Charge change estimation at short-burst energetic radiation in winter thunderstorm

*Takuma Tsuruda[1], Shusaku Takahashi[1], Masashi Kamogawa[1], David Smith[2], Gregory Bowers[2]

1. Department of Physics, Tokyo Gakugei University, 2. University of California, Santa Cruz

The physical mechanism of lightning-induced energetic radiation has been considered to be caused by the relativistic runaway electron avalanche hypothesis proposed by Gurevich and his group. For further comprehensive understanding of the mechanism, we conducted the observation of lightning-induced energetic radiation and atmospheric electric field using field mills at Uchinada, Kanazawa, Japan during 2015-2016 winter. In general, taking into account the lightning position identified by lightning location system, the observed transient electric field changes (normally detected by slow antenna) at two observation points provide charge changes inside the thundercloud at the time of lightning and the charge height. Although field mill might not be suitable for such observation due to signal smoothing, we evaluated these two parameters using four field mills. Our estimation shows that errors of two parameters was within 20 %. In the presentation, we show these parameters at the time of lightning-induced energetic radiation.

Keywords: Energetic radiation, Winter Lightning, Thunderstorm

Origin of summer-thunderstorm-induced energetic radiation

*Shusaku Takahashi[1], Gregory Bowers[2], Masashi Kamogawa[1], Akiko Ishikawa[1], David Smith[2], Tatsuo Torii[3], Syugo Hayashi[4]

1. Department of Physics, Tokyo Gakugei University, 2. University of California, Santa Cruz, 3. Japan Atomic Energy Agency, 4. Meteorological Research Institute

We conducted the radiation and atmospheric electric field measurements at the summit of Mt. Fuji during the summer of 2013 and 2016. On July 26 and Aug. 5 of 2013 and Aug. 26 of 2016, the long burst of the energetic radiation was observed with 10 % enhancement. From the analysis of X-band MP radar, the radiation was observed tin the dissipation stage of thunderstorm. In all the cases, negative electric field (upward direction) was observed with approximately -30 kV/m, which is not enough to cause relativistic runaway electron avalanche (RREA). Therefore, plausible radiation source might be around the positively charged area in the thunderstorm.

Keywords: Energetic radiation, Thunderstorm, Mt. Fuji

Study on lightning and precipitation activities by EM observations

*Yuki Miyamoto[1], Takeshi Morimoto[1], Yoshitaka Nakamura[2], Hideo Sakai[3], Masahito Shimizu[4], Kodai Nagata[4]

1. Kindai University, 2. Kobe City College of Technology, 3. University of Toyama, 4. Chubu Electric Power Co. Inc.

The lightning and precipitation activities are studied in this paper by Ku-band broadband radar (Ku radar), VHF Broadband Digital Interferometer (DITF) and Lightning Location System (LLS) observations. The authors have been conducting cooperative lightning observations in Toyama, Japan, in where winter thunderstorm are developed. This paper focuses on the time development of thunderstorm activities.

Ku radar is a low-power high-resolution Doppler radar for meteorological applications. Ku radar employs bistatic system which is composed of a pair of Luneberg Lens Antenna, and solid state amplifier which transmits the wideband signal (80 MHz) in Ku-band. The pulse compression technique, which has the advantage that high range resolution profiles can be acquired by low transmitting power, is applied. However, the range sidelobe of a compressed signal may contaminate the neighboring rain echo. To overcome this disadvantage, the intermediate frequency (IF) signal is acquired by a high-speed analog-to-digital converter (ADC), and then it is processed by sets of digital signal processors (DSPs). In the pulse compression processing, the cross correlation between the signal received from precipitation and reference, namely presampled transmitted signal. Observation time resolution for a full volume scanning and range resolution less than 1 minute and 2.5 m are realized with Ku radar, respectively.

DITF is a system to locate a source of VHF impulse based on the digital interferometric technique. A remarkable feature of DITF is its wide detection frequency range. The system observes the electric field change due to a lightning discharge in the ultra-wide VHF band, and Fast Fourier Transform (FFT) is applied to calculate various frequency components of the received electromagnetic (EM) pulse. Computed phase difference for each Fourier component between two antennas is a function of the incident angle of the EM pulse against the baseline. A couple of antennas as a two-element array of DITF are able to estimate the incident angle. Two pairs of antennas, and independent two baselines, enable two-dimensional (2D) mapping of sources in azimuth and elevation format.

At the time period of most active lighting activities, the bright band radar echo is disappeared. The reflectivity decreases in order of height from highest to lowest with active lightning. It indicates that the relations between deep convective and lightning.

Keywords: Lightning, Radar, thunderstorm

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

*Junpei Omura[1], Peng Han[2], Chie Yoshino[1], Katsumi Hattori[1], Michikuni Shimo[3], Toshiharu Konishi[4], Ryuichi Furuya[5]

1. Graduate school of Science, Chiba Uiversity, 2. The Institute of Statistical Mathematics, 3. Fujita Health University, 4. OHYO KOKEN KOGYO CO., LTD., 5. COM SYSTEM, INC.

The Ionospheric anomaly is one of the most promising precursory phenomena for large earthquakes. Lithosphere-Atmosphere-Ionosphere Coupling (LAIC) model has been proposed to explain these phenomena. To examine the possibility of chemical channel of LAIC through the monitoring of atmospheric electricity parameters, we have installed sensors for the atmospheric electric field (AEF), atmospheric ion concentration (AIC), radon concentration, radon exhalation quantity (REQ), and weather elements. We will report the properties of variation in atmospheric electricity parameters observed at Asahi station (ASA), Japan to identify earthquake-related signals in these parameters.
Radon exhalation quantity variation follows a clear negative correlation with 3 hours delay to the air pressure variation in clear days. 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. We also observed cases that AEF has showed a spike-like increase at the same time as the time when AIC has largely increased. It must be going to be checked whether AEF data was taken in fair-weather period, however, it suggested that change in local charge distribution may have influenced AEF.

Keywords: Lithosphere-Atmosphere-Ionosphere Coupling, atmospheric ion concentration, atmospheric electric field, radon exhalation quantity

Comparison study of Lightning Interfeometry via VHF Emission(LIVE)

*Ami Kudo[1], Michael Stock[2], Zenichiro Kawasaki[2], Tomoo Ushio[1]

1. Osaka University, 2. RAIRAN.Pte.Ltd

Lightning discharges radiate broad band frequency electromagnetic waves from ULF to UHF. Using sensors which detect this radiation is an effective technique to detect lightning flashes, even if they are in a cloud. Using multiple sensors, a lightning flash can be located using various techniques. At low frequencies, the power radiated by lightning is very high, but because the wavelengths are long, the location resolution is somewhat low. At very high frequencies, the wavelengths are much shorter allowing for much better location resolution, but the power radiation is also much lower, making it more difficult to detect. The VHF band is a good compromise between good location resolution, and good detection efficiency. One effective technique to locate VHF signals from lightning is interferometry. With this technique, the signals arriving at least three VHF broadband antennas are coherently combined to produce an 2D image of the lightning flash. The current generation broadband lightning interferometer being developed in Japan by RAIRAN and the University of Osaka called Lightning Interferometer via VIHF Emission (LIVE).
In 2016 summer season, LIVE is installed in Kaizuka, a city to the south of Osaka, near Osaka Bay to observe Japanese summer lightning with four VHF antennas. In the current study, we are tring to calibrate the detailed antenna locations and cable delays which is difficult to measure physically from cross correlate imaging, and comparing the high detail lightning maps produced by LIVE to the lower detail, 3D maps produced by a low frequency time-of-arrival system called the Broadband Observation network for Lightning and Thunderstorms (BOLT) which is spread around Kansai area in Japan.

Keywords: Interferometer

Statistical study of maximum ionospheric electron density deduced from lightning whistlers obtained by DEMETER

*Yididya Girma Gurmu[1], Yasuhide Hobara[2,3,1], Michel Parrot[4]

1. Department of Computer and Network Engineering, The University of Electro-Communications, Tokyo, Japan, 2. Earth Environment Research Station, The University of Electro-Communications, Tokyo, Japan, 3. Center for Space Science and Radio Engineering, The University of Electro-Communications, Tokyo, Japan, 4. LPCE/CNRS, 3A Avenue de la Recherche Scientifique, 45071 Orléans, France

Electromagnetic waves radiated by lightning discharges in the VLF frequency range penetrate through the ionosphere and are observed as plasma waves so-called whistlers. In this paper, we used the fractional hop whistlers recorded by the ICE experiment onboard the DEMETER satellite to estimate the maximum electron density of the ionosphere F2 layer from the dispersion of whistlers. We have developed an automatic long-term whistler detection technique which enables us to carry out the statistical study of many whistlers from the satellite data. As a result, the maximum electron densities estimated by whistlers has a good agreement with those from ground-based measurements by ionosonde. Moreover, statistical properties of latitudinal dependencies of electron-density in different local times and seasons were obtained.

Keywords: Whistler, Ionosphere, Maximum electron density, DEMETER