Japan Geoscience Union Meeting 2012
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MIS26-01 Room:203 Time:May 23 13:45-14:00

Response of the north polar vortex and its evolution to solar activity using chemistry-climate model and reanalysis data

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Variations in solar ultra violet radiation, ozone, and temperature over the equatorial upper stratosphere caused by 11-year solar cycle have been observed (e.g., Lean et al., 1997; Gray et al., 2009). In the solar maximum, these variations were related to meridional gradient of the temperature and the strong polar vortex over the Northern Hemisphere extratropics in early winter (November-December) (e.g., Kodera and Kuroda, 2002). Kodera and Kuroda (2002) suggested that the strong polar vortex could influence the Brewer Dobson (BD) circulation, affecting distributions of equatorial ozone and temperature through ozone transport and adiabatic heating. Yamashita et al. (2010) investigated the difference between solar maximum and minimum from output of CCSR/NIES CCM, and they suggested that a simulation period of about 140 years might be sufficient for detecting the responses of the circulation around the polar vortex, equatorial ozone, and temperature.

The variation in the polar vortex is related to the equatorial quasi-biennial oscillation (QBO) as well as the 11-year solar cycle (e.g., Labitzke and van Loon, 1988). Holton and Tan (1980) showed that on average, the polar vortex is strong (weak) throughout the winter when the equatorial zonal wind at 50 hPa is westerly (easterly). Thus, we suppose that effects of the solar maximum and the westerly phase of the QBO create the strong polar vortex. In fact, the strong polar vortex was seen in early winter (e.g., Gray et al., 2004). In contrast, the polar vortex tended to be weak in westerly phase during the solar maximum in late winter (January-February) (e.g., Labitzke and van Loon, 1988). The reason for the different behavior between the early winter and late winter is still unclear. In addition, it is not well understood how mechanism for the influence of QBO on the polar region changes with the solar activity.

Yamashita et al. (2011) proposed a possible explanation that the difference of wave propagation and circulation in the upper/middle stratosphere as well as lower stratosphere between the easterly and westerly phases is related to the polar vortex.

In this study, we investigated the mechanism for the QBO and solar cycle influences on the polar vortex using CCSR/NIES CCM output and JRA-25 dataset, with a focus on detailed evolution of the influence throughout the winter. Note that we performed three transient runs from 1960 to 2006, and the output for 138 winters was analyzed in order to gain sufficient data for detecting the solar response.

Four composites were compiled on the basis of both 11-year solar cycle phase and QBO phase defined at 50 hPa. The composite analysis for CCM output and JRA-25 dataset suggested that the strong (weak) polar vortex and cold (warm) temperature were seen in the westerly (easterly) phase of the QBO during solar maximum (minimum) in the lower stratosphere over the polar region around December-January, indicating the suppression (enhancement) of upward wave propagation, wave dissipation and the BD circulation in the lower stratosphere. For these cases, the responses of the QBO and solar cycle were similar and reinforced each other around the polar vortex, indicating the strong/weak polar vortex. It moved poleward and downward with the seasonal march throughout the winter. These movements were related to weak polar vortex appeared in the upper stratosphere around February in the westerly phase/solar maximum, in agreement with previous foundation by Labitzke and van Loon (1988). In contrast, the response in the westerly (easterly) phase of the QBO was canceled by the opposite signs of response during the solar minimum (maximum).

These results suggest that the effects of solar cycle and QBO on the polar vortex are explained as the reinforcement and cancellation processes occurred between the solar activity and QBO influences in early winter. Later, these effects would change with the seasonal march associated with the wave-mean flow interaction.

Keywords: middle atmosphere, 11-year solar cycle, chemistry-climate model

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MIS26-02 Room:203 Time:May 23 14:00-14:15

How do environments affect the size of tropical cyclones?

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Along-standing issue on how environments affect the size of tropical cyclones is studied through a series of numerical experiments using the cloud-resolving tropical cyclone model, TCM4, and the global cloud-system-resolving model, NICAM. To first order, the primary circulation of a tropical cyclone can be considered as a warm-cored, quasi-axisymmetric vortex in gradient wind and hydrostatic balance. As a tropical cyclone evolves slowly while its primary circulation remains in gradient wind and hydrostatic balance, the secondary circulation (radial and vertical circulation) can be considered as a result of the response to both diabatic heating and momentum forcing including surface friction. The secondary circulation transports high absolute angular momentum inward to spin up the tropical cyclone primary circulation. This spin-up process can be well described by the Sawyer-Eliassen equation following the classic work of Eliassen (1952).

The balanced contribution to the intensification of a tropical cyclone simulated in TCM4, in particular the size of the cyclonic circulation, is investigated by solving the Sawyer-Eliassen equation and by computing terms in the azimuthal-mean tangential wind tendency equation. Results demonstrate that the azimuthal-mean secondary circulation and the spin-up of the mid-tropospheric outer circulation in the simulated tropical cyclone are well captured by balance dynamics. The mid-tropospheric inflow develops in response to diabatic heating in mid-upper tropospheric stratiform (anvil) clouds outside the eyewall in active spiral rainbands and transports absolute angular momentum inward to spin up the outer circulation. Although the azimuthal-mean diabatic heating rate in the eyewall is the largest, its contribution to radial winds and thus the spin-up of outer core circulation in the mid-troposphere is rather weak. This is because the high inertial stability in the inner core region resists the radial inflow in the mid-troposphere, limiting the inward transport of absolute angular momentum. The result thus suggests that diabatic heating in mid-upper tropospheric stratiform clouds is the key to the continued growth of the storm scale circulation.

The 7-km run using NICAM successfully simulated tropical cyclones that formed in three months from 1June to 31August 2004. A multi-scale interaction between tropical cyclones and environment has been investigated. It is clear that the size of tropical cyclones was sensitive to the environmental relative humidity. In a relatively moist environment, the tropical cyclone developed considerable precipitation (and thus diabatic heating) outside the core accompanied by significant outward expansion of the wind field and increase in size of tropical cyclones.

Keywords: tropical cyclone size, multi-scale interactions, NICAM, TCM4

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MIS26-03 Room:203 Time:May 23 14:15-14:30

Meteorological influence of the solar wind ? Strong correlation of the temperature and the solar wind parameters at the

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Recent our findings strongly suggest that the solar wind affects the surface temperatures [1, 2]. The regions from the magnetosphere to the troposphere should participate to this phenomenon. In this presentation, we focus on the temperatures of the troposphere and the stratosphere.

Grid temperature data of the lower stratosphere and the troposphere (upper, middle and lower) were taken from the RSS satellite temperature data site. The data cover the period of 1979 to 2010. We mainly used Pa, rate of energy flow from the solar wind into the stratosphere, together with the aa index (a geomagnetic disturbance index). Years were classified into two groups using the wind phase of the QBO (easterly or westerly) at a suitable month. The Arctic Oscillation (AO) index was also considered because it gives correlation maps similar to those for the aa index (a geomagnetic disturbance index)[1].

Figure 1 shows examples of the correlation maps for the lower stratosphere and for the lower troposphere. Monthly temperatures and monthly Pa values for January were calculated for each year, and the correlation between their yearly variations was estimated.

When stratified using the QBO phase (easterly and westerly) at January, the correlation maps for the easterly and for those for the westerly were clearly different.

In Fig. 1, examples of correlation maps are shown. Specific procedures are as follows. Monthly values were obtained for the temperature, the aa index and Pa, and correlation was calculated using their time variations at each grid. The correlation maps largely depended on the QBO phase.

Figure 1a shows that the January lower stratosphere temperature positively correlates well with the January Pa at the Equatorial regions. The aa index gave similar results.

Figure 1b shows a correlation map for the lower troposphere. The spatial distribution is quite similar to that for the correlation map between the temperature and the AO index, where large correlation can be seen at, for instance, Europe and Siberia. The middle troposphere gave results similar to the lower troposphere.

These observations clearly show that the energy (and/or particles) transferred from the solar wind affects the stratosphere and the troposphere. It is strongly suggested that the QBO plays an important role in this phenomenon.

[1] Kiminori Itoh, JpGU, 2008-2011
[2] Kiminori Itoh and Shinya Matsuo, JpGU, 2012

Keywords: Solar wind, Temperature, Troposphere, Stratosphere, QBO, Arctic Oscillation

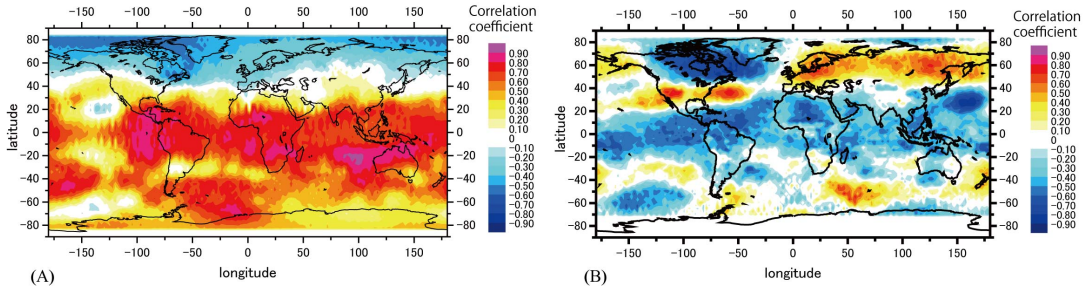

Fig.1. Correlation maps for the temperature and Pα (rate of energy flow from the solar wind into the magnetosphere) for the period of 1979-2010. A) For lower stratosphere, in January, and at QBO westerly phase. B) For lower troposphere, in January, and at QBO easterly phase.

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MIS26-04 Room:203 Time:May 23 14:30-14:45

The effects of sudden insolation change on the air temperature during a total solar eclipse over Dome Fuji, Antarctica

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The Moon cast a long shadow over Antarctica on 23 November 2003 in a total solar eclipse. The eclipse was observed at Dome Fuji Station, located at the highest point of East Dronning Maud Land, Antarctica, and lasted 1 h 41 min 37 s in a cloudless condition, during which the Sun was completely obscured for 1 min 43 s. This was the first total solar eclipse to be observed in the Antarctic ice sheet. During the eclipse at Dome Fuji, the air temperature at 1.5 m above the snow surface and the subsurface snow temperature decreased by 3.0 K and 1.8 K, respectively. Estimated surface snow temperatures decreased by 4.6 K. Atmospheric pressure and wind direction did not change, but the wind speed possibly decreased by 0.3 m/s with decreasing air temperature; natural variations in wind speed before and after the eclipse made it difficult to identify a true effect of the solar eclipse. Variations of energy components (net shortwave and longwave radiations, sensible and latent heat fluxes, and geothermal heat) during the eclipse were investigated. The total loss of global solar radiation during the eclipse was 0.60 MJ m-2, equaling 1.6% of the total daily global solar radiation. Regional effects of the eclipse due to a reduction of global solar radiation for air temperature and snow temperature ranged from 0.015 to 0.020 K (W m-2)-1. We additionally examined the relation between eclipse obscuration (the fraction of the Sun’s surface area occulted by the Moon) and the reduction of global solar radiation from the first to second contacts. The eclipse was also observed from space by the Moderate Resolution Imaging Spectroradiometer (MODIS) sensors onboard NASA’s Terra and Aqua satellites. The observational results of this study will contribute to detailed model calculations for clarifying the meteorological effects of eclipses.

Keywords: insolation change, air temperature change, total solar eclipse, Antarctic ice sheet, Dome Fuji

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MIS26-05 Room:203 Time:May 23 14:45-15:00

Estimation of solar ultraviolet radiation derived from analyses of solar imaging data

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We report the results on the estimation of long-term variations of solar UV/EUV radiations, which affect on the upper thermosphere, by using full-disk solar images. The SOHO/EIT has shown us full-disk features of the sun in EUVs over 15 years. Ground-based chromospheric observations also enable us to derive an indicator of solar UV emission. From these data, we try to derive the main features that affect on the upper thermosphere and to estimate the long-term UV/EUV variations.

Keywords: Solar Activity, Solar UV Radiation

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MIS26-06 Room:203 Time:May 23 15:30-15:45

Climatic cooling caused by a major weakening of the geomagnetic field

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The geomagnetic field's impact on climate through the modulation of cosmic ray (CR) flux is a long disputed problem. Its exact effects remain unknown. We carried out a paleoenvironmental analysis based on multiproxy records for five interglacials (marine oxygen isotope stages (MISs) 17, 19, 21, 25 and 31) between 0.7 to 1.1 Ma, and quantitatively evaluated the effect of the geomagnetic field on climate. Our samples come from a sediment core with an extremely high accumulation rate (ca. 50-70 cm/kyr) from Osaka Bay, Japan. The depositional environment of the bay has been strongly affected by glacio-eustatic sea-level changes, and the sediments clearly record the orbital cycles of environmental changes. In MIS 17, 21 and 25, the thermal maximum coincided with the sea-level highstand, as expected from Milankovitch theory. On the other hand, the thermal maxima of MIS 19 and 31 lagged the sea-level highstands by several thousand years. Additionally, cooling occurred at or near the sea-level highstand. The anomalous cooling cannot be caused by insolation changes. MIS 19 and 31 encompass the Matuyama-Brunhes (MB) and Lower Jaramillo (LJ) polarity reversals, respectively. Both cooling events coincided with the paleointensity low associated with the polarity reversals. The cooling interval occurred when the geomagnetic field intensity decreased to less than ca. 40% of present value, and the CR flux increased by more than 40%. The mean annual temperature estimated from pollen fossils using a modern analogue technique shows a cooling of ca. 1-4 degrees C. Despite their relatively low temporal resolution, a number of other paleoenvironmental records suggest a relatively cool climate before the MB and LJ boundaries in the low and middle latitudes. In contrast, ice core records from Antarctica shows no evidence of such a cooling event, and thus the magnetic field/CR effect on climate may not have occurred in polar regions. These results may indicate that the Earth's climate can be affected by the geomagnetic field.

Keywords: cooling, geomagnetic reversal, cosmic ray, paleoclimate, paleoceanography, paleomagnetism

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MIS26-07 Room:203 Time:May 23 15:45-16:00

Simulation study on bi-stability of cloud-rain system and cosmic ray influence on climate

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Although it has been pointed out many times that there is the correlation between solar activity, such as the Schwabe (11 year) cycle and the Maunder-type minima, and climate variability, the mechanism whereby the sun may affect climate is not yet well understood. Svensmark & Friis-Christensen (1997) proposed that galactic cosmic ray may control cloud through the ionization of atmosphere and the ion-induced nucleation. Recently, Kirkby et al. (2011) indicated in basis of experiments with artificial cosmic ray that the ion-induced nucleation is possible in the atmosphere if some conditions for chemical compounds and temperature are satisfied. However, although the experimental data show that the ion-induced nucleation rate for 1.7 nm diameter cluster J_1.7=10^-2 to 10^1cm^-3s^-1, it is not yet clear how this rate affects cloud and climate.

In this study, aiming at clarifying how the cloud-rain system depends on the change in the formation rate of cloud condensation nuclear, we have performed a systematic simulation study using super-droplet cloud model. The super-droplet cloud model is a novel computational technique to calculate the macro- and micro-physics of clouds (Shima, Kusano et al. 2009). We have implemented the super-droplet method on the cloud resolving model CReSS (Tsuboki & Sakakibara 2006), and developed an add-on function to create aerosols dynamically. Using it, we have surveyed the quasi-equilibrium state of cloud-rain system for different formation rate of 30 nm diameter aerosol J_30. The initial and boundary conditions are given by the data-set of RICO (Rain In Cumulus over the Ocean) project.

As the results of simulations for J_30 from 10^-6 to 10^0 cm^-3s^-1, we find that the cloud water path remains about 5 gm^-2 when J_30 is smaller than 10^-3cm^-3s^-1, but it quickly increases to 20 gm^-2 for J_30=10^-2cm^-3s^-1 and it keeps the value for higher J_30. On the other hand, the rain water path is about 6 gm^-2 for J_30 smaller than 10^-3cm^-3s^-1, but it drastically decreases to smaller than 1 gm^-2 for J_30 larger than 10^-3cm^-3s^-1. These results suggest that the cloud-rain system has the two different equilibrium states which are controlled by the formation rate of aerosols. Although the quantitative relation between the cosmic ray induced nucleation and the bifurcation of cloud-rain system is still unclear, our results implies how susceptible is the cloud-rain system on the nucleation rate.

Keywords: cloud, aerosol, space climate, cosmic ray, super-droplet, simulation

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MIS26-08 Room:203 Time:May 23 16:00-16:15

Climate change induced by changes in cloud droplet radius

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It has been pointed out that the colder climate during the Mounder Minimum was associated with the smaller number of sunspots. When the number of sunspots is low,the solar activity is also low although the total solar irradiance hardly decreases. The intesity of galactic cosmic ray into the terrestrial atmosphere increases when the solar activity is low. While it is not understood clearly, yet, the cosmic ray intensity may change the number of cloud condensation nuclei and the cloud droplets' radii.

We have conducted a set of numerical experiments with a three-dimensional coupled atmosphere-ocean general circulation model and a vertically one-dimensional radiative-convective equilibrium model with different cloud droplet sizes. When the droplet size is decreased (increased), climate becomes colder (warmer) according to our experiments.

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MIS26-09 Room:203 Time:May 23 16:15-16:30

An isotopic view on ionising radiation as a source of sulphuric acid

Martin B. Enghoff[3], Nicolai Bork[3], HATTORI, Shohei[1*], Carl Meusinger[2], NAKAGAWA, Mayuko[1], Pepke Pedersen Jens Olaf[3], DANIELACHE, Sebastian[1], UENO, Yuichiro[1], Matthew S. Johnson[2], YOSHIDA, Naohiro[1], Henrik Svensmark[3]

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Sulphuric acid is an important factor in aerosol nucleation and growth. It has been shown that ions enhance the formation of sulphuric acid aerosols, but the exact mechanism remains undetermined. Furthermore some studies have found a deficiency in the sulphuric acid budget, suggesting a missing source. In this study the production of sulphuric acid from SO2 through a number of different pathways is investigated. The production methods are standard gas phase oxidation by OH radicals produced by ozone photolysis by UV light, liquid phase oxidation by ozone, and gas phase oxidation initiated by gamma rays. The distributions of stable sulphur isotopes in the products and substrate were measured using isotope ratio mass spectrometry. All methods produced sulphate enriched in 34S and we find a

34S value of 8.7 permil for the OH reaction. Only UV light (Hg emission at 253.65 nm) produced a clear nonmass-dependent excess of 33S of around 0.3 permil. The pattern of isotopic enrichment produced by gamma rays is similar,but not equal, to that produced by aqueous oxidation of SO2 by ozone. This, combined with the relative yields of the experiments, suggests a mechanism in which ionising radiation may lead to hydrated ion clusters that serve as nanoreactors for S(IV) to S(VI) conversion.

Keywords: Cosmic ray, Sulphuric acid, Stable isotope

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MIS26-10 Room:203 Time:May 23 16:30-16:45

Possible influence of 27 day cosmic-ray variations on tropical cloud activity

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Galactic cosmic rays (GCRs) are one of the possible mediators of Sun-climate connection; however, the detailed mechanism of their influence has not been solved. In order to trace the influence of cosmic rays on climate system, we analyzed the daily data of outgoing long-wave radiation (OLR) for AD1979-2004 and the data obtained from International Satellite Cloud Climatology Project (ISCCP), and compared them with neutron monitor data obtained at Oulu University. We find that high altitude cloud around the tropical regions shows a similar time profile with the variations of cosmic rays at around the time scale of solar rotations. At this time scale, the depletions of cosmic rays occur associated with solar flares and current sheet passages.

Keywords: solar rotation, cosmic rays, tropical cloud activity

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MIS26-P01 Room:Convention Hall Time:May 23 17:15-18:30

Upper atmospheric variation inferred from the long-term trend in the geomagnetic solar quiet daily variation

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It has been well-known that the amplitude of geomagnetic solar quiet (Sq) daily variation depends on the intensity of global ionospheric currents flowing in the E-region from middle latitudes to the magnetic equator. These currents are generated by dynamo process via interaction between the neutral wind and ionospheric plasma in a region of the thermosphere and ionosphere (85-125 km). The motion of the neutral particles is driven by heat convection due to solar irradiance and by tidal force of the sun and moon. According to the Ohm's equation, the ionospheric currents strongly are related to ionospheric conductivity, polarization electric field and neutral wind. Then, to investigate the Sq amplitude using the long-term observation data of geomagnetic field is essential for understanding the long-term variations in the ionospheric conductivity and neutral wind of the thermosphere and ionosphere. Recently, Elias et al. [2010] found that the Sq amplitude tends to increase by 5.4-9.9 % in the middle latitudes (Apia, Fredericksburg and Hermanus) in a period of 1961-2001. They mentioned that the long-term variation of ionospheric conductivity associated with geomagnetic secular variation mainly determines the Sq trend, but that the rest component is ionospheric conductivity enhancement associated with cooling effect in the thermosphere due to increasing greenhouse gas. In this talk, we try to clarify the characteristics of the long-term variation in the Sq amplitude using the long-term observation data of geomagnetic field and neutral wind. These observation data have been provided from the IUGONET (Inter-university Upper atmosphere Global Observation NETwork) project which stated in facial 2009. In the present analysis, we used the F10.7 solar flux as a good indicator of the variation in the solar irradiance in the EUV and UV range, geomagnetic field data with time resolution of 1 hour observed at 184 geomagnetic stations. The definition of the Sq amplitude is the difference of the H-component between the maximum and minimum every day when the Kp index is less than 4. As a result, the Sq amplitude at all the geomagnetic stations shows a close correlation with the solar F10.7 index, and tends to be more enhanced during the high solar activities (19- and 22- solar cycles) than during the relatively low activity (20-solar cycle). This result implies that the Sq amplitude strongly depends on the solar activity. Therefore, in order to minimize the solar activity dependence on the Sq amplitude, we calculated second orders of fitting curve between the F10.7 solar flux and Sq amplitude during 1950-2011, and examined the residual Sq field defined as the deviation from the fitting curve. The residual Sq amplitude at all the geomagnetic stations clearly showed increase and decrease trends with the periods of 20 years. The minimum and maximum of the residual Sq amplitude appear around 1970 and 1990. The residual Sq amplitude around 2010 is almost the same level as that around 1970. Moreover, the similar tendency can be seen in the diurnal variation of geomagnetic field in the auroral zone and polar cap (Sqp field) driven by the twin vortex of ionospheric currents associated with energy input of solar wind into the ionosphere. Then, it seems that the trends in the residual Sq and Sqp fields are related to the long-term variation in the ionospheric conductivities associated with the secular variation of the ambient magnetic field and the upper atmosphere (for example, plasma and neutral densities associated with increasing concentrations of greenhouse gases). In order to verify qualitatively the above signatures, we need to investigate the long-term variation in the ionospheric conductivities calculated using the IRI-2007 and MSIS-00 models.

Keywords: Solar activity, Sq variation, Ionospheric cunductivity, Electron density, Geomagnetic secular variation, Global warming

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MIS26-P02 Room:Convention Hall Time:May 23 17:15-18:30

Reconstruction of summer insolation in the Yakushima island using stable carbon isotope in Yakusugi Cedar

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One of the most important climate feedback mechanisms is cloud cover effect. However, it is difficult to estimate the variability of the past cloud condition.

Tree ring d13C reflects the balance between stomatal conductance to incoming CO2 and photosynthetic rate. In the case of moist area, dominant control of d13C in tree ring is photosynthetic rate. The meteorological observations in the Yakushima island were conducted. As a result, Ishiduka region which is 900 m above sea level was extremely large amount of precipitation. Relative humidity was found to be almost 100% and to be very small changes. In this presentation, we will show the results of annual tree ring d13C over the past millennium.

Keywords: tree ring, stable carbon isotope, summer insolation

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MIS26-P03 Room:Convention Hall Time:May 23 17:15-18:30

Meteorological influence of the solar wind ? Correlation of the surface temperature and the aa index, and participation

ITOH, Kiminori[1*], Shinya Matsuo[1]

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We have shown the correlation between the surface temperature and the aa index [1], and are examining possible mechanisms now. The followings are examples of observations obtained so far. 1) Correlation between the winter aa index and the spring temperature was positive and high (r = ca. 0.7) at Northern Europe for the period of 1960-2001. 2) Correlation between the Arctic Oscillation and the surface temperature was strong for the winter-winter pair, and the correlation maps resembled those for the correlation between the temperature and the aa index. 3) The OMNI2 solar wind data gave high correlations between Pa (rate of energy flow from the solar wind into the magnetosphere, which highly correlates with the aa index) and the surface temperature. 4) The correlation between Pa and the Arctic Oscillation was high, for instance, for the January-January pair. 5) The correlation was high when the QBO was at easterly phase in January.

Thus, we can conclude that there should be certain connection between the solar wind and the meteorology. In this presentation, we extend our current approach by using the aa index because it has been shown that the aa index is a good measure of the effect of the solar wind.

The months employed in the stratification based on QBO phase was found to largely affect the correlation coefficient values. For the combination of the winter aa index and spring surface temperature, the r values were 0.78 for January as the stratifying month, 0.82 for February, 0.91 for March, 0.9 for April and 0.92 for May. The other months gave smaller values.

Northern Europe and North Atlantic regions gave high positive correlation at QBO easterly phase, and central part of the North Pacific regions gave high negative correlation at QBO westerly phase.

While the QBO is spatially limited to the equatorial stratosphere, its wind direction can affect, for instance, the propagation of planetary waves from the troposphere to the upper atmosphere.

Thus, the fact that the QBO takes part in the correlation between the aa index and the surface temperature shows that large-scale atmospheric circulations participate in the meteorological influence of the solar wind.

The high correlation between Pa and the aa index, together with the physical meaning of Pa, suggests that the correlation between these factors and the surface temperature may relate to the auroral electrojet current. Hence, there should be a link between the magnetosphere and the middle atmosphere, which can explain the meteorological influence of the solar wind.

[1] Kiminori Itoh, JpGU, 2008, 2009, 2010, 2011.

Keywords: Solar wind, Temperature, QBO, aa index, Arctic oscillation

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MIS26-P04 Room:Convention Hall Time:May 23 17:15-18:30

Influence of solar wind on the temperatures of the troposphere and lower stratosphere

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Influence of solar wind on the temperatures of the troposphere and lower stratosphere

The correlation between surface temperature and solar magnetic activity is evident though the cause is not clear. In this presentation, we analyze the vertical structure of the global atmosphere to examine the cause on the basis of the previous observations [1].

The OMINI2 solar wind data as well as the aa index data were used to detect the influence of the solar wind on the vertical temperature distribution. The period examined was 1980-2010, and the region examined was Sodankyla, Finland. The aerological data was obtained from Wyoming University HP.

In the analysis, the following factors were taken into account: 1) near UV is mainly absorbed by the atmosphere in the vicinity of 50 km altitude, and hence, the temperature there changes 1-2 degC during the 11 year solar cycle: 2) in the ionosphere, the height of the D layer will change with solar flares.

We analyzed the phases of the OMINI2 solar wind data and the aerological data to examine whether and how the effect of the solar wind propagates from the D layer to the lower stratosphere and troposphere. Meteorological rocket data will also be effective for the analysis in future.

References

K. Itoh, JpGU 2008-2011.

Keywords: solar wind, troposphere, lower stratosphere, geomagnetic activity index, temperature, correlation

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MIS26-P05 Room:Convention Hall Time:May 23 17:15-18:30

Maximum Entropy Production (MEP) in Global Heat Transfer (GHT) model

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[1]Hiroshi Serizawa, [2]Takashi Amemiya, [3]Kiminori Itoh

According to the Maximum Entropy Production (MEP) principle by Kleidon et al., dissipative systems in the state far from equilibrium are stabilized when entropy production is maximized. It is supposed that heat transportation on the Earth from the equatorial to the polar area occurs in such systems where the MEP principle is applicable. So far, the KL model by Kleidon and Lorenz [1] and the RB model by Reis and Bejan [2] are known as representative heat transfer models to testify such optimal theories. However, both are two-partitioned models that divide the Earth surface into only two parts, i.e., the heat absorption and the heat rejection regions, so we cannot help saying that these are too simple. In this exhibition, we provide the original multi-partitioned Global Heat Transfer (GHT) model to testify the MEP principle. The constructal theory by Bejan et al. [2] is another optimal theory similar to the MEP theory. The difference between two is that the former insists the maximization of heat transfer itself, while the latter does that of entropy production. Finiteness of the Earth surface is required as a necessary condition for the invocation of the constructal law, which restricts the choice of the model parameter. Meanwhile, the MEP theory does not necessitate such restriction, which guarantees a broader application to various kinds of climatic models.

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[2] Reis, A.H., Bejan, A (2006) Constructal theory of global circulation and climate. Int. J. Heat Mass Transfer. 49:1857-1875.

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[4] Bejan, A. (2010). Design in nature, thermodynamics, and the constructal law. Comment on Life, hierarchy, and the thermodynamic machinery of planet Earth by Kleidon. Physics of Life Reviews 7:467-470.

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Keywords: Global Heat Transfer (GHT) model, Principle of Maximum Entropy Production (MEP), Constructal theory, Dissipative structure, Far from equilibrium

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MIS26-P06 Room:Convention Hall Time:May 23 17:15-18:30

Spatial distribution of climate response to the solar cycles during the Maunder Minimum

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The Maunder Minimum (A.D. 1645-1715) is a useful period to investigate possible sun-climate linkages as sunspots became exceedingly rare and the characteristics of solar cycles were different from those of today. We have previously reported that climate (the rainy-season humidity in central Japan, the winter temperature in Greenland, and the mean annual temperature in the Northern Hemisphere) responded significantly to the characteristic solar magnetic cycles during the Maunder Minimum (Miyahara et al. 2008 EPSL; Yamaguchi et al. 2010 PNAS). At the solar cycle minima of negative polarity, we observed wet climate in Japan, and cold climate in Greenland and in the Northern Hemisphere. Here, we further examine climate responses to the solar cycles for wider areas including the Southern Hemisphere using the records of paleoclimate obtained from previous studies. We will discuss the spatial distribution of responses and its possible mechanism.

Keywords: Solar activity, Little Ice Age, Paleoclimate reconstruction, Tree rings, Maunder Minimum

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MIS26-P07 Room:Convention Hall Time:May 23 17:15-18:30

Causal Link between Solar Magnetic Variability and Japanese Climate Anomalies during the Maunder Minimum

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Causal link between solar variations and climate has been actively discussed for a various time scales. There is one major problem on this issue. It is difficult to distinguish each of the effects of solar parameters (total solar irradiance (TSI), solar ultraviolet (UV) radiation, and galactic cosmic rays (GCRs)) on climate changes as their variations are more or less synchronized. The characteristics of GCR variations associated with solar magnetic activity, however, are slightly different from other solar related parameters, such as TSI and UV. Especially, previous study has suggested that the cosmic ray variation was unique during the Maunder Minimum (A. D. 1645-1715), a period of prolonged sunspot absence. Comparison of annually measured tree-ring D14C and ice-core 10Be records revealed that GCRs had significant amplification associated with the magnetic polarity reversals of the Sun during the Maunder Minimum. This phenomenon enables us to estimate the GCR effect on climate.

In this study, we utilize tree rings that contain both climate and cosmic ray proxies (d18O, D14C) that can directly compare these reconstructions without any dating error. Our tree-ring d18O records from both high and middle latitude Japan show distinct negative spikes indicating cold and wet climate at every other 28 years at which anomalous GCR flux was detected in 10Be record.

Keywords: Solar Magnetic Activity, Galactic Cosmic Ray, The Maunder Minimum, Tree-ring isotope

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MIS26-P08 Room:Convention Hall Time:May 23 17:15-18:30

Laboratory experiment for verification of cloud condensation nucleation by cosmic rays

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Ion-induced nucleation of condensed particles has been suggested as one of mechanisms for correlation between the solar activity and the global climate change. The idea is that ions, which are produced by atmospheric ionization of cosmic-ray particles, promote growing-up of aerosol particles, then create cloud condensation nuclei and provide the increase of cloud amount. Recently some experiments have been planned or on progress in order to verify this scenario. We are also trying to verify independently of the other experiments. In a talk, we will explain our experimental method, report the progress and discuss the future prospect.

The galactic cosmic-ray flux reaching the earth is modulated by change in interplanetary magnetic field due to the solar activity. It was the start of the controversy that change in cosmic-ray intensity measured by neutron monitors on ground correlated well to the change in low cloud amount in the earth's atmosphere. Although there are many subjects to be examined such as method of cloud measurement, interpretation of cosmic-ray data and bias for the correlation, it would be valuable to investigate the relation between the ionizing radiation and cloud nucleation in laboratories under controlled conditions. We have introduced the air with some constituents simulating the real clean atmosphere into the chamber, which can be sealed or evacuated in order to reproduce the reactions in the atmosphere, and created a near-natural situation by irradiating with Sr-90 beta-rays and exposed to UV light, and measured ions and aerosol particles in the chamber. Assuming sulfuric-acid aerosols are the most effective to develop the size of aerosol particles, we have tried to create sulfuric-acid molecules based on sulfuric dioxides in air. Then water molecules condensate on the sulfuric-acid molecules and develop their size and, if exceeding the critical size, they can grow up to cloud condensation nuclei.

Our system consists of a gas mixing apparatus, a reaction chamber with ionizing radiation and UV radiation, and measuring instruments. The gas mixing apparatus mixes pure dry air, wet air involving water vapor, oxygen-based ozone and nitrogen-based sulfuric dioxide. The concentrations of these gases were controlled by changing the flow rates of the components. Typical total flow rate was 5 L/min. The reaction chamber is a cylinder of 40 cm in diameter and 60 cm in length and the volume is about 75 L. With a flow of 5 L/min, all gases in the chamber should be exchanged in 15 min. assuming the gas flow is uniform in the chamber. In the reaction chamber, the mixed gas is irradiated by beta rays and exposed to UV radiation. One can change the amount of irradiation by putting thin (0.1 mm thick) SUS plates between the chamber window of 0.2 mm thick and the radiation source. The UV window is made of quartz and a mercury lamp with light of 254 nm can be set at the window. No control of light yield was done. Considering the creation of sulfuric acid molecules, we first exposed the air with sulfuric dioxide, water vapor and ozone to the UV light. Then we irradiate the gas with beta rays and measure the change of products, that is, concentrations of ozone and sulfuric dioxide, densities of ions and condensed particles with a size larger than 2.5 nm, and temperature and relative humidity. We will report the results of measurements under several conditions.

Keywords: cosmic rays, solar activity, global climate, atmospheric ionization, aerosol, cloud formation

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MIS26-P09 Room:Convention Hall Time:May 23 17:15-18:30

Prosperity of Oshu Fujiwara clan and climatic change

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Last year, Hiraizumi in Iwate Prefecture was recognized as a UNESCO World Cultural Heritage site, where the ancient Oshu Fujiwara clan was flourished. Here, we regard as a prosperous era of the Oshu Fujiwara clan the period from 1087 A.D. when Gosannen no Eki ended and Kiyohira built up a firm foundation for the rule of Oshu as an only survivor of the Kiyohara clan to 1189 A.D. when the Fujiwara clan perished by the invasion of Minamoto no Yoritomo. This period of about 100 years spanning from the end of the Heian to the beginning of the Kamakura period is included within the Medieval Warm Period (900-1300), when temperatures on the Earth were elevated globally [1]. The view is broadly accepted that the prosperity of the Oshu Fujiwara clan was due to mass production of gold. However, it is also known that northern special products, as well as gold, such as tail feathers of sea-eagles and seal skins were presented to the court in Kyoto, which were highly appreciated among Heian aristocrats for the use of arrow feathers and harness. Furthermore, according to Azumakagami, the historical book of the Kamakura period, Kiyohira said proudly that people living in Karafuto and Siberia were obedient to me, which suggests the existence of the close relation with these areas [2]. In fact, the same iron arrowheads, which has the Z-shaped section, as excavated in the Nadedinskoe ruins in the Amur River basin was also found in the Atsuma town in Hokkaido. Thus, the possibility of the cultural interaction between Hokkaido and Siberia in those days is strongly suggested. Meanwhile, Japanese visitors to the Siberia continent in the Edo period, for example, Daikokuya Kodayu (1751-1828) and Mamiya Rinzou (1780-1844), told that the climate in these areas was very cold [3],[4],[5]. It should be noticed that this period overlaps the global cold period called Little Ice Age (1450-1850) including the Maunder Minimum (1645-1715) and the Dalton Minimum (the beginning of the 19th century). In the older times, other evidences for the inflow of the Siberian cultures can be found in the Sannai-maruyama ruins in the Jyomon period, when the climate are thought to have been comparatively mild. On the basis of these considerations, we could propose a following hypothesis, which connects the Japanese cultural history with climatic change on the Earth. That is, the exchange route was formed intermittently from Siberia to northern Japan via the Karafuto island in global warm periods, and that the inflow of continental cultures has been repeated.

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Keywords: Little Ice Age in Edo period, Oshu Fujiwara clan, Inflow of Siberian culture, Daikokuya Kodayu, Medieval Warm Period, Mamiya Rinzou

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MIS26-P10 Room:Convention Hall Time:May 23 17:15-18:30

Solar-Terrestrial Environment Project in Liberal Arts Education

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We had a class ”Introduction to Project Management on Space” as liberal arts education in Wakayama University. Aim of this class is to make students get project management skills. A characteristic point of this class is to focus on achieving a goal through collaboration work with team members.

In this class, we prepared a course ”Solar-Terrestrial Environment Project” which was focused on a relationship between global warming and solar activity, and a goal of this course is to make a brochure about the relationship for elementary school students.

Tasks of students are (1) election a leader and sharing roles in the project, (2) completing a preprint in several months, (3) making a presentation in front of elementary school students and having a questionnaire for them, (4) being reviewed by experts, (5) completing a brochure after repeating revisions of the preprint.

The students of the course achieved above all tasks. Especially, the presentation and the questionnaire were useful for polishing up the brochure. It was educational both for university students and elementary school students. We have a plan to improve the class.

Keywords: sun, climate change, education