Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

ACC32-01 Room:419 Time:April 29 14:15-14:30

Digital-image processing to analyze grain size variation in ice core from Gregoriev Ice Cap, Kyrgyz Tien Shan

MATSUHASHI, Yuta[1*] ; FUJITA, Koji[1] ; TAKEUCHI, Nozomu[2] ; VLADIMIR B, Aizen[3]

[1]Nagoya University, [2]Chiba University, [3]University of Idaho

It is known that impurities in ice core (etc. dust from continental) prevent grain growth rate at high-latitude regions. On the other hand, the effect of impurities for grain growth is not understood for ice cores retrieved from mid-low latitude glaciers, despite of higher dust concentration. This study aims to reveal relation between dust and grain size in an ice core drilled at Gregoriev Ice Cap, Kyrgyz Tien Siam in 2007.

We made thin sections which are reduced to thickness of 0.4mm. Three different images were taken by changing angle of crossed polarizers (0 deg, 30 deg, 60 deg). Changing controlled contrast and RGB, we converted the images into binary. Grain boundaries are then able to be picked by digital image-processing. This process made efficient extracting boundary and obtain area of grain using binary images.

We will present detailed procedures and preliminary results of comparison with dust concentration along the ice core.

Keywords: ice core, grain size, Grigoriev ice cap

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ACC32-02 Room:419 Time:April 29 14:30-14:45

Post-depositional alteration of major ions under different accumulation environment in Antarctica

HOSHINA, Yu[1*] ; FUJITA, Koji[1] ; IIZUKA, Yoshinori[2] ; MOTOYAMA, Hideaki[3]

[1]Nagoya University, [2]Institute of Low Temperature Science, Hokkaido University, [3]National Institute of Polar Research

Major soluble ions and water stable isotopes are important for reconstructing paleo-environment and atmosphere circulation. It is also known that ion and isotope signals are modified after deposition if firn or ice core samples are analyzed at high temporal resolution such as seasonal scale. In inland Antarctica, we revealed that low accumulation rates have resulted in significant post-depositional modification of ions and isotopes due to long time exposure of snow near the surface.

We further investigated relation between major ion concentration and accumulation rate using a several snow pits and firn cores taken from east and west Antarctica. To exclude the geographical factor (east or west), we analyzed correlations with ions against oxygen stable isotope. Correlations of sea salt against oxygen stable isotope are gradually changed from no correlations under higher accumulation sites near coast to more negative correlations under dry environment in inland. On the other hand, correlations of MSA (methanesulfonic acid) against oxygen stable isotope rapidly are changed from positive to negative correlations at 100 kg m^{-2} a^{-1} of accumulation sites. Those different trends suggest different mechanisms of post-depositional modification for these ion species.

Keywords: Antarctica, ice core

ACC32-03 Room:419 Time:April 29 14:45-15:00

Greenland temperature variability over the past 2000 years inferred from NGRIP and GISP2 ice cores

KOBASHI, Takuro[1*] ; GOTO-AZUMA, Kumiko[1] ; KAWAMURA, Kenji[1] ; VINTHER, Bo[2] ; BLUNIER, Thomas[2] ; BOX, Jason[3] ; BUIZERT, Christo[4] ; MUTO, Atsuhiro[5] ; WHITE, James[6]

[1]National Institute of Polar Reseaerch, [2]Copenhagen University, [3]Geological Survey of Denmark and Greenland, [4]Oregon State University, [5]Pennsylvania state University, [6]University of Colorado at Boulder

We reconstructed Greenland temperature change for the past 2000 years using argon and nitrogen isotopes in trapped air in NGRIP and GISP2 ice cores. To identify true variability of temperature, we also applied various methods such as borehole temperature inversion, Monte Carlo inversion of borehole temperature, oxygen isotopes of ice, forward and inverse methods for argon and nitrogen isotopes with borehole temperatures. We will present the results of analyses and implications.

Keywords: Greenland, temperature, ice core, GISP2, NGRIP, 2000 years

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ACC32-04 Room:419 Time:April 29 15:00-15:15

Greenland temperature variations in the last millennium climate simulation

YOSHIMORI, Masakazu[1*] ; ABE-OUCHI, Ayako[1]

[1]Atmosphere and Ocean Research Institute, The University of Tokyo

A series of climate simulations of the last millennium are conducted using the MIROC climate model. These include a simulation under volcanic-only, solar-only, or total forcings. Sensitivity experiments using different strength of volcanic and solar forcings are also conducted. With these dataset, we analyze the factors that influence Greenland temperature variations during the last millennium. Attention is paid to the effect of different external forcings and changes in the atmosphere and ocean circulations such as the North Atlantic Oscillation and the Atlantic meridional overturning circulation.

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ACC32-05 Room:419 Time:April 29 15:15-15:30

The variation of the Arctic cryosphere in the Last Millennium simulation using MIROC and MIROC-ESM

SUEYOSHI, Tetsuo[1*] ; OHGAITO, Rumi[1] ; YOSHIMORI, Masakazu[2] ; HAJIMA, Tomohiro[1] ; ABE, Manabu[4] ; O'ISHI, Ryouta[4] ; OKAJIMA, Hideki[1] ; SAITO, Fuyuki[1] ; WATANABE, Shingo[1] ; KAWAMIYA, Michio[1] ; ABE-OUCHI, Ayako[2]

[1]Japan Agency for Marine-Earth Science and Technology, [2]Atmosphere and Ocean Research Institute, University of Tokyo, [3]National Institute for Environmental Studies, [4]National Institute of Polar Research

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

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

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

Keywords: paleoclimate, climate modelling, Last Millennium, cryosphere, climate change

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ACC32-06 Room:419 Time:April 29 15:30-15:45

A long-term ^{10}Be record from Dome Fuji ice core and cosmic-ray stratigraphy

HORIUCHI, Kazuho[1*] ; SUGUCHI, Shota[1] ; SUDA, Kensuke[1] ; UCHIDA, Tomoko[2] ; AZE, Takahiro[3] ; YOKOYAMA, Yusuke[4] ; MURAMATSU, Yasuyuki[5] ; MATSUZAKI, Hiroyuki[6] ; MOTOYAMA, Hideaki[7]

[1]Graduate School of Science and Technology, Hirosaki University, [2]Institute of Geology and Paleontology, Tohoku University, [3]Graduate School of Science and Engineering, Tokyo Institute of Technology, [4]Atmosphere and Ocean Research Institute, The University of Tokyo, [5]Faculty of Science, Gakushuin University, [6]Graduate School of Engineering, The University of Toky, [7]National Institute of Polar Research

Cosmogenic nuclides (^{10}Be, ^{14}C, ^{26}Al, ^{36}Cl) in paleoenvironmental archives serve as a proxy indicator of the paleointensity of cosmic ray, controlled largely by the strength of the solar/geomagnetic fields. Here, we present a millennial record of cosmogenic ^{10}Be covering the past 300 kyr and obtained from ice cores drilled at the Dome Fuji station (77^{o}19'S, 39^{o}42'E), inland East Antarctica. A number of specific increases in ^{10}Be were observed in this record and were connected semi-quantitatively to those in the cosmic-ray intensity caused by geomagnetic excursions during the last 300 kyr. These features can be used as stratigraphic time-markers for synchronization of not only Antarctic ice cores but also various paleoenvironmental archives such as deep-sea sediments

ACC32-07 Room:419 Time:April 29 15:45-16:00

Age synchronization between an Antarctic ice core and Northern Hemisphere marine cores: with special focus on MIS 11

KAWAMURA, Kenji[1*] ; AOKI, Shuji[2] ; NAKAZAWA, Takakiyo[2] ; ABE-OUCHI, Ayako[3] ; SAITO, Fuyuki[4]

[1]National Institute of Polar Research, [2]Tohoku University, [3]University of Tokyo, [4]JAMSTEC

Investigation of the roles of different forcings (e.g. orbital variations and greenhouse gases) on climate and sea level requires a paleoclimate chronology with high accuracy. Such a chronology for the past 360 ky was constructed through orbital tuning of O2/N2 ratio of trapped air in the Dome Fuji and Vostok ice cores with local summer insolation (Kawamura et al., 2007). We extend the O2/N2 chronology back to ~500 kyr by analyzing the second Dome Fuji ice core, and find the duration of 11 ka, 5 ka, 9 ka, and 20 ka for MIS 5e, 7e, 9e and 11c interglacial periods in Antarctica, with similar variations in atmospheric CO2. The termination timings are consistent with the rising phase of Northern Hemisphere summer insolation.

Marine sediment cores from northern North Atlantic contain millennial-scale signatures in various proxy records (e.g. SST, IRD), including abrupt climatic shifts and bipolar seesaw. Based on the bipolar correlation of millennial-scale events, it is possible to transfer our accurate chronology to marine cores from the North Atlantic. As a first attempt, we correlate the planktonic d18O and IRD records from the marine core ODP 980 with the ice-core d18O and CH4 around MIS 11. We find that the durations of interglacial plateaus of planktonic d18O (proxy for sea surface environments) and benthic d18O (proxy for ice volume and deep-sea temperature) for MIS 11c are 20 and 15 ka, respectively, which are significantly shorter than originally suggested. These durations are similar to that of Antarctic climate and atmospheric CO2. However, the onsets of interglacial levels in ODP980 for MIS 11 are significantly later than those in Antarctic d18O and atmospheric CO2 (by as much as ~10 ka), suggesting very long duration (more than one precession cycle) for the complete deglaciation and northern high-latitude warming for Termination V. Atmospheric CO2 may have been the critical forcing for this termination. The long duration of Termination V is consistent with our new ice sheet simulations (extended from the work of Abe-Ouchi et al., 2013) in which an ice-sheet/climate model is forced by insolation and CO2 variations. In the presentation, comparisons for other interglacial periods will also be reported.

Keywords: Antarctic ice core, Marine core, Chronology, Glacial-interglacial cycles

ACC32-08 Room:419 Time:April 29 16:15-16:30

What is the major factor which control global climate in the ice age?

KUMON, Fujio[1*]

[1]Faculty of Science, Shinshu University

The author and his co-workers have been analyzed total organic carbon (TOC) and total nitrogen (TN) contents of the various lake and marine sediment cores. The temporal changes of TOC show quasi-periodic fluctuation patterns similar to LR04 marine oxygen isotope curve and delta 18O profile of NGRIP ice core. Among the several long records of TOC in and around the Japanese islands, the TOC record from the Japan Sea is the most excellent one, and can be correlated precisely with the NGRIP record both on the orbital- and millennial time-scale in the ice ages.

This intimate relationship of climate is confirmed between Greenland and the Japanese islands. The good concordance of climate change can be explained by a hypothesis that extension of ice sheets in the Arctic region is major factor to control global climate not only in orbital-time scale but also in millennium-time scale.

Keywords: organic carbon content, climate change, ice sheet, Japan Sea sediment, Milankovich hypothesis, pinge-purge model

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ACC32-09 Room:419 Time:April 29 16:30-16:45

The influence of glacial ice sheet on Atlantic Meridional Overturning Circulation through atmospheric circulation change

SHERRIFF-TADANO, Sam[1*] ; ABE-OUCHI, Ayako[1] ; YOSHIMORI, Masakazu[1] ; CHAN, Wing-le[1]

[1]Atmosphere and Ocean Research Institute, University of Tokyo

In glacial period, huge ice sheet covered the North America and the Northern Europe. Also, the Antarctica Ice sheet had expanded and increased its altitude. It is well known that these ice sheets (hereafter glacial ice sheets) have large influence on climate, for example atmospheric circulation, surface air temperature, and sea surface temperature. On the other hand, recent studies showed that wind stress changes play a crucial role on the AMOC under glacial climate. Moreover, increasing evidence suggests that glacial ice sheets have large influence on the Atlantic Meridional Overturning Circulation (AMOC). However the process how the ice sheets cause such a large impact on the AMOC is yet fully understood. Thus, in this study, we aim to reveal the detailed process of the ice sheet affecting the AMOC through atmospheric circulation change.

Commonly, the Atmosphere-Ocean General Circulation Model (AOGCM) is used to assess the influence of the ice sheet on the AMOC. However, as the atmospheric general circulation model (AGCM) and ocean general circulation model (OGCM) interacts in this model, the wind change as well as other process affect the AMOC. Therefore, it is difficult to divide each effect. Using the AGCM and the OGCM separately can overcome this problem because in this manner, they do not interact and the wind stress or other process can be treated as a boundary condition for the OGCM. This method consists of 2 steps. First, by using the AGCM, the effect of glacial ice sheets on the surface wind stress are evaluated by adding glacial ice sheets as a boundary condition. Second, by using the wind stress result as a boundary condition for the OGCM, the influence of the wind stress change on AMOC is estimated. In addition, by analyzing the results from each model, the underlying mechanism is explored.

As a result, glacial ice sheets largely intensified the AMOC under glacial climate. It was also found that the wind stress change at North Atlantic was important, thus glacial ice sheets at northern hemisphere were important. On the other hand, the AMOC was hardly influenced by wind stress change at Southern Ocean, which is mainly induced by the change in the Antarctica Ice sheet. Therefore change in the Antarctica Ice sheet had small impact on AMOC through surface wind stress change.

By analyzing the results from the AGCM and OGCM, it revealed that two processes were crucial; first, the strengthening of the northward salt transport, which resulted from enhanced westerly due to the North America Ice sheet. Second, the northward sea ice transport due to the southerly wind at Norwegian Sea forced by the Northern Europe Ice sheet. These two processes were found to drastically intensify the AMOC through affecting the sea ice distribution and shifting the NADW formation region.

Keywords: Ice sheet, Glacial climate, AMOC, wind stress

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ACC32-10 Room:419 Time:April 29 16:45-17:00

Reconstruction of paleo-vegetation distribution by using an atmosphere ocean coupled GCM and a DGVM

O'ISHI, Ryouta[1*] ; CHAN, Wing-le[2] ; ABE-OUCHI, Ayako[2]

[1]National Institute of Polar Research, [2]Atmosphere and Ocean Research Institute, the University of Tokyo, [3]JAMSTEC

" The replacement of Neanderthals by Modern Humans has been considered to have occurred during 60,000-30,000 BP, which is also characterized by millennial scale climate change known as the Dansgaard?Oeschger events. The distribution of Neanderthals and Modern Humans during this period suggests correlation with that of paleo-vegetation and animals. This relation reflects the difference between the adaptabilities of Neanderthals and Modern Humans to environmental changes by way of their ability to hunt animals as food resources. Hence, it is important for the RNMH project to predict distribution of fauna, flora and climate change during this period. When estimating fauna distribution of the past, it is necessary to evaluate the changes in flora and thus changes in climate of the past. This can be directly achieved by examining data from sediment proxies, e.g. pollen records and isotopes. However, the availability of such proxies to reproduce the distribution of flora and climate changes is limited.

In the present study, we tried to reconstruct the vegetation distribution across North Africa, the Mediterranean and Europe during 60,000-30,000 BP from the results of a paleo-climate reconstruction by using a general circulation model as input for a dynamical global vegetation model. GCMs consume huge amounts of computational resources and so experiments are usually run using lower resolution models whose grid sizes are not sufficiently small for anthropological studies. In this study, we developed an " anomaly procedure " in order to incorporate features from both a high-resolution model and paleoclimate information. As a result of this new method, we successfully obtained a high-resolution vegetation distribution for a specific period of the past. However, it is not yet clear how these results can be validated against paleovegetation records. We need further discussions on how the appropriate paleoclimate can be reproduced by the GCM and how the vegetation model results can make a robust contribution toward the RNMH project.

Keywords: D-O cycle, Paleoclomate, Paleovegetation, Modeling

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ACC32-11 Room:419 Time:April 29 17:00-17:15

Arctic amplification and the Greenland ice sheet at the Last Interglacial: the role of vegetation feedback

ABE-OUCHI, Ayako[1*] ; O'ISHI, Ryouta[1] ; TAKAHASHI, Kunio[2] ; SAITO, Fuyuki[2]

[1]University of Tokyo AORI, [2]JAMSTEC

We calculated the climatic conditions, mass balance and the transient volume of the Greenland ice sheet in the last interglacial period using the atmosphere slab-ocean vegetation general circulation model ASVGCM MIROC-LPJ and IciES ice sheet model. Taking into account the vegetation feedback, the annual mean temperature anomaly increases from +1 K to +2 K, and of summer temperature anomaly from +4 K to +6 K in central Greenland. This is close to the +5 K at NGRIP and +8 K at NEEM as inferred from ice core isotope data, which takes into account that summer precipitation contributes more to oxygen isotope values{reference}. The vegetation feedback, also increases precipitation by 20% averaged over the entire ice sheet and by 30 % in northwestern Greenland. The combination of the sea ice-temperature feedback and the vegetation feedback amplifies both the temperature and precipitation changes in the Eemian.

The increased ablation caused by high temperatures in central Greenland is partly compensated by the increased precipitation. The ice volume loss of Greenland in the Eemian compares to present day amounts to 1 to 2.5 meters sea level equivalent depending on the inferred present day reference climate and model parameters, such as lapse rate. The spatial pattern of increased temperature and increased precipitation is supported by the fact, that the modeled Eemian Greenalnd ice sheet covers all locations of ice core cites (GRIP/GISP, NGRIP, NEEM and Dye3), for which the existence of Eemian ice is confirmed. The reconstructed sea level elevations in the Eemian range from 6 to 9 m{references} above present day sea level. Thus, our results imply that the larger part of the difference in sea level between Eemian and present day stems from the Antarctica ice sheet.

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ACC32-12 Room:419 Time:April 29 17:15-17:30

Sensitivity of Greenland ice sheet to climatic parameters during the last interglacial

TAKAHASHI, Kunio[1*] ; ABE-OUCHI, Ayako[2] ; SAITO, Fuyuki[1] ; O'ISHI, Ryouta[3]

[1]Japan Agency for Marine-Earth Science and Technology, [2]Atmosphere Ocean Research Institute, University of Tokyo, [3]National Institute of Polar research

In the last interglacial (LIG), sea level was 5 to 9 m above present, including contribution from Antarctica. Whole melting of the Greenland ice sheet (GIS) can contribute to the global sea-level rise of up to 7 m. It is important source of sea-level change. In the previous IPCC report in 2007 (IPCC AR4), estimates the GIS contribution to sea-level change during LIG range between 4 to 6 m. New IPCC AR5 points out that based on ice-sheet model simulations consistent with elevation changes derived form a new Greenland ice core, the Greenland ice sheet *very likely* contributed between 1.4 to 4.3 m sea level equivalent.

In this study, we present numerical experiments of GIS from 140 ka to 110 ka by using anomaly approach (present-day climate + perturbation obtained from MIROC-AGCM simulations including dynamic vegetation). We focus on the influence of the climatic parameters such as AMOC or northern hemisphere ice sheets. Our results are consistent with IPCC AR5. Considering of transient response to transient climate change are important to moderate ice melting. Several uncertainties remain however, such as the reference climate condition (influence melt from south, north or both?). and related the ice sheet model itself, more numerical studies are required.

Keywords: Last interglacial, Greenland, Ice sheet, Sea-level

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ACC32-13 Room:419 Time:April 29 17:30-17:45

Sea-level changes and crustal deformations in Greenland based on the loading histories derived from 3D ice sheet model

OKUNO, Jun'ichi[1*] ; SAITO, Fuyuki[2] ; ABE-OUCHI, Ayako[3] ; TAKAHASHI, Kunio[2]

[1]NIPR, [2]JAMSTEC, [3]AORI, Univ. Tokyo

We study the implications of a recently published ice sheet history in Northern hemisphere and Greenland ice sheet, derived from the 3D thermo-mechanical ice sheet model (Ice Sheet for Integrated Earth system Studies: IcIES developed by Abe-Ouchi et al. 2013). To characterize the effects of this glaciologically consistent ice sheet history, we examine the time-variations of various geophysical quantities in response to the ice and water mass redistributions. They include vertical uplift and subsidence, global patterns of sea-level change, and regional sea-level variations along the coasts of Greenland. Relative sea-level (RSL) changes in response to past ice and water load variations are obtained solving the sea-level equation, which accounts for the crustal deformation due to glacio-isostatic adjustment (GIA). In this study, we report the predictions of RSL and geodetic signals in Greenland induced by GIA process based on the glaciologically and climatologically consistent ice loading history. And also, we show the temporal and spatial characteristics of predicted geophysical signals in Greenland in comparison with these observations. We expect that using the ice sheet histories derived from IcIES as input in GIA model may put better constraints on postglacial rebound and current rates of crustal deformation.

Keywords: Greenland ice sheet, relative sea-level change, crustal deformation, isostasy

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ACC32-P01 Room:Poster Time:April 29 18:15-19:30

Chemical compositions of non-volatile particles in NEEM (Greenland) ice core over the last 100,000 years

OYABU, Ikumi[1*] ; IIZUKA, Yoshinori[2] ; KARLIN, Torbjorn[3] ; FUKUI, Manabu[2] ; HANSSON, Margareta[3]

[1]Graduate school of Environmental Science, Hokkaido University, [2]Institute of Low Temperature Science, [3]Department of Physical Geograohy and Quaternary Geology, Stockholm University, Sweden

The polar ice cores provide us with information of past atmospheric aerosols. Soluble aerosols in polar ice cores are well discussed by using proxies of ion concentration/flux, however, there are few studies about chemical compositions of soluble aerosols in ice cores. Using a sublimation method, we show differences in the compositions of non-volatile aerosols over the last 100,000 years in the NEEM ice core, which was drilled during 2008?2012 on the northwest ridge line of Greenland ice sheet (77 ′ 27 ″ N, 51 ′ 03 ″ W).

A total of 86 samples were distributed from NEEM ice core sections from 220 to 2195 m, which covers from late Holocene to Dansgaard-Oeschger event 24. Non-volatile particles were extracted from the ice by sublimation system [Iizuka et al., 2009]. Constituent elements of each non-volatile particle were measured by a scanning electron micro scope and energy dispersive X-ray spectroscopy. We made a classification of non-volatile particles into insoluble dust, soluble sulfate salts and soluble chloride salts as following; if Si found in a particle, we regard the particle as dust (Silicates); if S found, we regard the particle as sulfate; if Cl found, we regard the particle as chloride salt. For the sulfate salt, we did further classification that a particle containing Ca and S are assumed as CaSO4, Na and S are Na2SO4, Mg and S are MgSO4, K and S are K2SO4, the residual sulfate particles are " the other sulfate salt (other-S) " . In the same way, for chloride salts, we assumed NaCl, CaCl2, MgCl2, KCl and the other chloride salt (other-Cl).

The number ratio of soluble salts to total particles is 9±6 % during Dansgaard?Oeschger (DO) events. In Last Glacial Maximum (LGM), the ratio decreased in 3±2%. In Bolling-Allerod (BA), ratio of soluble salts slightly increased (10±5%). In Younger Dryas (YD), the ratio decreased again (6±3%). After Holocene, the ratio increased (16±10 %). In summary, more than 90 % of particles contain insoluble dust during the cold stages. These ratios suggest that during cold periods, insoluble dust concentration is higher contribution to total non-volatile particles than that in warm periods.

We examined chemical characteristics of non-volatile particles by dividing into 7 climatic stages (Late Holocene; LH, Early Holocene; EH, YD, BA, LGM, DO events-warm; DO-W and DO events-cold; DO-C). The 7 stages can be sorted into 2 types; interglacial-type (LH, EH and BA) and glacial-type (YD, LGM, DO-W and DO-C). For the interglacial-type, number of Na-containing particles is larger than that of Ca-containing particles (Na:Ca = 4:3). On the other hand, for the glacial-type, number of Ca-containing particles is larger than that of Na-containing particles (Na:Ca = 5:9). Ca-containing particles is suggested to mainly comes from terrestrial materials and Na-containing particles is mainly comes from sea-salt [Steffense et al., 1997]. Our results of the ratio of Ca and Na particles may be explained by not only absolute concentration of dust and sea-salt but also relative valance of those concentrations. In the three interglacial-type, the ratio of other-S and other-Cl, those are sulfate and chloride salts without Na, Mg, K, nor Ca, during the LH are relatively higher than the other stages. Since NH4+ concentration increased due to increasing of vegetation area and biological activity by warming in LH [Fuhrer and Legrand, 1997], other-S and ?Cl might be ammonium sulfate and ammonium chloride, respectively. Focusing on Ca-particles more in detail in the four glacial-type, number of Ca-containing particles without S and Cl is higher in LGM (11%) and DO-C (12%) than that in YD (6%) and DO-W (7%). Since the X-ray spectroscopy cannot detect carbon, the Ca-containing particles may be CaCO3 in the LGM and DO-C because CaCO3 was founded during the LGM by single particle measurement in the GRIP (Greenland) ice core [Sakurai et al., 2009].

Keywords: ice core, aerosol, paleo climate, greenland, ice sheet, NEEM

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ACC32-P02 Room:Poster Time:April 29 18:15-19:30

Modelling the climate and the terrestrial carbon cycle for the last millennia

ABE-OUCHI, Ayako[1*] ; O'ISHI, Ryouta[1] ; YOSHIMORI, Masakazu[1]

[1]University of Tokyo AORI

Climate-induced changes in the terrestrial biosphere and the ocean modulate the release and uptake of carbon dioxide and this, in turn, alters atmospheric composition and influences the climate. This is known as the climate-carbon cycle feedback. The Coupled Carbon Cycle Climate Model Intercomparison Project (C4MIP), using models of the ?terrestrial and ocean carbon cycles inside ocean-atmosphere general circulation models, has shown that the carbon cycle-climate feedback appears to be positive BUT there is great uncertainty about the magnitude. It is important to know the magnitude of this feedback because it affects the amount of carbon dioxide that can be emitted in the future in order to stabilize the concentration of CO2 at a given level. There are projects attempting to reduce these uncertainties through systematic evaluation of carbon cycle models against observations of the contemporary carbon cycle. An alternative approach is to use knowledge about past variations in climate and CO2 to provide additional constraints. Here we therefore work on the last millennium (LM) climate-carbon modeling and examine the factors that contribute to atmospheric CO2 change. Ice core is the only proxy that provides the CO2 content in detail for the last millennium and it shows up to 10ppm change around the Little Ice Age and during the LM. Several LM experiments by AOGCM are used to drive the terrestrial carbon cycle model LPJ. We investigate the role of external forcing of climate such as volcano and solar forcing as well as that of internal variability of climate in an unforced experiment of decadal to centennial time scale. We show that the CO2 changes in the same order of magnitude in the unforced experiment as in the forced experiment.