text{C}$), CaCO_3 , benthic and planktonic foraminiferal $\delta^{18}\text{O}$, BIT index for terrestrial organic carbon input, IP25 for sea ice condition, and the coarse grain size fraction. The 8m length sediment core was retrieved in the northern Northwind Ridge in the far western Arctic Ocean, during the MR08-05 cruise by R/V Mirai. An age model based on oxygen isotope stratigraphy, radiocarbon dating and lithological constraints suggests that the core records paleoenvironmental changes of the last 155 kyr. In this conference, we discuss presented millennial scales records of glacial erosion, intermediate water and/or surface water and sea ice variabilities during cold/warm episodes of the last two glacial interglacial cycles in the light of ice sheet and ocean-atmosphere dynamics.