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

MIS024-01 Room:301B Time:May 25 14:15-14:30

Susceptibility of Climate to the Formation of Cloud Condensation Nucleus and Solar Influence to Climate

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How the solar activity affects the climate is a crucial issue for the understanding of long-term climate variability. Although the two major hypotheses, those proposed that the changes in solar irradiance and cosmic ray may affect the climate, have been proposed, the correlative analyses of the proxy data have not been able to discriminate them. In this paper, we focus on the Dickinson's hypothesis (1975) that the ionization due to galactic cosmic ray may affect the formation of cloud condensation nucleus (CCN), and discuss about the susceptibility of climate to the formation of CCN. In particular, we study the possibility that the feedback interaction between the CCN formation and the precipitation efficiency enhances the influence of cosmic ray, and discuss the mechanism of solar influence to the climate by comparing the theoretical analysis and the multi-scale simulation study performed recently by our group.

Keywords: climate, cloud, CCN, the sun, cosmic ray, sunspots

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

MIS024-02 Room:301B Time:May 25 14:30-14:45

Possible influence of cosmic-ray 27-day variation on cloud activity

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We have examined the possible effect of solar rotation on the tropical convective cloud activity based on the data of outgoing longwave radiation (OLR) for AD1979-2004. The signal of 27-day solar rotational period has been most significantly detected around the Indo-Pacific Warm Pool, but only at the maxima of the eleven-year solar cycle. The amplitude of the 27-day variation in OLR is about 10-20% of overall variability.

The connection between cloud activity and solar rotation can be possibly explained by solar-related parameters such as solar irradiance, solar-UV, solar wind, and solar and galactic cosmic rays. In order to identify the possibility of cosmic-ray influence on cloud activity at this time scale, we have analyzed the OLR data more in detail, taking into account the characteristics cosmic-ray 27-day variation caused by the drift effect of cosmic rays in the heliosphere. In this paper, we report the preliminary results of the analyses obtained so far.

Keywords: cosmic rays, solar activity, cloud activity, solar rotation

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

MIS024-03 Room:301B Time:May 25 14:45-15:00

Simulation study of global climate variation depending on cloud droplet size

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Since it was pointed out that the variation in galactic cosmic-ray intensity and the change in low-cloud amount are well correlated with each other, effects of cosmic rays on global environment have been discussed. Particularly a hypothesis that a higher intensity of galactic cosmic rays cools the global climate by enhancing nucleation of cloud particles through atmospheric ionization has attracted attention. According to this hypothesis, it is likely that the averaged size of cloud droplets becomes smaller as the galactic cosmic ray flux is increased, because the increase of number of cloud condensation nuclei may reduce the size of droplet when a constant amount of liquid water is present in the cloud. Then the earth albedo increases, and the earth surface temperature becomes cold as a result. The purpose of this study is to investigate the influence of the diameter of the cloud droplet gives to the earth surface temperature using a coupled atmosphere-ocean general circulation model. As a result, it is shown that the temperature decreased about three degrees in ten years when the diameter of the cloud droplet is halved, while the temperature increased about three degrees in ten years when the diameter of the cloud droplet is doubled. Interestingly, the cloud amount does not uniformly increase but it decreases in some regions when the diameter of the cloud droplet is halved. Also, the amount of the cloud does not always increase in the region where the temperature largely decreased. Based on the simulation results, we quantitatively discuss the detailed mechanism how the temperature changes when the radius of the cloud droplet is changed.

Keywords: cloud droplet, cloud amount, galactic cosmic-ray

Japan Geoscience Union Meeting 2011
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MIS024-04 Room:301B Time:May 25 15:00-15:15

Present status of experiments on ion-induced nucleation originating from cosmic rays

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Ion-induced nucleation is considered as one of mechanisms which describe the effect of solar activity on the global climate. The senario is that atmospheric ionization due to cosmic rays promotes the grawing fo aerosol particles and give increase the cloud amount. Recently some experiments which aim to verify the hypothsis are planned or in progress. In the presentation, we will review these experiments, describe their characteristics and discuss the future prospects.

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

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MIS024-05 Room:301B Time:May 25 15:15-15:30

An experimental verification of the relativity of galactic cosmic rays and aerosol nucleation

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It is well known that the galactic comic ray (GCR) flux is modulated by the change of solar magnetic activity. It has been pointed out that there is a strong correlation between the GCR flux and the amount of the cloud in the lower atmosphere (altitude $<$ 3.2km) by the recent studies(Svensmark et al ; 1997,2000). There is a hypothesis to explain this correlation that the aerosols are created by the effect of ions that were produced through the ionization by the GCR, then grow up to the cloud condensation nuclei and finally form seeds of the cloud. However, the mechanism has not been well understood quantitatively. An experiment called SKY-experiment(Svensmark et al; 2007)was conducted to reproduce a part of this physical process, but some questions were still left uncertainly.

With the aim to obtain a decisive mechanism connecting to the correlation of the GCR and aerosol nucleation, we have conducted an experiment with the gas chamber in which the reaction of the atmosphere by the irradiation of beta rays as the GCR and of the ultraviolet of 253.7 nm is reproduced. For the experiment, we have arranged a gas supply system to control concentration of SO_2, H_2O and ozone in air, a chamber for reaction and an ion detector to measure the ion density in the chamber. Then we have measured a change in the aerosol density in the mixed gas with the irradiation of beta rays and the ultraviolet of 253.7 nm.

In this presentation, we report our recent results of the experiments.

Keywords: galactic cosmic rays, aerosol, ion, clouds

Japan Geoscience Union Meeting 2011
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MIS024-06 Room:301B Time:May 25 15:30-15:45

Molecular Simulation of Homogeneous Vapor-Liquid Nucleation

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Atmospheric aerosol particles are ubiquitous and have an influence on the Earth's environment by scattering and absorbing solar radiation and affecting cloud formation and precipitation. New particle formation in the atmosphere is a major source of ultrafine aerosol particles and is thought to regulate the number concentrations of cloud condensation nuclei. New particle formation consists of nucleation of small molecular clusters and their subsequent growth. These processes are still poorly understood. Ion-induced nucleation due to atmospheric ions created by cosmic rays and radioactive substances such as radon has been proposed as a mechanism of new particle formation.

Classical nucleation theory, which is based on a simple liquid droplet model, is widely used as a method to describe nucleation processes. There is a considerable discrepancy between nucleation rates estimated by the theory and experimental values. The failure of the theory is thought to be caused by the incorrectness of the liquid droplet model. Nucleation is controlled by small molecular clusters, and it is inappropriate to assume such small clusters as macroscopic droplets.

In this study we conducted simulations of nucleation using the molecular dynamics method and constructed a kinetic model to describe the processes. We additionally calculated thermodynamic properties of ion clusters involved in ion-induced nucleation. The stability of the ion clusters compared to the corresponding neutral clusters will be discussed.

Keywords: Vapor-Liquid Nucleation, Molecular Dynamics Simulation

Japan Geoscience Union Meeting 2011
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MIS024-07 Room:301B Time:May 25 15:45-16:00

Temperature and ozone response to the 11-year solar cycle in the ensemble MRI-CCM simulation from 1960 to 2006

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Ensemble simulation was made with the chemistry-climate model of Meteorological Research Institute (MRI-CCM) under the CCMVal REFB1 scenario, in which observed forcings of SST, sea-ice, greenhouse gases, halogens, the 11-year solar cycle, and volcanic aerosols are given. The integration period covers 46 years from 1960 to 2006. Multiple linear regression analysis is used to isolate specific signals from the anomalies in temperature and ozone data using reference variables of the mean value, the linear trend, the QBOs at 20 and 50 hPa, the volcanic aerosols of huge volcanic eruptions, El Nio/Southern Oscillation (ENSO), and the 11-year solar cycle. As an ensemble average of the annual-mean solar signals, MRI-CCM reproduced observed feature of ozone in the tropical stratosphere: the first maximum in the lower stratosphere and the second one in the upper stratosphere. Analysis of temperature and ozone solar signal for each member reveals that the first ozone maximum comes from a chemical effect of intensified UV radiation and cooling due to upwelling and that the second one is a dynamical effect due to transport of ozone-rich air accompanying downwelling.

Keywords: solar 11-year cycle, chemistry-climate model, ozone, temperature

Japan Geoscience Union Meeting 2011
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MIS024-08 Room:301B Time:May 25 16:00-16:15

Multiscale Interactions on the Lifecycle of Tropical Cyclone simulated by Global Cloud-System Resolving Model

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The global cloud-system-resolving model, NICAM, successfully simulated the lifecycle of Tropical Storm (TS) Isobel that formed over the Timor Sea in the austral summer 2006. The multiscale interactions on the lifecycle of the simulated storm have been analyzed in this study as the large-scale and meso-scale aspects. The westerly wind burst accompanied by the onset of a Madden-Julian Oscillation (MJO) event over the Java Sea enhanced the cyclonic shear and convergence in the lower troposphere, providing the pre-conditioned large-scale environment for the genesis of Isobel. In the subsequent evolution, five stages are identified for the simulated Isobel, namely, the initial eddy, intensifying, temporary weakening, re-intensifying, and decaying stages.

At the initial eddy stage, small-/meso-scale cyclonic vortices (eddies) developed in the zonally-elongated rainband organized in a convergent shear-line in the lower troposphere over the sea north of Java. As the MJO propagated eastward, the cyclonic eddies moved southeastward with intensifying convective activities, showing the signal of cyclogenesis over the Timor Sea. As a result of multi-vortex interaction/merging in an environment with enhanced low-level cyclonic vorticity and weak vertical shear, a typical tropical cyclone structure developed, leading to the birth of Isobel (intensifying stage). An approaching subtropical high from the southwest exposed Isobel to a large-scale stretching deformation field with strong vertical shear. This change led to the development of asymmetric structure in the inner core of Isobel and interrupted its intensification, causing a temporary weakening (temporary weakening stage). As the vertical shear weakened and changed the direction in response to the upper-level northerlies, Isobel re-intensified in response to the reformation of its eyewall as a result of the inward spiraling rainband that was formed on the downshear left side (re-intensifying stage). Finally Isobel decayed due to the land effect as it approached the land and made landfall in northwest Australia (decaying stage).

A multiscale interaction associated with the genesis of Isobel has been investigated. It is clear that the large-scale cyclonic shear closely related to the WWB in the MJO provided a favorable condition for deep convection over the sea north of Java. The deep convection was accompanied by small-scale high low-level cyclonic potential vorticity with diameters less than 40 km, very similar to the so-called vortical hot towers discussed by previous studies (e.g., Montgomery et al. 2006). Isobel thus formed as a result of the following events: increased cyclonic shear due to the WWB, collective heating from the vortical hot towers, the merging and strengthening of low-level potential vorticity of the hot towers, and eventually the axisymmetrization of meso-scale features by the storm-scale low-level cyclonic circulation over the sea south of Java.

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MIS024-09 Room:301B Time:May 25 16:30-16:45

The climate prediction; 21 Century is the entrance of global cooling ?

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The 21Century is the most difficult time for the survival of human being through the history since its birth. Limitation of fossil fuel resource, food supply, together with anomalous population increases of human being and domestic animals to disappear forests; all of these suggest the destroy of the sustainable society of human being. In addition, the climate change, particularly the global cooling if it happens, would give a critical damage for the world.

Based on the past climate change through the last 3000 years (isotope, pollen, sea-level change, and written records of climate and related things), the 4-5 time periods of turning point from global warming to cooling are summarized as follows. They are characterized by the large temperature fluctuation in a year, i.e., hotter summer and colder winter) and increased rain or ice falls. To interpret these changes, a model is proposed. Heat stocked during the global warming period in the ocean supplies more steams into atmosphere which is cooled down by the cooling from the top through the outer forcing by the decreased solar activity and increased cosmic rays to accelerate cloud formation. The temperature curve does not synchronize with humidity which delays several tens of years from temperature.

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MIS024-10 Room:301B Time:May 25 16:45-17:00

Link between geomagnetic field and climate during geologic time

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The main goals of climatology are to reveal the climate change and ascertain the cause of it. The climatic records during the geomagnetic field reversal would be the most suitable to examine the geomagnetic impact on climate, a long-term disputed subject. We report that the climate changes from marine oxygen isotope stage (MIS) 31 to 17 based on the palynological data from the Osaka Bay core. During this period, two geomagnetic polarity reversals occurred during interglacial periods; the Lower Jaramillo (LJ) and the Matuyama-Brunhes (MB) polarity reversals in MISs 31 and 19, respectively. The climate changes well accord with marine oxygen isotope variations which are dominated by the Earth's orbital elements. However, the climates of MISs 31 and 19 have an anomalous cooling event, which cannot be explained by the Milankovitch theory. Both cooling events are almost correlated with the time of low-geomagnetic field intensity (below 20-30% of a normal intensity) just before the main polarity boundaries, and the warming occurred in conjunction with the geomagnetic field intensity recovery. More than 60% of increase in CR flux is estimated for such low field intensity. Such an increase in CR flux would cause cooling by 2-3 deg. C, estimated by the cloud radiative forcing. The same degree of cooling can be estimated by applying the modern analogue technique to palynological data. These lines of evidence demonstrate a link between the Earth's magnetic field and climate.

Keywords: Svensmark effect, Cooling, Geomagnetic polarity reversal, Cosmic ray, Paleoclimate

Japan Geoscience Union Meeting 2011
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MIS024-11 Room:301B Time:May 25 17:00-17:15

Separation of natural variability and anthropogenic trend in the Arctic

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The sea ice cover in the Arctic Ocean has been reducing with growing interannual variability in last 40 years and low ice in the Pacific sector and the Siberian Shelf as the more recent characters. The first EOF of sea level pressure is the Northern Annular Mode (NAM). The second EOF is the Arctic Dipole Mode (ADM) energetic in winter with two poles over Siberia and Greenland at opposite signs. In spring and summer, another dipole mode (ADMSS) stands out at a dominant quasi-biennial cycle, having two poles over Europe and Canada. The decadal ice variability was mainly explained by the NAM until 1990. During 1980s, the most influential atmospheric mode shifted to the ADM and correlated with the ice anomalies: i.e., the Pacific (Atlantic) sector had low (high) ice cover at a 1-year lag from the positive ADM with a low pressure over Siberia. The quasi-biennial ice variability is distinct in the East Siberian-Laptev Sea correlated with the ADMSS in the same year due to seaward winds. Thus, the space-time distributions are much more complicated than a straightforward ice melting caused by global warming. They have to be examined against observed data and model results in the atmosphere-ice-ocean system, and separated from the signal of global warming.

Keywords: Arctic Ocean, sea ice, climate change, global warming

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MIS024-12 Room:301B Time:May 25 17:15-17:30

Change in temperature reconstructed by cherry blossom phenology in Kyoto, and its correspondence with solar variation

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The change in springtime temperature in Kyoto was reconstructed, using cherry blossom phenological data deduced from many historical documents. Calibration enabled accurate estimation of March temperatures after smoothing (RMSE of temperature estimates fell within 0.1 degree C). Phenological data for 792 years (scattered from 812 to 2010 AD) is now available. Including data added by our previous studies (Aono and Kazui, 2008; Aono and Saito, 2010), phenological data for 792 years (scattered from 812 to 2010 AD) is now available to applying climatic reconstruction.

The nearly continuous series of March mean temperature since 9th century was reconstructed. The reconstructed 10th century March mean temperatures were around 7 degree C, indicating warmer conditions than at the present normals, which were excluded urban warming effect. After the 1300 AD, the reconstructions suggested the existence of four cold periods, 1330-1350, 1520-1550, 1670-1700, and 1825-1830, during which periods the estimated March mean temperature was 4-5 degree C, about 3-4 degree C lower than the present normal temperature. These cold periods coincided with the less extreme periods, known as the Wolf (1280-1350), Spoerer (1460-1550), Maunder (1645-1715), and Dalton minima (1790-1820), in the long-term solar variation of Suess cycle. Those cold periods tend to appear with time-lag of decades from corresponding solar minima. The sunspot cycle length in a short-term solar variation (Schwabe cycle) was also compared with the temperature estimates, with the result that a time-lag of about 15 years.

Keywords: climatic reconstruction, phenology, cherry blossom, solar variation

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MIS024-13 Room:301B Time:May 25 17:30-17:45

Long-term predictability of solar activity and discreteness of the amplitude

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First, it is shown that the average of the sunspot number (SSN) over a cycle is well correlated with the maximum SSN in the cycle. Yoshida and Yamagishi (2010) showed that the correlation between the monthly smoothed SSN and the maximum SSN of the succeeding cycle is highest for the SSN at a point three years before the minimum. This proves also to be the case for the monthly smoothed SSN and the average SSN. That is, the correlation coefficient between the average SSN over a cycle and the smoothed SSN at a dividing point becomes largest when cycles are cut at a point three years before the minimum. Further, the best correlation between the average SSN and the maximum SSN is also obtained when solar cycles are divided at a point three years prior to the minimum. These facts suggest that the SSN in the final several years of a cycle may include some critical information about the amplitude of the following cycle. Here, we would like to emphasize that the correlation coefficient between the SSN at a dividing point and the amplitude of the following cycle becomes larger when the average SSN is taken as the amplitude. We take all of these results to suggest that the average SSN over the course of a cycle is a proper quantity for representing the amplitude of a cycle and the point three years prior to the minimum may be the most appropriate point at which to define a cycle beginning/ending point. Taking the average SSN as representative of the amplitude of a solar cycle, we show that a number of intriguing phenomena become visible. A most remarkable finding is that the average SSN over a cycle tends to take discrete values, i.e., integral multiples of 20. Further, it is shown that there exists a positive correlation in the amplitude between even-numbered cycles and succeeding odd-numbered cycles and an inverse correlation between (2n+1) cycles and (2n+4) cycles where n represents an integer. If these two correlations are combined, it turns out that there exist two mutually independent series of cycles which do not mix or merge. It is rather extraordinary that using the relationships between the cycles belonging to each of the two series, we can perform long-range prediction of the amplitude of solar activity.

Keywords: sunspot number, average over a cycle, amplitude of solar activity, dicreteness, correlation between cycles, long range predictability

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MIS024-14 Room:301B Time:May 25 17:45-18:00

Influence of the Solar Wind on Climate and Weather - Towards Constructing Space Meteorology

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Introduction. Elucidating/analyzing the influence of solar activity changes on climate and weather is a centuries-long topic [1], and is important as well for estimating the contributions of natural variations and anthropogenic influences. In environmental policies, local and short-term approaches are necessary, and hence, conventional yearly/globally averages are often meaningless. The effect of solar activity changes should be discussed in such a view as well. In fact, we recently demonstrated high correlations between winter geomagnetic indices (aa index, in particular) and spring surface temperatures, and suggested the participation of the Arctic Oscillation [2].

Thus, it should be beneficial to discuss solar wind parameters which directly control the geomagnetic activities. Here, the OMNI 2 data set (daily data, in particular) [3] was employe.

Method. According to Finch & Lockwood [4], P_{alpha} (eq.1, power extracted from solar wind into magnetosphere) [5, 6] is most suitable to discuss the relation between the geomagnetic activities and the solar wind. We mainly used P_{alpha} because it has a clear physical meaning.

$$P_{alpha} = k\, m^{(2/3-alpha)} M_E^{2/3}\, N^{(2/3-alpha)}\, V^{(7/3-alpha)}\, |B|^{2\,x\,alpha}\, \sin^4(\mathrm{theta}/2) \quad (1)$$

Here, k is a constant, m is the mean ion mass, M_E is the magnetic moment of the earth (assumed to decrease about 5%/century), N is the solar wind particle density, V is the solar wind velocity, B is the solar wind magnetic field, and theata is the clock angle of the interplanetary magnetic field (GSM frame). Coupling exponent, alpha, was set as 0.3. Since the OMNI 2 data set is not continuous, months with little data were not included in the analysis.

The surface station data employed are, for instance, those of Sodankyla (Finland) [2]. The Arctic oscillation (AO) and the quasi-biennial oscillation (QBO) of tropical stratospheric wind were taken into account.

Results and discussion. Winter P_{alpha} showed high correlations with the surface temperature and with AO when the January QBO was easterly. Figure 1 shows the surface temperature of Sodankyla (March to May average) vs P_{alpha} (January) and AO (March) vs P_{alpha} (February). Correlation coefficient values for these examples were, 0.75 for the surface temperature (1966-2004) and 0.63 for the AO (1968-2008). With the QBO westerly phase, correlation was weak, and negative for the temperature and positive for AO.

From Fig. 1, the surface temperature and AO appear to change with P_{alpha}. The geomagnetic activity indices like the aa index have high correlations with P_{alpha}, and hence, they are nearly linear to the energy flowing from solar wind to the magnetosphere [1]. Thus, the correlation between the aa index and the surface temperature [2] can be explained by the energy flow from solar wind and subsequent processes.

As for the participation of QBO, significant correlations are observed for meteorological phenomena synchronized with the sunspot number when QBO is westerly [1], contrary to the present work that showed high correlations for the QBO easterly phase.

From the results above, we think it possible to construct Space Meteorology that deals with the influence of solar activity changes (and other space-origin influences) on short-term local meteorological phenomena.

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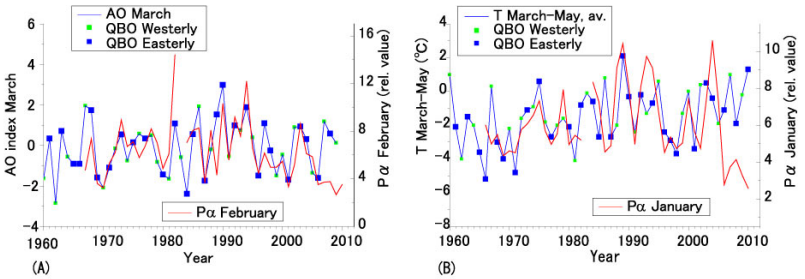

Fig. 1. (A) Relation between the AO index (March) and February Pα (energy extracted from solar wind), and (B) that between the surface temperature (Sodankyla, Finland, March - May average) and January Pα. Easterly and westerly phases of the QBO are marked with blue squares, and green small squares, respectively.

Keywords: solar wind, climate, weather, geomagnetic activity, space meteorology

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Calculation of entropy balance equations in a nested system

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[1]AIST

A viewpoint of non-equilibrium thermodynamics is useful for the investigation of environmental phenomena such as climate changes and the oceanic circulation [1,2]. Especially, the entropy production is a useful quantity because it works as a potential function for the system of our concern under certain conditions [1,2]. It is defined as the time derivative of entropy produced inside the system. We have been investigating the change in entropy production and the flow of entropy in a nested reaction-diffusion system in order to seek for a universal rule for the time evolution of non-equilibrium dynamic systems.

We firstly examined the relation between the entropy production and the pattern dynamics in a simple reaction-diffusion system [3-5], and revealed that the entropy production can be used as an index of self-organized patterns. Then, by introducing a newly defined chemical potential, we showed the way to calculate the entropy flow [5]. The entropy flow is the time derivative of the entropy that is produced through the interaction between the system and its environment. Concomitantly, the sum of the entropy production and the entropy flow can be calculated as well. This sum is called the entropy change.

We applied this method to calculate these thermodynamic quantities when a reaction-diffusion system sustained self-replicating pulses. The result indicated that the entropy change depends on the dynamics of the system. The entropy change converges to zero when the pattern in the system looks quiescent (i.e., a quasi steady state is achieved), whereas it moves away from zero while the pulse self-replicates. Consequently, the entropy change varies proportional to the speed of the pattern development. Therefore it might be regarded as the thermodynamic distance from a steady state. This property is coincident with an intrinsic property of entropy as a state function of a system.

Next, we considered a nested open system. Dealing with a nested system is important for better understanding of nature, even through mathematical models, because of the following reason. We used to introduce a steady assumption for the environment of a mathematical model. However, this is a rough approximation of nature. In an environmental system or in a biological system, for example, both the system of our concern and its environment have their own dynamics and interact each other through the open boundary of the system. Sometimes biological systems seem to make their profits of such interactions, and this could be expected similarly in a dynamical geo-system.

Our nested system consists of two subsystems: a bath and a one-dimensional reaction-diffusion medium. The bath is a continuously-stirred tank reactor which is connected with its environment. We assume that only one of chemical species (the substrate) flows into the bath from its environment, and all chemical species can flow out from the bath to the environment. The one-dimensional medium is immersed in the bath and all the chemical species in the bath can diffuse in and out from the medium across its surface. In the presentation, we will show that mutual interactions between the medium and the bath causes in the medium a new quasi-stable state that cannot be realized when the dynamics of the bath is stable. We will also refer to the relation among the dynamics and thermodynamic quantities and revisit the meaning of the 2nd thermodynamic law.

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Keywords: entropy balance, entropy production, reaction-diffusion system

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Emergence of dissipative structures and Maximum Entropy Production (MEP)...Application to climatic system

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Since before, it has been well known that dissipative structures characterized by low entropy can emerge spontaneously in open systems maintained in the state of far from equilibrium. However, optimization theories that show how dissipative structures are stabilized have not been sufficiently investigated. In recent years, two major trends, the principle of Maximum Entropy Production (MEP) by Kleidon [1] and the Constructal theory by Bejan [2], have occurred in this field. A controversy as for which is more fundamental has started last year, and two theories are expected to progress further through mutual arguments [3],[4]. It seems that low entropy in dissipative structures and MEP are inconsistent with each other. In this presentation, we first give outlines of these two theories, using basic heat transfer models from the tropical to the polar region. Next, we intend to resolve the dilemma, mainly referring to the MEP theory, where a two-hierarchy model with the dissipative structure (the internal of the system) and environment (the external of the system) is proposed. The important point is that MEP means maximization of entropy emission from the internal structure to the external environment. Assuming that the energy source such as the sun is included in external environment, the second law of thermodynamics is also guaranteed, because the total system can be regarded as almost isolated. It seems to be various kinds of dissipative structures on the Earth such as lives and human societies. We finally discuss the applicability of optimization theories introduced in this presentation to other fields such as biology, sociology and economics beyond climatology and meteorology. In the appended figure, the filled circle (dark gray), the ring (light gray) and the arrow mean the dissipative structure, external environment and maximized entropy production, respectively.

[1] Kleidon, A., Lorenz, R.D. (2004). Non-equilibrium thermodynamics and the production of entropy: life, Earth, and beyond. Springer Verlag, Heidelberg.

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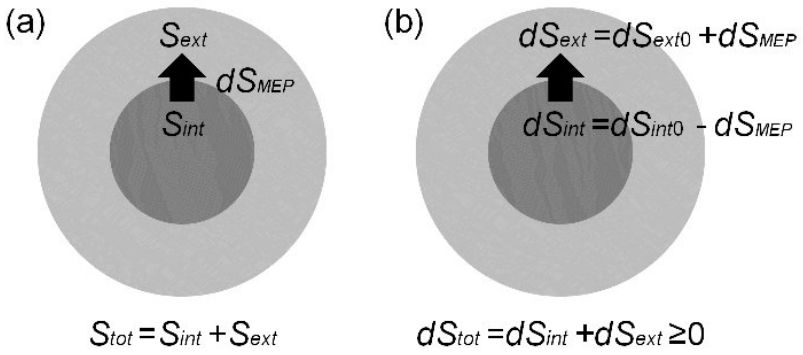

Keywords: Principle of Maximum Entropy Production (MEP), Open system, Constructal theory, Dissipative structure, Far from equilibrium, Non-equilibrium thermodynamics

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Could properties and the effect on climate

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The existence of clouds causes great uncertainty for predicting the climate change. Clouds reflect the solar radiation to cool the earth-atmosphere system, while they absorb the infrared radiation from the system to heat it. The net effect on climate depends on cloud properties such as optical characteristics, cloud cover rate, and cloud height. Since these cloud properties are determined through the microphysical processes of a few micron-scale cloud droplets, it is difficult to estimate net cloud effect precisely. Also, according to the recent hypothesis that galactic cosmic rays at the earth affects microphysical process, the cloud properties are the key to understand the climate, especially to understand the mechanism that connects cosmic phenomena and climate. In this study we numerically estimate the effect on climate as induced by the variation of parameters that affect optical characteristics, such as droplet radius and liquid water contents. We also evaluate the effect of macro parameters, such as cloud cover rate and cloud height. As a result, it is found that the optical characteristics do not significantly affect climate. We therefore conclude that the cloud cover rate is a dominant factor for the climate change by cosmic ray intensity variation.

Keywords: Cosmic ray, Cloud, Climate, Modeling

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Statistical analyses of solar activity and climate change

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Introduction

There are a lot of studies about the relationship between the solar activity and the climate change, and various theories have been proposed. However, there is no definite theory. Then, the purpose of this study is to find how the solar activity influences Earth's climate.

Analysis

We compared the annual mean global temperature, precipitation, sea surface temperature and amount of low cloud with the sunspot number. The data of the sunspot number that we used are provided by Solar Influences Data Analysis Center (SIDC).

Result

The correlations were not significant when we compared the annual mean global temperature, precipitation, sea surface temperature and amount of low cloud with the sunspot number. About the amount of the low cloud, our result is the same as Svensmark's (Svensmark, 2000) between 1983 to 1991 and 1998 to 2009, i.e. these inversely correlated. However, from 1991 to 1998, our result is not the same as Svensmark's.

Conclusion

The correlation of the sunspot number and the annual mean global temperature, precipitation, sea surface temperature and amount of low cloud was not significant. As for the Svensmark's theory, our result partly consisted of his theory, but partly contradicted his.

Keywords: solar activity, climate change, cosmic ray, cloud amount, statistical analyses, correlation

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Influence of solar magnetic activity on climate ? comparison between different geomagnetic activity indices

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Introduction. The relation between the aa index and surface temperatures has been long reported, but it is a kind of mystery in a sense that its mechanism is unknown, and hence, has been regarded as unconvincing. We, however, recently showed that a local-based short-term approach is useful to elucidate the relation [1]. For instance, winter aa index has high positive correlation with spring surface temperature of Scandinavian regions, and high negative correlation with southern regions of Greenland. We explained this result considering the participation of the Arctic Oscillation.

In this report, we consider geomagnetic indices other than the aa index, and show the possibility of similar observations. Furthermore, we use solar wind data to make further discussions.

Method. Geomagnetic indices used are, the aa index, the AE index, the ap index, the Dst index etc. By utilizing the open data base such as OMIN 2 [2], the relations between these indices and between the indices and the surface temperature data were examined.

Moreover, BV^2 that is calculated from solar wind magnetic field B and solar wind speed V, and P_{alpha} calculated as energy extracted from the solar wind [3], are utilized for the correlation studies.

Results and discussion.

It was observed, for instance, that daily changes of ap and AE were well correlated. Correlations between the geomagnetic indices and solar wind parameters such as BV^2 and P_{alpha} were high as well. Thus, different geomagnetic indices should show correlations against the surface temperatures. In fact, for instance, ap (January) and Dst (January) shows high correlation with the surface temperature (March) of Sodankyla, Finland as high as the case for the aa index.

AE is a measure of the Aurora electro jet, and Dst is a measure of the equatorial ring current, and thus, the hourly time course of their changes are different [4, p. 59]. However, considering that the magnetic field changes such as AE, aa and ap due to currents in the ionosphere are linearly correlated with P_{alpha} [3] and that Dst is proportional to the energy accumulated in the magnetosphere [4, p. 172], we consider it reasonable that the difference between the geomagnetic indices becomes small when daily and/or monthly average data were concerned.

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Keywords: geomagnetic activity index, temperature, solar wind, correlation

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Raison d etre of simple climate models

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Now that GCM simulations using high-performance supercomputers are at the height of prosperity, is there any 'raison d'etre' in simple climate models that can be simulated by reasonable-priced PCs? The heat transfer model devised by Kleidon for explaining the Maximum Entropy Production (MEP) principle seems to be one of the proper examples to answer this philosophical question[1]. Generally speaking, the simplification of mathematical models has a merit to ease capturing the essence of phenomena. For example, it has been well known that dissipative structures characterized by low entropy can emerge spontaneously in open systems maintained in the state of far from equilibrium. Then, the Kleidon's heat transfer model is thought to contain all the elements indispensible for the formation of dissipative structures. To be concrete, these elements include heat or energy sources, space to dump degraded heat and materials, temperature gradient for heat flow, and so on. These are also necessities for dissipative structures other than atmospheric convection. There exist uncountable dissipative structures with low entropy on the Earth such as various types of lives and human societies. Energy sources that drive human societies are mineral resources and fossil fuel such as coal, oil and natural gas as well as the sun. Space to abandon disused goods is natural environment on the Earth or outer space. Moreover, freshness (the reciprocal of degradation) of the product would correspond to the temperature in the Kleidon's model. That is, new products have high temperature (freshness), while the temperature of exhausted products is low. Then, entropy in human societies could be defined as the division of the quantity of resources and energy used in production by freshness. In this session, we survey the application of the MEP theory to ecology, sociology and economics, redefining variables or parameters used in the Kleidon's model. Another theory well known in this field is the Bejan's constractal theory[2]. Last year, the MEP vs. constructal dispute has occurred as for which theory is more fundamental[3],[4],[5], which will be discussed also in this session.

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[2] Bejan, A., Reis, A.H. (2005). Thermodynamic optimization of global circulation and climate. International Journal of Energy Research 29:303-316.

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Keywords: Principle of Maximum Entropy Production (MEP), Temperature, Constructal theory, Dissipative structure, Heat transfer model

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Plant phenological change in Korea and its relation to air temperature and circulation

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Plant phenology, the study of the timing of recurring biological phenophases such as budding, flowering, and leaf colouring provides useful information for environmental monitoring because of the capability of detecting changes and correlating climatic parameters with natural ecosystems. It also can provide a mean whereby the general public can get motivated to contributing to monitoring and discussing climate changes issues because of the simplest method to observe and the simple concept to understand. Therefore, phenological observations of tree developmental stages are the most effective impact indicators of climate change.

In the present study, the plant phenological change in Korea was analyzed and related to air temperature and atmospheric circulation. The budding and flowering dates of five spring species, forsythia (*Forsythia koreana*), azalea (*Rhododendron mucronulatum*), cherry (*Prunus yedoensis*), peach (*Prunus persica*) and pear tree (*Pyrus pyrifolia*) from 1960 to 2009, and the beginning and peak dates of leaf colouring of two autumn species, ginkgo (*Ginkgo biloba*) and maple (*Acer palmatum*) from 1989 to 2009 used in this study. The increase in mean air temperature from February to March of 0.5 degrees Celsius per decade over last 50 years (1960-2009) led to earlier phenophases of spring by 1.7 to 2.6 days per decade. In contrast to these, the autumn phenophases of plant were significantly delayed by 2.4 to 3.4 days per decade for the short period 1989-2009. The observed trends in plant phenology in Korea corresponded well with changes in air temperature. Spring phenophases advanced by 3.2 to 3.9 days with the increase of air temperature of 1 degree Celsius from February to March, whereas warming in October by 1 degree Celsius caused a delay in the autumn phenophases by 1.4 to 2.8 days. The spring phenological phases also had high correlation with Siberian High intensity and Arctic Oscillation (AO) in late-winter and early-spring (February-March). These results suggest the possibility of using the air temperature, as well as AO-index and Siberian High for predicting phonological dates of plant.

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Keywords: phenology, climate change, temperature, AO, Siberian High