Dependence of atmospheric electric field on solar activity

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The vertical atmospheric electric field variations depend on the state of the global circuit. Under the fair weather condition, atmospheric electric field directs vertically downward. The direction is due to the electric potential in the ionosphere and the Earth's surface. Thus ionospheric state seems to affect atmospheric electric field.
Kleimenova et al. [2010] examined atmospheric electric field at the time of substorms. They concluded that the deviations of Ez at high latitudes are the result from an enhanced polar convection or change in the ionospheric potential.
Since the report was established based on high-latitude data, we focused on low-latitude atmospheric electric field variation related with ionospheric state. In this study we analyzed the low-latitude atmospheric electric field Ez at KAK (G.G. Lat.: 36.2 N, G.G. Lon.: 140.2 E) and solar F10.7 index which is derived from solar radio flux at a 2.8 MHz. The solar F10.7 flux is well known that related with ionization in the ionosphere through solar extreme ultraviolet (EUV) emission. Daily Ez amplitude for high solar-activity (F10.7 > 100) periods shows higher value than that for low solar-activity (F10.7 < 100) periods. The tendency is predominant in July and August. When solar EUV flux is intense, ionization in the ionosphere are promoted and ionospheric potential becomes higher. We, therefore conclude that potential difference between the ionosphere and the Earth's surface becomes larger and the atmospheric electric field is enhanced during high solar-activity periods.

Keywords: atmospheric electric field, solar activity

Prediction of Nighttime VLF Signal Amplitude for Mid-and High-Latitude Paths

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The amplitude of Sub-ionospheric Very Low Frequency (VLF) propagation is sensitive to the lower ionospheric. Accordingly, VLF waves have been proposed to study and monitor the lower ionospheric conditions. However the temporal dependence of VLF amplitude has complicated and large daily variabilities in general due to combinations of both effects from above (space weather effect) and below (atmospheric and crustal processes) of the ionosphere. Thus the modelling and prediction of VLF wave amplitude are important issues to study the lower ionospheric responses from various external parameters and to also detect the anomalies of the ionosphere.
In this paper, the NARX (Nonlinear Autoregressive with Exogenous Input) neural network is used as a novel method for predicting daily nighttime averaged amplitude of VLF transmitter signals indicating the ionospheric perturbation around the transmitter-receiver path. The NARX neural networks has a good accuracy in predicting time series data and thus are more suitable for dynamic modelling. The NARX model, which was built based on daily input variables of various physical parameters such as stratosphere temperature, cosmic rays, total column ozone, K-index, AE-index and Dst, possessed good accuracies during the model building. The NARX model for VLF transmitter in Hawaii, USA (NPM) and receiver in Chofu (CHF) Tokyo, Japan (mid-latitude path), which was constructed based on above mentioned. In addition, the high-latitude path from the transmitter in Washington, USA (NLK) to receiver in Chofu (CHF) Tokyo, Japan, which was built as well.
As a result, the constructed models are capable of performing accurate one step (1 day) ahead predictions of the nighttime VLF amplitude from January 1st, 2011 to December 31st, 2013 for NPM-CHF path with the Pearson correlation coefficient (r) of 0.93 and with Root Mean Square Error (RMSE) of 2.0 dB and also the results for multi-step ahead 5 days prediction (r = 0.86, $RMSE$ = 1.88) and multi-step ahead 10 days prediction (r = 0.74, $RMSE$ = 2.35). Furthermore, result for NLK-CHF path with r of 0.91 and RMSE of 2.64 dB. In addition, we will demonstrate multi step ahead prediction of daily nighttime VLF amplitude for NLK-CHF paths. We conclude the model built according to the proposed methodology provides accurate predictions of the electric amplitude of VLF wave for both NPM-CHF and NLK-CHF propagation paths.

Keywords: very low frequency, VLF transmitter, nonlinear autoregressive with exogenous input, one-step ahead prediction, multi step ahead prediction

Lower ionosphere perturbations caused by Hokuriku winter lightning

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Intense electromagnetic pulses (EMP) radiated from lightning discharge could cause heating and ionization in the ionospheric D-region. While theoretical studies show that change in ionization state in the D-region depends on intensity of EMP, there is no clear observational evidence that shows quantitative relationship between them. The purpose of this study is to reveal influence of the CG(Cloud-to-Ground) and GC(Ground-to-Cloud) lightning discharges on the D-region and to confirm theoretical predictions by observation. The change in ionization state in the D-region is detected using perturbation in low frequency (LF) manmade radio waves which propagate in an earth-ionosphere waveguide. For this purpose, LF radio observation system was installed in Takine (Fukushima Pref.) and measured radio signal from JJY transmitter(60kHz) at Mt. Haganeyama. The midpoint of radio propagation path is located over the coast of Hokuriku area. This enables us to investigate Hokuriku winter lightning effect on the lower ionosphere near the 1-hop point of LF radio propagation. Distance between Takine and Mt. Haganeyama is 1045km and the 1-hop theory is well applicable to predict signal phase at the receiver. The LF sub-ionospheric perturbations which are called as early events have been observed from December 12, 2014 to March 31, 2015. World-Wide Lightning Location Network was used to identify lightning location and timing during this period and totally 189 sets of sub-ionospheric perturbation and causative lightning were detected. A peak current of causative lightning which is a proxy of the EMP intensity was derived from LF atmospherics observation at Suzu (Ishikawa Pref.). Charge moments of the lightning were also derived from ELF magnetic field observation at the Syowa station (Antarctica). The charge moments derived were distributed from 200 to 500 C-km and suggest that quasi-electrostatic field was lower than breakdown threshold at the lower ionosphere and was not responsible for producing sub-ionospheric perturbation observed. Modeling studies predict that EMP produced from a CG discharge creates torus-shaped ionization pattern around 90km height above a causative lightning and horizontal scale depends on intensity of EMP. We statistically examined sense of the phase change as functions of strength of EMP and distance of causative lightning from the 1-hop point along radio propagation path. Based on the 1-hop theory, positive and negative changes in the phase correspond to downward and upward shifts of radio reflection height, in other words, increase and decrease in ionization in the lower ionosphere near the 1-hop point, respectively. Result shows that sense of the phase change strongly depends in both strength of EMP and distance of causative lightning from the 1-hop point; (1) phase increase (which correspond to the ionization increase) was found when a distance between a causative lightning and the 1-hop point was within 100km and the peak current was smaller than 200kA. The distance increased up to 150km when the peak currents were larger than 200kA. This shows that ionization area extends further due to more intense EMP. (2) Outside of these distances, on the other hand, the phase decreases (which correspond to the ionization decrease) was found. Intensity of EMP degreases as distance from a causative lightning. When the electric filed strength becomes lower than the breakdown threshold, electron attachment rate dominates ionization rate, causing decrease in ionization state. (3) Less occurrence of sub-ionospheric perturbation was found inside the distance of 20km from the 1-hop point compared to the surrounding area. This suggests that EMP does not affect ionization state in the lower

ionosphere just above CG/GC discharge. These results are consistent with the theoretical expectations.
Acknowledgement: We would like to thank T. Ohno, Hoshinomura astronomical observatory, Fukushima, for cooperating LF radio observation.

Keywords: lightning discharge, ionospheric D-region, early event

Development of a new multipoint observation system for gamma-rays from winter thunderstorm

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Recent observations have shown that winter thunderstorm along the Japan sea radiates gamma-rays with energy extending up to 10 MeV (Torii et al., 2002, Tsuchiya & Enoto et al., 2007). Inside the thunderstorm, electrons are accelerated to relativistic energy by strong electric field. So far, since observations have been performed at a single location, it has been difficult to trace generation, growth, and disappearance of the acceleration region of relativistic electrons. In order to reveal this acceleration mechanism, we are planning to build a multi-point mapping system of the gamma-ray radiation which can trace a path of the radiation and can detect a change of gamma ray intensity and spectrum. Since a typical velocity of the winter thunderstorm is about 500 meter per min and a duration of the gamma-ray radiation at a single point is about a few minutes, new observation sites are expected to be about 20 points with their separation of a few kilometers. We have developed a small radiation detector composed of scintillators (CsI, BGO, and plastic) coupled with new data acquisition system using a small computer Raspberry Pi. The detector size is about 30 cm. In 2015FY winter, we set these detectors on the roof at Kanazawa University and one high school at Kanazawa, and started the observation, collecting photon energy and arrival time of individual photons, and environmental temperature. We are planning to increase observation sites. This project has been also supported by fund from an academic crowd-funding.

Keywords: winder thunderstorm, gamma-ray, electric field, electron acceleration

Lighting-induced bremsstrahlung X-rays observed near the leader.

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Energetic radiation, bremsstrahlung X ray in energy range of gamma ray, associated with lightning activities and thunderstorm have been reported. The lifetime of lightning-generated X rays, termed short burst, is in the order of millisecond. These X rays are considered to be generated by bremsstrahlung along the leader, termed short burst. During the winter, the bright short burst with more than 100 millisecond duration was detected on 4 Dec. 2015. In this analysis , we compare radiation data with VLF lightning location data and high speed camera data.

Keywords: Energetic radiation, Winter Lightning, Thunderstorm

Cloud-to-ground flashes with multiple strokes observed by Broadband Digital Interferometer

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It is known that the overwhelming majority of negative cloud-to-ground flashes contain more than one stroke. Some of them create more than one channel termination to the ground with the spatial separation. This paper discusses the precedent and subsequent leader developments of negative cloud-to-ground flashes mapped by Broadband Digital Interferometer. Seven flashes have multiple terminations out of focused 13 negative cloud-to-ground flashes with multiple strokes observed at Gifu prefecture, Japan in summer 2014. In these observations, whether the subsequent leader deflects from the previously formed channel and creates a new termination or follows the previous channel does not depend on the time interval between strokes. Even the events are observed that first and subsequent leader traverse two channels alternately. The mechanism of multiple strokes is very complicated.

Keywords: lightning discharge, multiple storke, broadband digital interferometer

Highly time resolved tracking of the torrential rain from lightning data

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Previous studies suggested that there exists a good relationship between frequency of lightning and atmospheric convection or precipitation [e.g. Deierling and Petersen, 2008]. Therefore, lightning data can be used as a proxy for the presence of deep atmospheric convection and precipitation. To monitor time series behavior of lightning activity, it is possible to understand more detailed relationship between the lightning activity and atmospheric convection and it is also possible to predict the distributional area of precipitation.
Our purpose of research is to estimate rain activity by the information of cloud to ground (CG) lightning discharge location. Therefore, we compare the movement of the torrential rain area with the lightning cell by a calculation of a time variation of the CG lightning frequency and that of spatial distribution of lightning.
We analyzed 3,909 events of CG lightning from 14:00, August 11th 2013 to 15:29 (JST) and 3,693 events of CG lightning from 17:30, August 12th 2013 to 19:24 (JST) observed by Japan Lightning Detection Network (JLDN) in Kanto region to estimate the frequency and spatial distribution of CG lightning for 10 min and with 1km square grid. We use the C-band rain radar data provided by the Japan Meteorological Agency (JMA) as the data of rain intensity. The temporal and spatial resolutions of the data are 10min and 1km.
As a result of comparing spatial distribution of lightning with that of precipitation, it is possible that there is a good correlation between the CG lightning distributional area with torrential rain area (>50mm/h) and it is possible that we can estimate the torrential rain area (>50mm/h) to monitor the time variation of the CG lightning frequency and that of spatial distribution of lightning.
We calculated the cross correlation function between the CG distribution at a certain time and that of the one 1 later in order to estimate the motion vector of CG area and we required the luminance centroid to track CG lightning area. We also calculated the cross correlation function between the torrential rain area (>50mm/h) at a certain time and that of the 10 minute later in order to estimate the motion vector of rain area and we required the luminance centroid to track rain area.
As a result of comparing the lightning luminance centroids and that of precipitation, we can estimate the luminance centroid of the torrential rain area (>50mm/h) with an accuracy of 2km by using the luminance centroid of lightning distributional area and it is possible that we can estimate the motion of the torrential rain area with highly time resolution by CG lightning data.
In this presentation, we will discuss the adequacy of analysis method and our initial result. Also we will consider the relationship between the distributions of the CG lightning frequency and torrential rain area.

Keywords: Lightning, Cloud to ground lightning discharge, Tracking of the lightning cell

Relationship between charge structure and vertical air motion in a thunderstorm revealed by a phased array weather radar and 3D lightning mapper

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Thunderstorm observation has been conducted in Osaka, Japan, with a use of an X-band phased array weather radar (PAWR) and a 3D lightning mapper, called Broadband Observation network for Lightning and Thunderstorm (BOLT), for further understanding of relationship between electrification mechanism and vertical air motion, which plays an important role in non-inductive charging process. PAWR employs mechanical and electrical scans, respectively, in azimuthal and elevation direction, succeeding in quite high volume scan rate. BOLT is a LF sensor network that receives LF emission associated with lightning discharges and locates LF radiation sources in 3D. BOLT is capable of estimating charge structures removed by both intra-cloud (IC) and cloud-to-ground (CG) flashes. In this presentation, we focus on lightning activity and charge structure in a convective cell recorded on 30 July 2015. The convective cell involved severe lightning activity in 15 minutes and the both IC and CG flash rate (the number of flash per minute) changed drastically within the 15 minutes. We divide the 15 minutes lightning activity into three stages; the first, the second and the last 5 minutes, respectively, are termed developing, mature, and dissipating stages, based on IC and CG flash rates. In the developing stage, IC flash rate increased drastically from a few to about 10 flashes min^{-1}. In the mature stage, IC flash rate are quite high and had a peak of 12 flashes min^{-1}, while CG flash rate increased gradually. In the dissipating stage, IC flash rate drastically decreased, while CG flash rate had a peak of 5 flashes min^{-1}. In the developing stage, updraft in the mid-level (about 7 km) developed into the upper level (10 km or more in AGL). In this presentation, we estimate existence of updraft from Doppler velocity and ascending echo. The echo top of the convective cell increased rapidly. The main positive charge region estimated by BOLT was located around the updraft region in the upper level. In the mature stage, the updraft was further intensified and the echo top reached the tropopause altitude of 14.5 km. The main positive charge region was again located in the updraft of the upper level. In the dissipating stage, divergence at the echo top produced cold downdraft in the rear flank of the convective cell. The cold downdraft descended to mid-level (about 7 km) and suppressed the updraft at mid-level so that the updraft in the upper level was weakened. These observation results indicate a strong relationship between electrification for IC discharges and updraft strength. In the dissipating stage when CG flash rate peaked, main negative and pocket positive charge regions estimated by BOLT were located near the mixture region of the cold downdraft and updraft from the lower level. We speculate that the pocket positive charge region was mainly produced by the collisions between graupel in the downdraft originated form in the upper level and the ice pellets ascending form the lower level. These simple speculation support that non-inductive charging mechanism in thunderstorms.

Keywords: lightning, updraft, charge structure

Study of observational accuracy of non-rotating dual-polarization phased array radar

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At present, a phased array radar (PAR) that has high time resolution (30[sec]) and high spatial resolution (100[m]) has been already developed and under operation in Osaka University. PAR has lower accuracy of observation than duel polarization radar because of using only single polarization. Although the development of the dual polarization phased array radar that has both high-speed scanning and high-precision observation is expected, to maintain a high observation accuracy is difficult because of the effect of deterioration of the antenna characteristics by digital beam forming and reduction of cross polarization discrimination which is performance to distinguish between horizontal pattern and vertical pattern. In order to solves such problems and develop dual polarization phased array radar, we designed three types of array (planar, cylindrical, and hemispherical) and simulated.
By comparing the performance of the three types of array, it is found that the hemispherical array is superior to the others because its shape is facing in all directions equally.

Keywords: phased array radar, dual-polarization, pricipitation observation

Development of a polarimetric phased array weather and adaptive beamforming technique

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Development of a polarimetric phased array weather radar as a subsequent project of the phased array weather radar (PAR) is under discussion. The design of a polarimetric phased array weather radar has been the object of several experimental development. The polarimetric phased array weather radar has significantly advanced the following points. 1) to classify types of precipitation, 2) to provide quantitative estimates of precipitation accumulation, 3) to obtain high spatial and temporal resolution volumetric radar data. 1) and 2) are contributed by a polarimetric sensing technique, and 3) is provided by the digital beam forming techniques in a phased array radar system. In this paper, precipitation radar signal simulations based on the under considering radar concept are carried out to discuss the estimation accuracy of polarimetric precipitation profiles (differential reflectivity, specific differential phase, and copolar correlation coefficient) with two DBF methods that are based on Fourier and minimum mean square error (MMSE) methods. The comparison of the performance of the two methods indicates that MMSE is superior in an observation accuracy because of the effect of a stable and robust main lobe and adaptively suppressed side lobes.

Keywords: weather radar, Phased array antenna

Development of precipitation attenuation correction technique in a dual-pol radar network

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Dense radar network systems with low power transmitters at X-band has been proposed which can fill in observation gaps in low altitudes and have good accuracy and resolution. An X-band dual polarization radar network is the main stream of weather observation to make rapid scanning at low altitude. The dual polarization products such as differential reflectivity (Z_{DR}), specific differential phase (K_{DP}) and correlation coefficient (ρ_{hv}) provide us with detailed information about drop size distribution (DSD) and rainfall rate estimation. K_{DP} can be calculated from differential phase Φ_{DP}.

On the other hand, a weather radar, especially with transmitting short-wavelength pulses, is affected by precipitation attenuation. Various attenuation correction techniques for horizontal reflectivity (ZH) and Z_{DR} using Φ_{DP} and K_{DP} were proposed. However, measured differential phase Ψ_{DP} consists of Φ_{DP} and backscattered phase shift δ_{co}.

Especially at C-, or X-band, contamination due to delta cannot be ignored. Some δ_{co} removing techniques were proposed. Scarchilli et al. (1993) suggested recursive algorithm to remove delta from Ψ_{DP} in an individual radar using δ_{co} - Z_{DR} relationship. They assumed coefficients in the power-law relationship. However, the relationship actually depends on DSD. In this paper, probabilistic attenuation correction technique based on the Bayesian theory in multiple dual polatimetric radar network, is proposed. The proposed technique considering δ_{co} effects also derive coefficients of relationships.

Keywords: meteorological radar, rain

The prediction method of sever hazards(Lightning strikes, Hails, etc.) by using Phased Array Weather Radar(PAWR)

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The prediction method of sever hazards(Lightning strikes, Hails, etc.) by using Phased Array Weather Radar(PAWR) will be presented in this session. Several new prediction techniques are presented.

Keywords: Phased Array Weather Radar, Lightning strikes, Hails

Mechanism of generating thunders

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1.None

1. Mechanism generating thunders at middle latitudes
At middle latitudes, water drops in cumulonimbus change into ice crystals in the area where the temperature is about -10 deg. The melting temperature of a solid is lower on the surface than the inside, so at about -10 deg. the ice crystals are covered with liquid water film. The inside of the crystals there are free electrons and positive holes, and the electrons can move to the surface water, but the holes can't. So the water film is negatively charged, and the solid part of crystals is positively charged. In the cloud, the crystals collide with each other, the collision is approximately elastic one where lower than -10 deg., and the change of speed of the smaller crystals is larger than that of larger ones. Then the negative charge in the surface film on the smaller crystals moves to the larger crystal, and the smaller crystals become smaller and charged positive, are blown up to the cloud top, and make it high voltage. On the other hand, the larger crystals become larger, negative and drop down on the ground (Fig.1 & 2).
2. Mechanism generating thunders at low latitudes
At low latitude, in the cloud no water crystal exists, so the mechanism differs from that one at middle latitude. The top of thunderclouds has the voltage up to about 100 MV, by the mechanism stated in above Chap.1 (Fig.2), and the electrons and negative ions flow into the clouds from the ionosphere. As a result, the ionosphere has a few MV, so in the cloud upward electric fields of about 1 kv/m are generated. So, water drops are polarized such as the top is negative and bottom is positive. When they collide, the negative charge on the top of smaller water drops, which have higher speed than the larger ones, neutralizes the positive charge on the bottom of the larger water drops, and the smaller ones become positively charged and are blown up to the cloud top (Fig.3), resulting the high voltage.
3. Mechanism generating thunders in the smoke of a volcano
In the smoke billowing from a volcano, the lightning is observed, where ashes, cinders and blocks collide with each other, and where are charged by frictional electricity (Fig.3). By the same reason shown in chapter 2, the charge is polarized and high voltage in the upper part of the smoke is generated. As this high voltage is observed, the explanation mentioned above will be valid.
4. Earthquake prediction by observing electric fields (Fig.2)
The precursory seismic electric fields will be generated by the mechanism as follows:
(1) Before earthquakes, micro-cracks run in the source regions, and into these cracks pore water pours.
(2) Uranium compounds, radium compounds and radon, which exist in crystal boundaries, dissolve into the pore water.
(3) The cracks connect the pore water and spring water, and the radio active materials appear on the surface of source regions.
(4) The active materials ionize the lower atmosphere above the source regions, and the electric conductivity increases there locally and temporarily.
(5) The increase generates the current along the trace of cosmic shower between the surface and the ionosphere.
(6) As the current is intermitting and pulsating, it radiates wide band radio-waves, which are observed as the precursory waves.

Keywords: earthquake prediction, precursory seismic electric fields, thunder in middle-latitude, thunder in low-latitude , thunder in smoke of volcano

Fig.2 [A Negative Current in the Atmosphere]

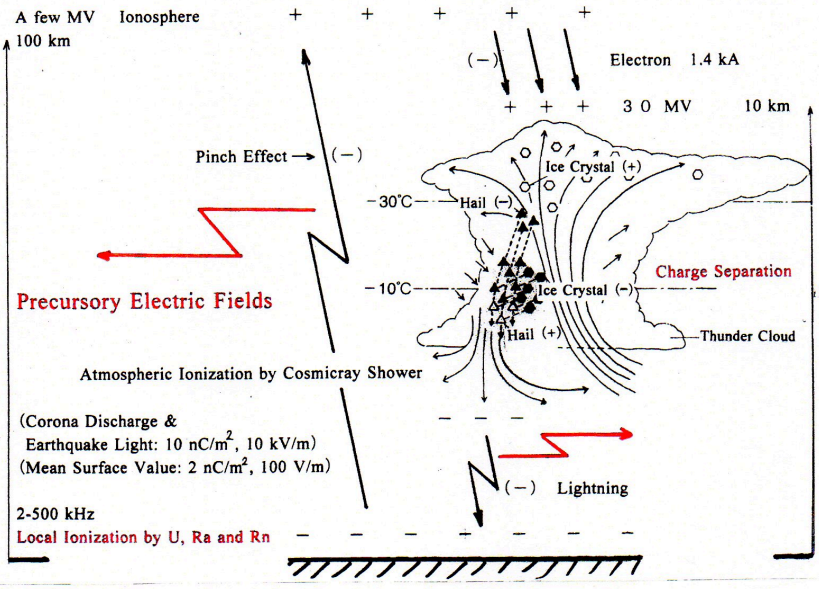

Fig.1

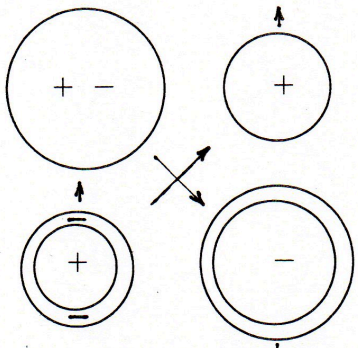

Fig.1 At middle latitude

Fig.3

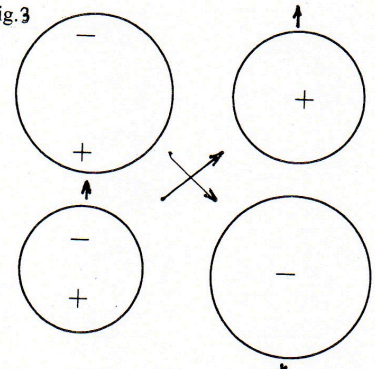

Fig.3 At low latitude

Measurements of radon and thoron decay products at Tarobo, a base of Mt. Fuji, Japan

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The atmospheric activity concentrations of the short-lived radon and thoron decay products were measured at Tarobo (1300 m a.s.l.), a base of Mt. Fuji, from July 2014 to Aug. 2015. Radon and thoron concentrations were calculated with energy spectra of *arfa*-ray emitted from radioactive aerosols collected on a filter with a time resolution of 2 or 4 h by using a radon monitor. In addition, size distributions of aerosols from about 10 nm to 5000 nm in diameter were measured with a scanning mobility particle sizer and an optical particle counter. In order to estimate the history of air masses, the backward trajectories from 72 h ago to 48 h ago were computed using the HYSPLIT trajectory model (https://ready.arl.noaa.gov/HYSPLIT_traj.php).
Clear seasonal variations of total counts of decay products were found that monthly averaged values were high between autumn and winter, and low between spring and summer. On the other hand, diurnal variations were not observed clearly. It is supposed that the cause of seasonal variations is due to the deference of air mass. These patterns were compared with the results measured at Jungfraujoch (Gaggeler, *et al*., 1995).
Acknowledgments
This work was partly supported by JSPS KAKENHI Grant Number 25340017.
References
Gaggeler, H. W. *et al*., Atmospheric Environment, 29, 607-616, 1995

Keywords: radon thoron decay products, seasonal variation, Mt. Fuji

Properties of variation of atmospheric electricity parameters (atmospheric electricity field (AEF), atmospheric ion concentration (AIC), and radon concentration) at Asahi, Boso Peninsula, Japan

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The total electron content anomaly preceding the large earthquake is one of the most promising precursory phenomena in the upper atmosphere. Lithosphere-Atmosphere -Ionosphere coupling (LAI coupling) model has been proposed to explain the earthquake-related phenomena in the atmosphere and ionosphere. We evaluate the possibility of chemical channel of LAI coupling through the monitoring of atmospheric electricity parameters such as the atmospheric electricity field (AEF), atmospheric ion concentration (AIC), and radon concentration. In this paper, we will report about the property of atmospheric electricity parameters observed at Asahi station (ASA), Boso Peninsula, Japan. AIC, AEF, atmospheric radon concentration, radon exhalation quantity from the ground, and weather elements have been observed at ASA. First, we compare seasonal variation, daily variation, and response to precipitation of atmospheric electric parameter observed at ASA and those at Kiyosumi station (KYS).
Variations of AIC and AEF before precipitations are quite similar at both stations; AIC increases quickly when a precipitation starts and AEF begins to be disturbed three hours before rain starts. But the variations after stopping precipitation have individual properties. Both parameters keep high values for a few hours at ASA and it takes longer than KYS to back to the normal level. Daily variation in each season also differs in each site. In summer, AIC takes minimum value at 15:00 LT. in the daily variation at ASA. But at KYS, it takes maximum value at 15:00 LT. In winter, AEF decreases from 09:00 LT to noon and gradually increases in daily variation. In other seasons, it takes maximum value at 20:00 LT and fluctuated in relatively large range. Daily variation of AEF in winter is mostly similar to the typical daily variation at KYS for all season.
Radon exhalation quantity variation has a clear negative correlation with 3 hours delay to the air pressure variation. Each season differs in daily pattern. AIC and AEF variations show lag correlation with radon exhalation quantity variation. To extract anomalous radon variation related to earthquakes, we should set a network of Radon monitoring and establish a model of radon variation for the future detailed analysis.

Keywords: atmospheric electricity field, atmospheric ion concentration, radon concentration

Short burst radiation at the time of lightning observed in Noto peninsula.

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During our observation period, one short and four long bursts were detected. Short burst with 3-millisecond duration was detected on 31 Dec. 2014. At the same time, cloud-to-ground lightning occurred. Considering the AEF polarity, we identified the occurrence of the positive cloud-to-ground lightning, which produced the short burst.

Keywords: Energetic radiation, Winter Lightning, Thunderstorm

