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

ACC029-01 Room:102 Time:May 26 11:45-12:00

Is the source of iron River Amur or Asian Dust? -Estimation of air-borne Fe flux from ice core

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Iron is an essential nutrient for phytoplankton and plays an important role in the control of phytoplankton growth. Iron enrichment experiments carried out in the western and the eastern subarctic Pacific reveal that the iron limits phytoplankton growth in these areas. Possible sources of iron in the Sea of Okhotsk and/or Oyashio regions in the western subarctic Pacific are thought to be the iron-rich intermediate waters transported to surface by upwelling, and atmospheric dust that are lifted by dust storms generated over the Asian continent. We estimated air-borne iron fluxes into the northern North Pacific by an ice-core obtained from Mount Wrangell in Alaska, and aerosol monitoring carried out at Kushio and Toikanbetsu in Hokkaido. Estimated annual fluxes of air-borne iron were ranged from 10 to 270 mg/m^{2}yr, which can influence to biological productivity in the northern North Pacific. We conclude that impact of air-borne Fe input is spatiotemporally limited and may have a role for sporadically occurring phytoplankton blooms in the open ocean, and consistently occurring events such as spring bloom in Oyashio region is controlled by iron originated from River Amur.

Keywords: ice core, aerosol, air-borne iron, Oyashio region, Okhotsk, Amur river

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

ACC029-02 Room:102 Time:May 26 12:00-12:15

Elemental and mineralogical compositions and Sr and Nd isotopic ratios in surface dust on mountain glaciers in Asia

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Snow and ice on glaciers contain various impurities, such as mineral dusts and pollens. Dust deposited on glaciers in the past can be obtained by ice core drilling. The geochemical information of the dust in ice cores can reveal various environmental conditions in the past.

In this study, we analyzed elemental and mineralogical compositions of silicate mineral in the surface dust on Asian mountain glaciers (Altay, Tien Shan, Qillian Shan, and Himalayan) as well as the isotopic ratios to identify their provenance.

XRD analysis showed that the surface dust consisted of similar mineral compositions. They were mainly 5 silicate minerals: quartz, plagioclase, chlorite, and clay minerals such as illite and kaolinite. The minerals were most likely derived from desert sand and loess in China. In contrast, the elemental compositions of surface dust significantly varied among glaciers. both the glaciers are located in Tien Shan Mountains, the compositions of glacier in Kyrgyzstan (western part of Tien shan) and those of glacier in China (eastern part of Tien Shan) showed slight differences. This suggests that the elemental compositions reflect the sources of silicate minerals on the glacier.

Keywords: Sr, Nd isotopic ratios, surface dust on the glacier, XRD analysis

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

ACC029-03 Room:102 Time:May 26 12:15-12:30

The variation in oxygen stable isotope for 12,500 years of an ice core drilled from Grigoriev ice cap in Kyrgyz Tienshan

Nozomu Takeuchi[1*], Koji Fujita[2], Shuntarou Sera[1], Yusuke Yokoyama[3], Sachiko Okamoto[2], Kazuhiro Naoki[4], Vadimir Aizen[5]

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In 2007, ice cores were successfully drilled on Grigoriev Ice Cap located in the Tien Shan Mountains, Kyrgyztan. The elevation of the drilling site was 4600 m a.s.l. and entire core length was 87 m. Radiocarbon dating revealed that the soil corrected from the bottom of the ice core was 12,500 cal year bp. Oxygen stable isotope of the ice core showed that recent increasing trend and siginificant negative value before 6,000 cal year bp.

Keywords: glacier, ice core, Holocene, stable isotope, climate change, central asia

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

ACC029-04 Room:102 Time:May 26 12:30-12:45

Characteristics of Isotope and Chemical Composition in the Fedchenko Glacier, Pamirs

Shun Amemiya[1*], Nozomu Takeuchi[1], Koji Fujita[2], Sumito Matoba[3], Sachiko Okamoto[2], Evgeny Podolskiy[2]

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Analysis of soluble chemical ions in ice cores can reveal various environmental information in the past, such as atmospheric circulation and land cover. In this study, we analyzed the oxygen stable isotope and soluble chemical ions in shallow ice cores drilled on Fedchenko Glacier located in Central Pamirs. The glacier is the largest mountain glacier in this region and the thickest part of the glacier ice is more than 600m. The two ice cores, 5 m and 10 m in depth, were collected at middle of the glacier at the elevation of 5,000 m in 2009.

The stratigraphy of the cores, show that it was composed of the firn, ice, and dust layers. Based on the dust layers, which is formed in every spring, the 5 m and 10 m cores covered three and seven years, respectively.

The oxygen stable isotope ratio showed a clear seasonal variation in the upper part of the 10 m core, but no significant changes in the lower part and in the 5 m core. The seasonal signals in the lower part had probably removed by intra-glacial meltwater.

The concentration of major chemical components revealed that Ca, Cl, SO_4, and Na were the four most dominant species and they accounted for more than 80 % (w/w) in the measured ions. The chemical profiles in the core showed the distinct peaks in the upper part of the core. The chemical components of each peak were divided into two categories: Type 1 was composed of Ca, NO_3 and SO_4, and Type 2 was composed mainly of Cl, SO_4, Na and Ca. Comparison with stable isotope ratios, Type 1 was corresponding to the event in summer, while Type 2 to the event in winter. Based on the seasonal atmospheric circulation change in this region, Type 1 components are likely to be derived from the vast arid regions in northeast side of the glacier, carried by the northeasterly wind in summer, and Type 2 components are likely to be derived from the western Asia blown by the southwesterly wind in winter.

Keywords: Fedchenko Glacier, ice core, stable isotope ratio, soluble chemical ions

Japan Geoscience Union Meeting 2011
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ACC029-05 Room:102 Time:May 26 14:15-14:30

Snow algae in an ice core drilled on Grigoriev Ice cap in the Kyrgyz Tien Shen Mountains

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Snow algae are photosynthetic microorganisms and are living on the surfase of glaciers. They grow on melting surface from spring to summer and their the biomass and community structure are changed with physical and chemical conditions on glaciers. Ice cores drilled from glaciers also contain snow algae that grew in the past. Studying biomass and community structure of snow algae in ice cores may reveal that not only temporal variation in snow algae in the past but also environmental condition relating propagation of snow algae. In this study, we aim to describe snow algae on the surface and in an ice core of Grigoriev Ice cap located in eastern Kyrgyzstan of the central Asia.

The ice and snow samples corrected at various parts on the glacier surface contained at least three taxa of filamentous cyanobacteria, a unicellular cyanobacterium, and two green algae. The samples of pit and ice core collected on the top of the glacier also contained a filamentous cyanobacterium, an unicellular cyanobacterium, and an green alga. The quantitative analyses of the algae in the 18 m deep ice core samples revealed that the algal biomass showed several peaks. Based on the dating by pollen grains, the 18 m core covers 46 years. The results suggest that the snow algae did not grow every year on the top of the ice cap, and their biomass and community structure varied greatly from year to year.

Keywords: snow algae, ice core, Grigoriev Ice cap

Japan Geoscience Union Meeting 2011
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ACC029-06 Room:102 Time:May 26 14:30-14:45

Reconstructions of past flora using DNA analysis from ice core samples on Gregoriev Glacier, Kyrgyz Tienshan

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Analyses of ice cores have often been used as a means to reconstruct past environments. The species composition of the organism such as microorganism and plant in the ice cores could reflect the environmental condition at that time. Thus, organisms in ice cores could be useful to reconstruct past environments. However, analysis of the biological contents in ice cores is still very limited. In this study, we examined DNA from ice core sample (about 7,500, 8,000 and 12,500 years old) collected on the Gregoriev Glacier, Kyrgyz Tienshan. We extracted inner part of ice core samples by melting device. Genes of microorganisms and plant plant were subjected to PCR amplification and nucleotide sequencing. We also showed phylogenetic diversity of a microbial flora and metagenomic survey of the metabolic potential. Our results implied that DNA from preserved organisms could be recovered from the ice core samples, leading reconstructions of past flora. Biological information could be used as an environmental marker for past environmental studies.

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

ACC029-07 Room:102 Time:May 26 14:45-15:00

A 274-year environmental record of from Aurora Peak ice core, Alaska.

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We drilled a 180m ice core from Alaska range in Alaska in 2008. Our chemical analysis of the ice core indicated the followings: (1) Age of the ice core was estimated with annual counting of delta-D seasonal cycles, and reference signals of eruptions Mts. Spurr and Katmai and tritium. (2) Annual average values of delta-D did not correlated with annual precipitation observed at several weather stations in Alaska, but with variation of PDO (Pacific Decadal Oscillation) index. (3) Annual accumulation rate estimated by seasonal cycle of delta D increased slightly from the beginning of 1900s, and increased remarkably from 1970s. Because the concentrations of sea salt also increased from 1970s, the increase of precipitation from 1970s can be caused by enhancement of storm activities in winter at Gulf of Alaska. (4) Increase of NH_4, NO_3, K originated from biomass burning from 1950s can indicate increase of frequency of wildfire in Alaska.

Keywords: ice core, Alaska, environmental change, hydrogen isotope

Japan Geoscience Union Meeting 2011
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ACC029-08 Room:102 Time:May 26 15:00-15:15

Reconstruction of summer temperature by Aurora Peak ice core, Alaska Range

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In May and June 2008, a 180 m long ice core was obtained at Aurora Peak, Alaska Range. The age scale was derived from the seasonal variation of hydrogen isotope ratio and melt feature percentage (MFP) which means the percentage of melt layers relative to annual layer. The ice core is considered to cover the period from 1734 to 2008.

This study focuses on melt features in the ice core. In the previous studies, past summer temperatures were reconstructed from melt features. We evaluated the climatic representativeness of melt features in Aurora Peak ice core by comparing to summer temperature at Gulkana Glacier, located 60 km southeast of Aurora Peak. The U.S. Geological Survey (USGS) operates a long-term program to monitor this glacier and meteorological data are available. We confirmed that estimated summer temperature by air temperature at Gulkana Glacier has remained almost below zero. The distribution of melt feature thickness shows that most are less than 2 cm (although there exist melt feature greater than 5 cm). These results suggest that little meltwater would percolate to the layer of the previous year.

We examined the relation between annual melt feature thickness and summer temperature at Gulkana Glacier and it showed significant correlation ($r = 0.94$, $p<0.001$). It means that melt features reflect summer temperature histories.

Keywords: Ice core, summer temperature, Melt feature

Japan Geoscience Union Meeting 2011
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ACC029-09 Room:102 Time:May 26 15:15-15:30

Reconstruction of the climate and environment during the past 150kyrs under the NEEM project

Kumiko Goto-Azuma[1*], Shuji Aoki[2], Nobuhiko Azuma[3], Yoshinori Iizuka[4], Jun Uetake[1], Kenji Kawamura[1], Hiroshi Kanda[1], Takayuki Kuramoto[1], Takuro Kobashi[1], Kimikazu Sasa[5], Motoyuki Sato[3], Takahiro Segawa[1], Chikako Takamura[1], Takakiyo Nakazawa[2], Motohiro Hirabayashi[1], Yoshiyuki Fujii[1], Shuji Fujita[1], Akira Hori[6], Kazuho Horiuchi[7], Takayuki Miyake[1], Atsushi Miyamoto[4], Hideaki Motoyama[1], Dorthe Dahl-Jensen[8], Jorgen Peder Steffensen[8], Sigus J. Johnsen[8]

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To improve the projection of future Arctic climate and environment changes associated with global warming, including retreat of Greenland ice sheet, advancement in ice sheet and climate modeling is required. For this goal, long-term records of the past Arctic warmings and their impacts, and the understanding of the mechanisms are necessary. An international ice coring project NEEM (North Greenland Eemian Ice Drilling) was initiated to obtain the oldest ice core in the northern hemisphere, covering the last interglacial period (Eemian), which is thought to be 3-5^{o}C warmer than today. The drilling reached the bedrock in July 2010. Using the NEEM core, we aim at reconstructing the climatic and environmental changes during the Eemian, early Holocene, and the abrupt climate changes in the last glacial period (Dansgaard-Oeschger events). Based on an accurate chronology, relative timing of changes in Greenland air temperature, greenhouse gases, sea level, global ocean temperature, Antarctic temperature and orbital parameters will be investigated. Results of this project will shed light on the mechanisms of climate and ice sheet changes, and also provide important data for improving climate and ice sheet models. Part of the NEEM ice core and snow pit samples have been transported to Japan and analyzed. Results of the preliminary analyses will be presented.

Keywords: Greenland, ice core, NEEM, Eemian

Japan Geoscience Union Meeting 2011
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ACC029-10 Room:102 Time:May 26 15:30-15:45

Synchrony between Greenland temperature change and wide-spread alpine glacial changes for the last four millennia

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Glacial melting at polar and alpine regions and associated sea-level rise is one of the major concerns in the future climate change induced by increasing greenhouse gases. However, how global to hemispheric temperature change will affect glacial advances/retreats is poorly understood. Here, we reconstructed the last 4000 years of Greenland temperature (a hemispheric temperature proxy) using argon and nitrogen isotopes in air bubbles in Greenland ice cores (GISP2). We found Greenland temperature changed synchronously with the wide-spread glacial advances/retreats (e.g., the Great Aletsch glacier in the Swiss Alps) for the last 4000 years in a multi-centennial to millennial scale. Especially, two periods, peaking around 600-500 B.C.E. (Iron Age Cold Epoch) and 1300-1850 C.E. (Little Ice Age) were the coldest periods of the last 4000 years at the time of near-global glacial advances. We hypothesize that signals of climate forcings (e.g., changes in solar activity) are amplified by ice-albedo feedback in polar and alpine regions so that common signals are recorded in the Greenland temperature and glacial histories.

Keywords: Greenland, Ice core, Gas analysis, Thermal diffusion, Firn

Japan Geoscience Union Meeting 2011
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ACC029-11 Room:102 Time:May 26 15:45-16:00

Reconstructions of temperature histories of the Dome Fuji site and its moisture source using water isotope records

Ryu Uemura[1*], Valerie Masson-Delmotte[2], Jean Jouzel[2], Amaelle Landais[2], Francoise Vimeux[2], Hideaki Motoyama[3], Barbara Stenni[4]

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A stable isotope ratio (D/H or $^{18}O/^{16}O$) of the polar ice cores is widely used as an air-temperature proxy. Further, a combined use of these isotopes provides a parameter, deuterium-excess (d), and provides the information on the ocean surface conditions in the moisture source for polar precipitation. Here we re-evaluate several coefficients used for reconstructing Antarctic site temperature and temperature in the moisture source regions. The new coefficients were applied to the revised D/H and $d$records of Dome Fuji core which cover past 360 kyr period. Differences between this study and previous estimations will be discussed.

Japan Geoscience Union Meeting 2011
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ACC029-12 Room:102 Time:May 26 16:00-16:15

Dependence to Glacial Ice Sheets in Amplifying the Polar Climate

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Larger climate change in the high latitude known as polar amplification is anticipated to occur and ice core cites and paleoiclimate model experiments are used to evaluate the climate sensitivity of the Climate models used for future climate projection. For the boundary condition of the Last Glacial Maximum (LGM) experiment of PMIP (Paleoclimate Modelling Intercomparison Project) phase 3, a new ice sheet is applied, which is the average of three ice models derived from different method. Here we compare the ice sheet boundary condition to the previous boundary conditions of PMIP phase 1 and PMIP phase 2 and also examine the dependence of the result of polar amplification to the choice of ice models. The PMIP3 LGM ice sheet in NH is now thinner and flatter than in PMIP2, which decreases the topography effect of ice sheet and influences the stationary wave and storm tracks. On the other hand, PMIP3 LGM ice sheet in SH is now thicker in West Antarctica (WAIS), broader in the east (EAIS), which cools down the zonal mean in the high southern latitude. The EPICA and DomeF cores are reproduced even if the altitude is corrected in the East Antarctica. We find that the extent of EAIS and the WAIS change influence the zonal mean and even in the Domes of EAIS. We also find from our GCM sensitivity experiments that both the ice sheets and Greenhouse gas amount contribute to the temperature at the ice core cites. This implies that the ratio of polar amplification throughout the ice age cycle could depend on the ice sheet history especially in the WAIS as well as the history of Greenhouse Gas. The long term temperature change that could not be explained by the change of radiative forcing of Greenhouse gas, orbital change and abrupt climate change can be largely attributed to the size of WAIS/EAIS for the ice cores in the Southern Hemisphere and to the size of Northern Hemisphere ice sheets for the ice cores in the Northern Hemisphere.

Japan Geoscience Union Meeting 2011
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ACC029-13 Room:102 Time:May 26 16:30-16:45

Constraint on age model of North Atlantic marine cores using O2/N2 chronology of the Dome Fuji ice core

Kenji Kawamura[1*], Shuji Aoki[2], Takakiyo Nakazawa[2], Ayako Abe-Ouchi[3], Fuyuki SAITO[4], Kazue Suzuki[1]

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Investigation of the roles of different forcings (e.g. orbital variations and greenhouse gases) on climate requires a paleoclimate chronology with high accuracy (˜1/10 of precession cycle). Recently, we established such a chronology for the past 360 ky through orbital tuning of O2/N2 ratio of trapped air in the Dome Fuji and Vostok ice cores with local summer insolation. We here show the O2/N2 chronology back to ˜500 kyr from the second Dome Fuji ice core, Antarctica. We find the duration of 11 ka, 5 ka, 9 ka, and 20 ka for MIS 5e, 7e, 9e and 11c interglacial periods in Antarctica. The termination onsets lag behind the Northern Hemisphere summer solstice insolation minima by 2-7 ka.

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, the planktonic d18O and IRD records from the marine core ODP 980 are correlated with Dome Fuji d18O and CH4 at the end of termination V and the first two millennial-scale events after MIS 11c. We find that the durations of plateaus of planktonic and benthic d18O for MIS 11c are 20 and 15 ka, respectively, which are significantly shorter than originally suggested. These durations are similar to that of interglacial warmth in Antarctica. 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 of ice sheet melting and northern high-latitude warming for termination V. The investigations on other interglacial periods and other marine cores are ongoing, and the results will also be reported.

Keywords: Ice core, Dome Fuji, O2/N2 age model, Interglacial period, Glacial period, Marine sediment cores

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ACC029-14 Room:102 Time:May 26 16:45-17:00

Geomagnetic field intensity as a tool for chronostratigraphic correlation between marine sediments and ice cores

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Recent progress in paleomagnetic studies of marine sediments has revealed long-term (10 to 100 kyr) variations in geomagnetic field intensity (relative paleointensity). The accumulation of these relative paleointensity records has enabled the development of a composite geomagnetic field intensity stack for time intervals spanning the period from the last few tens of thousand of years to the last few million years and has helped establish an age model for marine sediments. This technique can be a powerful tool for synchronizing different geological archives, such as marine sediments and ice cores, by comparing the flux of cosmogenic nuclides. This synchronization is essential for understanding the initiation and propagation of changes in the Earth's climate system. However, there are some arguments concerning the limits of marine sediment age determination from relative paleointensity records. For example, uncertainty can be introduced into the synchronization by the lock-in of a paleomagnetic signal at some depth below the sediment-water interface in marine sediments through the acquisition of post-depositional remanent magnetization (PDRM). This article presents the current understanding of the PDRM process and offers examples of relative paleointensity-assisted correlation or dating in marine sediments. Possible sources of uncertainty and future prospects for this technique are also discussed.

Keywords: Relative paleointensity, marine sediments, Age model, Post-depositional remanent magnetization, Lock-in depth, Cosmogenic nuclides

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ACC029-15 Room:102 Time:May 26 17:00-17:15

Dating of a Dome Fuji (Antarctica) shallow ice core by volcanic signal matching with B32 and EDML1/EDC3 chronologies

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We used volcanic signature matching between the DF01 shallow ice core from Dome Fuji (Dome F) and the B32 ice core from Dronning Maud Land, East Antarctica, to transfer the B32 chronology constructed by annual layer counting and the top part of the correlated EDML1/EDC3 chronology to the portion of the DF01 core between 1900 and 1 AD. Matching was done by careful comparison of non-sea-salt sulfate ($nssSO_4^{2-}$) data, which have a temporal resolution of about 1 year, between the DF01 and B32 cores. Synchronization of the volcanic signatures was extremely good, enabling us to date the DF01 core, in particular the part before the last ˜800 years, which has been difficult before this.

In total, 31 volcanic eruptions were synchronized between 1900 and 180 AD, and 4 volcanic eruption dates from EDML1/EDC3 chronology were additionally used for a tentative dating of the DF01 core until 1 AD. The newly obtained chronologies are called DFS1 (transferred from the B32 chronology) and DFS2 (transferred from EDML1/EDC3 chronology). We found that the mean accumulation rate between the synchronized volcanic horizons of the Dome F relative to that at the B32 core drilling site does not differ significantly over the past ˜1700 years, adding further confidence on the matching approach. We also determined the absolute mean accumulation rates at Dome F from 1900 AD back to 1 AD.

Keywords: ice core, Dome Fuji, core dating

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ACC029-16 Room:102 Time:May 26 17:15-17:30

Detailed stratigraphy of a 4m-deep pit at Dome Fuji, for better understanding formation of ice core signals

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To better understand physical structure of the snow stratification, a 4-m deep pit was dug at Dome Fuji. Physical structure such as density, grain size etc. were investigated. We will present most updated data and interpretation in terms of ice core signal formation.

Keywords: Antarctica, Dome Fuji, core, firn, snow

Japan Geoscience Union Meeting 2011
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ACC029-17 Room:102 Time:May 26 17:30-17:45

Water stable isotope of near surface snow and environment of snow accumulation at inland of Antarctica

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Water stable isotope ratios in ice cores are believed to represent pale-temperature. It was also often pointed out by modeling studies, on the other hand, that isotope ratios were altered after snow deposition due to the water vapor transport within the sub-surface snow. In the inland of Antarctica, snow accumulation is extremely low and thus snow should stay for several years near the surface. Therefore, significant change isotope ratios are expected. This phenomena has not been so far confirmed by observational approaches.

We dug two snow pits at Dome Fuji (DF) and Meeting Point (MP) (approximately 380 km from Dome Fuji Station) at 2007. Water stable isotope ratios, major ion concentrations, tritium contents of the snow pits are analyzed. We put time seals on the snow pits using tritium contents, non-sea-salt sulfate ion, nitrate ion and crust layers. Annual accumulation rates of the MP and DF pits are estimated as 40.3 and 29.3 kg m^{-2} a^{-1}, respectively. The oxygen isotopic profile in the MP pit seems to preserve clear seasonal cycle, whereas several-year cycle with large amplitude of oxygen isotope ratios is found in the DF pit. This DF cycle corresponds to neither seasonal cycle nor any fluctuation of air temperature in Antarctic stations. Calculations of the water vapor flux using the observation snow temperature indicate that the maximum convergence of water vapor from surface to 20 cm depth. If snow accumulation rate was constant, every snow layer would get the same amount of water vapor and thus the seasonal cycle of oxygen isotope ratios should be preserved. However, observation data at DF shows the variability of snow accumulation rates ranging from -20 to 90 kg m^{-2} a^{-1} with several-year cycle. We simulate water vapor convergence of each snow layer with taking the observed variability of snow accumulation rate into account. The results show temporally inconstant fluctuation of water vapor condensation. This water vapor profile is consistent with the isotope ratios cycle of DF pit. We conclude that the oxygen isotope cycle of DF snow pit should be formed by vapor condensation at the sub-surface and large variability of snow accumulation rate.

Keywords: Antarctica, water stable isotope

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ACC029-18 Room:102 Time:May 26 17:45-18:00

Molecular and stable isotopic compositions of terrestrial biomarkers in fresh snow from Sapporo, northern Japan

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Homologous series of high molecular weight *n*-alkanes, *n*-alkanols and *n*-alkanoic acids are typical biomarkers that originate from terrestrial higher plant waxes (Eglinton and Hamilton, 1967). These organic compounds are easily sloughed off from the leaf surface, and can become airborne. Because the terrestrial biomarkers in the atmosphere are eventually scavenged and deposited over ice sheet and ocean without suffering major modification due to their refractory nature, understandings of their transport processes can provide a base for paleoclimatological studies of ice cores and marine sediments. In the Japan sea-side of the Japanese islands, the cold and dry air of the Asian winter monsoon causes intensive snowfall with the supply of the heat and moisture from warm Tsushima current over the Sea of Japan. Hence, the snow in northern Japan should contain the imprint of aeolian inputs of terrestrial biomarkers. In this study, we investigated molecular distributions of terrestrial biomarkers and stable carbon ($d^{13}C$) and hydrogen (dD) isotope ratios of C_{22-28} *n*-alkanoic acids in fresh snow samples from Sapporo, northern Japan, to better understand their source regions and transport pathways. The snow samples are found to contain higher plant-derived *n*-alkanes, *n*-alkanols and *n*-alkanoic acids as major components. Relative abundances of these three biomarker classes suggest that they are likely derived from higher plants in the Asian continent. The C_{27}/C_{31} ratios of terrestrial *n*-alkanes in the snow samples range from 1.3 to 5.5, being similar to those of the plants growing in the latitudes $>$ 40N of East Asia. The $d^{13}C$ values of the *n*-alkanoic acids in the snow samples (-33.4 to -29.0 per mil) are similar to those of typical C_3 gymnosperm from Sapporo (-34.4 to -30.4 per mil). However, the dD values of the *n*-alkanoic acids (-181 to -165 per mil) are found to be significantly depleted with deuterium (by up to 48 per mil) than those of plant leaves from Sapporo. Such depletion can be most likely interpreted by the long-range atmospheric transport of the *n*-alkanoic acids from vegetation in the latitudes further north of Sapporo because the dD values of terrestrial higher plants tend to decrease northward in East Asia reflecting the dD of precipitation. Together with the results of backward trajectory analyses, this study suggests that the terrestrial biomarkers in the Sapporo snow samples are likely transported from Siberia, Russian Far East and northeast China to northern Japan by the Asian winter monsoon.

Keywords: stable carbon isotopes, stable hydrogen isotopes, terrestrial biomarker, snow, Asian monsoon