Preliminary Modelling of the vegatation-climate, wet area and past methane emission by a general circulation model and a dynamical global vegetation model

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Past time series of methane concentration in the atmosphere is reconstructed from ice core. Generation and emission of methane depend on temperature, wetness and amount of soil organic carbon which reflects climate change and vegetation change. Hence past methane information is useful for validation of paleoclimate modelling. In the present study, we predict some typical past climate (mid-Holocene, the Last Glacial Maximum, the Last interglacial and mid-Glacial) by a general circulation model MIROC and corresponding past vegetation by a dynamical global vegetation model LPJ-DGVM. Furthermore, by introducing a formulation based on Cao et al. 1996, we try to predict the distribution of past methane emission and its total global amount.

キーワード：古気候、植生、メタン
Keywords: paleoclimate, vegetation , methane

Response of oceanic carbon cycle during Heinrich events

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Paleoproxy indicate that a substantial weakening of the Atlantic Meridional Overturning Circulation (AMOC) during Heinrich events was often accompanied by a notable atmospheric CO_2 increase. However, previous modeling studies show conflicting atmospheric CO_2 responses to an AMOC shutdown. In this study, we investigate the response of ocean carbon cycle to weakening AMOC using freshwater experiment conducted with a coupled atmosphere-ocean general circulation model MIROC and offline ocean biogeochemical model. The weakening of AMOC under mid-Glacial condition leads to an oceanic carbon reservoir decrease and to a 4 ppmv atmospheric CO2 increase, which is smaller than the ice core date of 15 ppmv CO_2 rise. The weakening of the North Atlantic leads to a loss of DIC in the North Atlantic intermediate and deepwaters, resulting in CO2 outgassing into the atmosphere. In contrast, the greater mixing in the Southern Ocean enhances biological pump and thus increases CO_2 uptake from the atmosphere. Because thse two process cancel each other out, our simulation underestimates the observed atmosphric CO_2 increase. We also discuss the potential mechanisms which cause the additional CO_2 increase of 10ppmv in this presentation.

キーワード：ハインリッヒイベント、炭素循環
Keywords: Heinrch events, Carbon cycle

Precise dating of cosmic ray events in the 17th century found by the analysis of beryllium-10 content in Antarctic ice core

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The records of beryllium-10 content in ice cores from Greenland and Antarctica have indicated five events of cosmic ray flux enhancement around the Maunder Minimum from the late 17th century to the early 18th century. These events are suggested to have occurred associated with the change in the heliospheric environment due to the disappearance of sunspots. In order to determine absolute ages of these events, we conducted high precision measurements of carbon-14 in tree rings. Although the peaks in carbon-14 content is strongly attenuated in carbon cycle, they have been detected by the measurement with 0.1% precision.

キーワード：氷床コア、宇宙線生成核種、太陽活動
Keywords: Ice core, Cosmogenic nuclide, Solar activity

Seasonal scale dating of a shallow ice core from Greenland using oxygen isotope matching between data and simulation

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A precise age scale based on annual layer counting is essential for investigating past environmental changes from ice core records. However, the uncertain seasonal cycle (i.e., non-sinusoidal pattern) of oxygen isotope ($\delta^{18}O$) records causes inevitable errors in the dating. Here, we propose a dating method based on matching the $\delta^{18}O$ variations between ice-core records and records simulated by isotope-enabled climate models. We applied this method to a new $\delta^{18}O$ record from an ice core obtained from a dome site in southeast Greenland. The close similarity between the $\delta^{18}O$ records from the ice core and models enabled correlation and the production of a precise age scale, whose accuracy was ±2 months. A missing $\delta^{18}O$ minimum in the 1995/1996 winter is an example of the uncertain $\delta^{18}O$ seasonal cycle, which hampers annual layer counting. Our analysis suggests that the missing $\delta^{18}O$ minimum was likely caused by a combination of warm air temperature, weak moisture transport, and cool ocean temperature. Based on the age scale, the average accumulation rate from 1960 to 2014 was reconstructed as 1.02 m yr^{-1}. The annual accumulation rate increases with a slope of 3.6 (mm $year^{-1}$), which is mainly caused by the increase in the autumn accumulation rate (2.6 mm $year^{-1}$), which is likely linked to the enhanced hydrological cycle caused by the decrease in Arctic sea ice area. On a seasonal time-scale, our reconstructed accumulation suggests that the ERA re-analysis data overestimates the seasonality in this southeast dome region.

キーワード：グリーンランド、アイスコア、季節レベルの時代決定、酸素安定同位体、気温、涵養量
Keywords: Greenland, ice core, seasonal scale dating, oxygen isotope, air temperature, annual accumulation rate

A 60-year record of atmospheric sulfate and nitrate depositions preserved in the high-accumulation dome ice core, South East Greenland

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Southeastern Greenland has a dome whose elevation is higher than 3000 m a.s.l. with high accumulation rate (about 1 m yr^{-1}) in water equivalent, which is suitable conditions for reconstructing past environmental changes with a high-time resolution. In this study, we measured major ion fluxes in 90 m ice core drilled from the SE-Dome region in 2015, and obtained records of annual ion fluxes from 1957 to 2014. High average NO_3^- flux (68.9 mg m^{-2} yr^{-1}) with low $\delta^{15}N$ value in the SE-Dome ice core suggests negligible effect of the post depositional NO_3^- loss. Thus, the SE-Dome region is one of the best locations for reconstructing nitrate fluxes. Decreasing trend of non-sea-salt (nss) SO_4^{2-} flux from 1970 to 2010 follows well that of anthropogenic SOx emission from North America, suggesting that the SO_4^{2-} flux in SE-Dome ice core mainly records anthropogenic emission of SOx from North America. In contrast, the decadal trend of NO_3^- flux in SE-Dome ice core differs from the decreasing trend of anthropogenic NOx emission in North America. The exact cause of the apparent non-linear relationship remains unclear but a formation of ammonium nitrate particles enhanced by SOx reduction appears to be an important mechanism as suggested by excess ammonium flux over sulfate. Our NO_3^- flux record is similar to other ice cores in Greenland high elevation sites on 5-yr running average, suggesting that NO_3^- concentrations records from these ice cores are reliable.

キーワード：グリーンランド、アイスコア、硫酸イオン、硝酸イオン、人為起源排出量
Keywords: Greenland, ice core, sulfate ion, nitrate ion, Anthropogenic emission

The triple isotopic composition of oxygen for sulfate and nitrate in surface snow in a latudinal transect in East Antarcica

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The isotopic compositions of sulfate (SO_4^{2-}) and nitrate (NO_3^-) reflect their sources and oxidation pathways. In particular, triple oxygen isotope compositions ($\Delta^{17}O$) are potential tool to reconstruct how the oxidants work in past and present atmosphere. Antarctica is an ideal place to investigate the past proxy, because the ice core preserves in past hundred thousands Earth’ s history. However, recently we found the annual mean $\Delta^{17}O$ values for atmospheric SO_4^{2-} at coastal Antarctica is not matched with the $\Delta^{17}O$ values preserved in the inland Antarctic ice core records. In addition, the lack of observation, spatial variations of $\Delta^{17}O$ values are limitedly reported.
In order to test spatial variation of isotopic compositions, especially for the difference in $\Delta^{17}O$ values between coastal site and inland site, here we present latitudinal variation of $\Delta^{17}O$ value and conventional isotopic compositions ($\delta^{34}S$, $\delta^{15}N$, and $\delta^{18}O$) of SO_4^{2-} and NO_3^- in surface snow in eastern Dronning Maud Land, East Antarctica. Snow samples were collected from the surface at low- and high-elevation sites during the 54th and 57 th Japanese Antarctic Research, respectively. $\Delta^{17}O$ values of non-sea-salt (nss)-SO_4^{2-} at the East Antarctica ranges from 2.2 to 3.3‰, and the $\Delta^{17}O$ value of nss-SO_4^{2-} for coastal site was lower than those for inland site. Thus, this result suggest that oxidizing chemistry for biogenic sulfur is different among coastal and inland sites, although small sulfur isotopic variations are observed and source of sulfur is biogenic and homogeneous. For the isotopic compositions of NO_3^-, considerably increasing values of $\delta^{15}N$ of NO_3^- are observed from coastal to inland sites. The $\delta^{18}O$ and $\Delta^{17}O$ of NO_3^- values, on the other hand, decreases with increasing of $\delta^{15}N$ values, indicating the secondary formation of NO_3^-. Thus, spatial variations of isotopic compositions of NO_3^- reflect the post-depositional processes on the East Antarctic snow.

キーワード：安定同位体、三酸素同位体組成、硫酸、硝酸
Keywords: stable isotope, triple oxygen isotopes, sulfate, nitrate

A year-round observation of sulfur stable isotopic compositions of atmospheric sulfate at Dumont d'Urville, coastal Antarctica

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Sulfur stable isotopic compositions ($^{34}S/^{32}S$, $^{33}S/^{32}S$ and $^{36}S/^{32}S$) of sulfate in the Antarctic snow and ice cores have been used to investigate the contribution of its sources such as marine biogenic activity and volcanic emissions, as well as its formation pathways (e.g., Patris et al., 2000; Uemura et al., 2016; Baroni et al., 2007). However, temporal variability of those signatures in the present Antarctic atmosphere has never been examined. Here we report a year-round observation of sulfur isotopic compositions of sulfate in aerosol samples collected at Dumont d'Urville (66°40' S, 140°01' E), coastal Antarctica, throughout the year 2011. In summer months, $^{34}S/^{32}S$ ratios were similar to the values observed in dimethyl sulfide (DMS) produced by marine biota (Amrani et al., 2013; Oduro et al., 2012), in contrast to ^{34}S depletion during winter, which suggest the contribution of other sources or unknown processes. Throughout the year, $^{33}S/^{32}S$ and $^{36}S/^{32}S$ ratios suggested no significant contribution of reactions causing mass independent fractionation.

キーワード：安定同位体、南極、硫酸
Keywords: Stable isotope, Antarctica, Sulfate

花粉の安定同位体比分析による陸域古気候復元の可能性の検証
Stable isotope analysis of pollen grains for terrestrial paleoclimate reconstruction revisited

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堆積物に残存する花粉化石は、その保存の良さから主に第四紀の古環境復元に利用されてきた。近年、気温や湿度の指標として花粉の安定同位体比を使用するアプローチが提案されているが、その妥当性には議論がある。本発表では、日本各地で採取された樹木花粉の安定同位体比と各種環境指標との関連を再検証した結果について報告する。

キーワード：安定同位体、花粉、古気候
Keywords: stable isotopes, pollen, paleoclimate

アイスコア中の^{17}O-excess の変動傾向
Variation trend of ^{17}O-excess in an Arctic ice core

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Ice cores obtained from glaciers and ice sheets are important archives for reconstructing changes in the paleoclimate. The most important climate changes, such as the variation in temperature, precipitation, and the hydrological cycle, are reconstructed from stable water isotope ratios (δ^{18}O, δD, and a second-order parameter, the d-excess, defined as d−excess = δD −8δ^{18}O) measured in ice cores.
With the improvment of water isotope analyzers, the ability to measure δ^{17}O in water with high precision provided another second−order parameter, the ^{17}O−excess, defined as ^{17}O−excess = ln (δ^{17}O+1) −0.528 ln(δ^{18}O+1). Previous studies reported that ^{17}O−excess in polar snow is mainly controlled by the relative humidity in the water vapor source region, therefore expected as a new proxy of past climate change. However, at the present, there are few studies of ^{17}O−excess in ice core, and therefore an undrestanding of variation factor of that is incomplete.
In this study, we analyzed δ^{17}O and ^{17}O−excess in an ice core which was drilled in Alaska. We also discussed the variation factors of those associated with environmental change.

キーワード：アイスコア、北極域、17O-excess
Keywords: ice core, Arctic region, 17O-excess

天山山脈グリゴレア氷帽アイスコア中の固体粒子のSEM観察

SEM observation of insoluble particles in an ice core drilled from Grigoriev Ice core, Tien Shan Mountains.

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アイスコアには大気を介して氷河に飛ばされてきた火山灰や花粉、鉱物粒子など様々な固体粒子物質が保存されている．アイスコアの固体粒子は、年代決定や地表面環境のプロキシーとして広く利用されている．例えば、極域のアイスコアでは、火山灰粒子のSEM-EDS分析から起源となる火山を特定し層の絶対年代の決定に利用されている．一方、低緯度山岳域の氷河のアイスコアでは、極域に比べ高濃度の鉱物粒子が含まれており、その濃度は砂塵嵐や気候の乾燥度のプロキシーとして利用されている．一般に、固体粒子濃度は、パーティクルカウンター等で機械的に定量されることが多く、含まれる粒子の形態、種類等に注目した分析は少ない．固体粒子の鉱物種や化学成分等の分析によって、その粒子の起源を特定し、過去のより詳しい地表面環境や大気循環を明らかにできる可能性がある．そこで、本研究では、中央アジア・天山山脈グレゴリア氷帽で掘削されたアイスコア中の固体粒子についてSEM-EDS分析を行った結果を報告する．

分析に使用したアイスコアは，2007年にグリゴレア氷帽（4600m）の頂上部で掘削された全長約87mのコアである．年代決定は，花粉濃度および放射性炭素同位体によって行われ，底部は約13000年前であることが明らかになっている．年代の異なる層を選択し，含まれる固体粒子を電子顕微鏡（JSM-6010PULUS/LA，日本電子）で観察した．低真空モードで観察し，各粒子のEDSによる元素分析を行った．観察された鉱物粒子は直径数 μmから30 μmの範囲で、特に10 μm以下の粒子が多く観察された．観察された鉱物粒子についてEDXによる元素分析を行い構成元素による粒子の分類を行った．その結果、年代に関係なくどの層でもSiまたはAlが主成分のタイプである鉱物粒子が，分析数の60-90%を占めた．これらは主に砂漠に由来する石英や斜長石などの珪酸塩鉱物と考えられる．一方，残りの鉱物粒子は MgやFe、Caを比較的豊富に含む粒子であった．これらのタイプは年代によって含有率が異なった．この含有率の違いは，鉱物粒子の供給源の違いを示している可能性がある．

1980年ヒマラヤ山脈エベレスト・クンブ氷河ウエスターンクームで掘削された浅層アイスコア解析

Shallow ice cores from the western Cwm of the Khumbu Glacier of Mt. Everest in Himalayas drilled in 1980

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1980年12月，植村直己隊長率いるヒマラヤ山脈エベレスト冬季登山隊によってクンブ氷河の涵養域ウエスタンクーム（標高6100-6400 m）にて，2本のアイスコアが掘削された．掘削されたコアは，冷凍されたまま日本に輸送され，国立極地研究所の低温室に保管された．このアイスコアは冷凍のまま保存されているヒマラヤの氷資料として非常に貴重なものである．アイスコアはそのまま長い間解析されることなく保管されていたが，2016年になってコアの再確認が行われ，千葉大学で解析が行われることになった．2本のアイスコアについて，層位観察，コア長・密度の測定，さらに水素・酸素安定同位体比と主要化学成分濃度の分析を行い，アイスコアの基礎的特徴を明らかにすることを目的とした．コアの層位観察の結果，Core1とCore2では大きく層位が異なった．Core1は全層位の98%がザラメ層で，2%が氷板層，ダスト層は唯一深さ7.3 m付近で観察された．一方，Core2は全層位の15%がザラメ層で，85%が氷板層であった．さらに砂や礫を含む層が多く見られ，特に深さ0.40~0.60 m，1.2 m，3.4~4.0 mに顕著な層があった．以上の結果は，Core1は比較的融解の少ない連続的なコアであるのに対し，Core2は融解が激しく，さらにエベレスト南壁からの雪崩の影響を大きく受けていることを示唆している.アイスコア中の水素・酸素同位体比を分析した結果，Core1はそれぞれ平均で-126.4 ‰，-17.6 ‰，Core2はそれぞれ平均で-163.3 ‰，-21.5 ‰であった．わずか300 mの標高差で大きく同位体比に差がついたのは，Core2には南壁上部の同位体比の小さい雪が雪崩によって供給されているためと考えられる．アイスコア中の主要化学成分も２つのコアに差があった．Core1は，Cl^-とNa^+が全体の60 %以上を占めたのに対し，Core2は，Ca^{2+}が平均72 %を占めていた．これは，Core2に含まれる南壁からのデブリ，および融解再凍結の影響と考えられる．

キーワード：浅層アイスコア、雪氷化学、ヒマラヤ、山岳氷河
Keywords: Shallow icecore, Snow chemistry, Himalayas, Mountain Glacier

