**Japan Geoscience Union Meeting 2012**
(May 20-25 2012 at Makuhari, Chiba, Japan)


MIS02-01 Room:203 Time:May 22 09:00-09:15

# Global lightning characteristics deduced from ELF/VLF electromagnetic emissions observed by the DEMETER spacecraft

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The global distributions of the ELF/VLF electromagnetic waves originated from world-wide thunderstorm activities are derived based on six-year record of the low altitude spacecraft data. The lightning electromagnetic pulses in the troposphere are observed as lightning whistlers by both electric and magnetic instruments onboard the low Earth orbit DEMETER satellite. The location and source intensity of each lightning event is determined by calculating approximate Poynting flux based on the survey frequency spectrum at the satellite orbit together considering transmission loss of the ionosphere. As a result three major thunderstorm active regions are clearly identified by enhanced Poynting flux values both for ELF and VLF frequency ranges. The region of high lightning activities in ELF frequency range representing the proxy of lightning discharges with a large charge moment change are differ from those in the VLF frequency range indicating a large peak current. Spatial distribution of the global lightning with a different time scale such as day-night asymmetry, seasonal migration and yearly dependence are presented as well. Finally, the source locating accuracy and magnetic conjugate effect of the VLF propagation are examined by the aid of the World Wide Lightning Location Network (WWLLN) data.

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MIS02-02 Room:203 Time:May 22 09:15-09:45

# Comparison of ELF Inversion Methods for Global Lightning Activity

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The natural Earth-ionosphere waveguide provides a framework for global lightning detection at both ELF and VLF frequencies. Increased attention has been given recently to ELF methods, primarily because of the reduced attenuation and the smaller number of receiving stations required. In the inverse problem in the Schumann resonance band (4-40 Hz), measurements of background field spectra at multiple stations (giving a number of measured inputs N) are used to infer the global distribution of lightning sources (as a number M of unknown quantities). Two entirely independent approaches have been pursued over the last decade, and are to be compared in this study. The first inversion method (Shvets et al., 2010) involves a two -step process. The first step makes use of a forward model with a uniform Earth-ionosphere waveguide and lightning sources on each of 20 annuli (M=20) surrounding each receiving station but with spectral resolution of 0.1-0.2 Hz for a total N= 350 inputs from field spectra over the Schumann band. The solution is overdetermined. The second step, a tomographic procedure, makes use of 3 receiving stations with 20 source points each, for a total N =60-120. Unknown sources are mapped on a grid with 5o resolution (0.5 Mm) from 60oN to 60oS for a total M = 61 x 72 = 4392, in an underdetermined calculation. The second inversion approach (Mushtak and Williams, 2011) employs a non-uniform (day/night asymmetry) model for the waveguide, and a forward model with three dominant chimney sources: the Americas, Africa and the Maritime Continent. The input quantities for the iterative inversion are the modal peak intensities and frequencies for 3-4 resonant modes for all measured fields (at most, two magnetic and one electric) at 5-6 receiving stations, for a total N = 50 to 100. The unknown quantities are the source strengths and locations for each of three chimneys (M = 9) in an overdetermined calculation. Key features targeted for comparison are the relative strengths of the three dominant chimneys, the comparative strengths of secondary sources, and the day-to-day stability of the lightning activity in absolute units (C2km2/sec) on individual days in January 2009. Detailed results will be reported as they are available at conference time.

Keywords: Schumann resonances, inversion methods, global lightning, Earth-ionosphere cavity

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MIS02-03 Room:203 Time:May 22 09:45-10:00

# Discharge height of lightning narrow bipolar event and its relationship with thundercloud

WU, Ting[1*], Wansheng Dong[2], Yijun Zhang[2], Tsuyoshi Funaki[1], Satoru Yoshida[1], Takeshi Morimoto[1], Tomoo Ushio[1], ZenIchiro Kawasaki[1]

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Narrow bipolar event (NBE) is one of the most special types of lightning discharge events. In order to study the characteristics of NBE, two experiments using VLF/LF lightning location network in Guangzhou and Chongqing of China were carried out, and thousands of both polarities of NBEs were recorded.

In order to accurately determine the discharge height of NBE, we developed a method employing ionospheric reflection pair of NBE. The VLF/LF signal produced by NBE is reflected between the ionosphere and the ground, producing ionospheric reflection pulse and ground-ionospheric reflection pulse. With simultaneous observations of the NBE by multiple stations, 3-D location of the NBE can be determined by time delays between the original signal of the NBE and its ionospheric and ground-ionospheric reflection signals. This method proves to be much more accurate than traditional time-of-arrival (TOA) technique.

With this method, discharge heights of thousands of NBEs were calculated. In Guangzhou, there are a total of 1318 and 625 height results for +NBEs and -NBEs. The geometric means (GMs) of discharge height are 12.1 km and 17.3 km. In Chongqing, there are a total of 5489 and 1400 height results for +NBEs and -NBEs with GMs of 9.9 km and 17.5 km. An interesting result of our calculation is that very few NBEs are above 19 km. The highest results in Guangzhou and Chongqing are 19.6 km and 19.9 km, but there are only 0.31% of NBE in Guangzhou and 0.26% of NBE in Chongqing that are above 19 km, all of which are negative polarity.

Distribution of NBE discharge height shows that +NBEs and -NBEs occur in two different altitudes, with -NBEs mostly higher than +NBEs. Most +NBEs occur between 8 and 16 km while most -NBEs occur between 16 and 19 km. On the basis of such distribution and discharge polarities of positive and negative NBEs, we conclude that +NBEs are probably produced between the main negative charge layer and the upper positive charge layer while -NBEs are probably produced between the upper positive charge layer and the screening negative charge layer at the cloud top.

In order to further study the relationship between NBE and thundercloud, we utilized observations of two thunderstorms producing more -NBEs than +NBEs by conventional S-band Doppler weather radar. The result shows that bursts of -NBEs are clearly related with strong convection within the thunderstorm. When large number of -NBEs are produced, 30-dBZ reflectivity height is higher than 15 km, indicating the thundercloud top is even higher, probably comparable to the discharge height of -NBE.

Keywords: Narrow bipolar event, Intracloud lightning discharge, lightning discharge height, convective strength, lightning location network

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MIS02-04 Room:203 Time:May 22 10:00-10:15

# A Lightning observation network in Kansai using VHF and LF broadband digital interferometers

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We have been designing and developing VHF and LF broadband digital interferometers (DITFs) that detect electromagnetic (EM) waves associated with cloud-to-ground and intracloud discharges, and locate the EM wave sources. We have been building up a lightning observation network consisting of VHF and LF DITFs around Osaka. The observation network covers the areas from Kobe to Nara. In this presentation we compare and discuss the observation results located by the observation network.

Keywords: Atmospheric Electricity, lightning discharge, Remote sensing

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MIS02-05 Room:203 Time:May 22 10:15-10:30

# Simultaneous Optical and Electrical Observations for One Downward Bipolar Flash

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A downward bipolar flash, containing a positive first return stroke and 5 negative subsequent return strokes, was simultaneously recorded by two high-speed cameras, two Lightning Attachment Process Observation Systems (LAPOS), one fast antenna and one slow antenna at 17:54:14, 29 July 2010 (local time) in Guangzhou, Guangdong, China. The analysis shows that:

(1) The overall flash duration is about 864 ms and all 6 strokes occur and propagate along a single channel. The interval between the first stroke (positive) and the first subsequent stroke (negative) is 279 ms, apparently bigger than those between the subsequent strokes, which are 76, 111, 78 and 149 ms. The average inter-stroke interval is about 138 ms. The peak current of the first positive stroke is 142.6 kA, much larger than those 5 negative ones, 4 of which are recorded by lightning location system with peak current values of from -22.9 kA to -32.0 kA.

(2) The downward positive leader exhibits quite smooth channel without any branch in the view range of high-speed camera. The 2D velocity of the positive leader ranges from 2.1 to 3.4 $*$ $10^6$ m/s, with a median value of about 2.5 $*$ $10^6$ m/s. The positive leader propagates downward with a rising velocity trend. The 1D velocity of the positive return stroke is estimated to be about 1.2 $*$ $10^8$ m/s. The 20% to 90% rising time of luminosity pulse of the positive stroke is about 2.5 us, and the duration from 20% front to 50% tail is about 55.4 us. The first positive stroke is followed by about 100 ms continuing current superposed with multiple pulse events.

(3) The 2D velocities of subsequent dart-leaders range from about 4.0 $*$ $10^6$ m/s to more than 12.4 $*$ $10^6$ m/s. The 1D velocities of the subsequent negative return strokes range from about 1.2 to 1.3 $*$ $10^8$ m/s. The 20% to 90% rising time values of luminosity pulses of the subsequent negative strokes range from 1.3 to 2.2 us, and the durations from 20% front to 50% tail range from 64.8 to 82.3 us. Continuing current process with duration ranging from 3 to 11 ms as well as 2 to 4 evident M-components is observed following each negative stroke.

Keywords: natural downward lightning, bipolar, optical pulse, return stroke, velocity

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MIS02-06 Room:203 Time:May 22 10:45-11:15

# Observation of lightning discharges using VHF broadband interferometers

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Compact intracloud discharge (CID) is a distinct intracloud lightning discharge characterized by strong VHF emissions, and it is one of the most mysterious lightning events. The CID channel evolution images obtained by using VHF broadband interferometers are presented for the first time. Analysis of 11 CIDs shows that the channels of CIDs develop mainly in a vertical direction. The vertical scale of CIDs is in the range of 0.40?1.9 km. The average duration of VHF broadband emissions is 15 ms. The average apparent speed of CIDs is in a range of $0.44?1.0*10^8$ m/s with a mean value of $0.61*10^8$ m/s. The temporal-spatial evolution of the radiation sources of the CID shows an oscillation pattern, confirming the previous prediction that there is an oscillating current being reflected at the two ends of the CID channel. The estimated speed of the current wave in the CID channel is in a range of $0.56?2.6 * 10^8$ m/s with a mean value of $1.4 * 10^8$ m/s.

In this study, the spatial and temporal characteristic, power spectral density (PSD) in the 30MHz to 290MHz band and pulse train structure of 10 CPT records were analyzed. We found that the breakdown process associated with CPT is negative and similar with attempt leader or dart leader. The statistical result shows the average progression speeds of 10 CPT events are about $3.23*10^6$ ms-1 ˜$1.93*10^7$ms-1 with the mean value being $1.02*10^7$ ms-1. The average PSD of the CPT in the 30MHz˜290MHz band is 1.8˜11.6dB and 2.4˜12dB larger than that of the step leader and dart leader in the same negative cloud to ground lightning. The mean value and standard deviation of the pulse separations in these chaotic pulse trains are 5.3 ˜ 9.0us and 2.7 ˜ 4.9us.

Keywords: Compact Intracloud Discharges (CIDs), Pulse Burst, Lightning Locating, Broadband Interferometer

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MIS02-07 Room:203 Time:May 22 11:15-11:30

# Numerical simulations VLF signal perturbations due to red sprites

IWAMOTO, Masahiko[1*], HOBARA, Yasuhide[1], Ryosuke Naruke[1], Kenji Ohta[2], Kazuaki Hiroki[3], Tetsuya Minatohara[3], HAYAKAWA, Masashi[1]

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In this paper we perform 3D finite-difference time-domain (FDTD) method to compute the subionospheric VLF signal perturbations due to the ionization from mesospheric transient event such as red sprites. Spatial scales of columns are determined by the sprite images obtained from our optical observations during winter lightning activities over the sea of Japan. Numerical results indicate that the multiple sprites generate the complicated scattering pattern of the VLF transmitter waves depending on special orientation and extent of sprite ionization columns. Spatial dependence of the scattered amplitude are compared with those from the experimental results of VLF observation network.

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MIS02-08 Room:203 Time:May 22 11:30-11:45

# Numerical modeling of the TLE-related particle precipitations due to wave-particle interactions in the magnetosphere

MUKAI, Norihito[1*], HOBARA, Yasuhide[1], HAYAKAWA, Masashi[1], YAMAGISHI, Hisao[2], OKADA, Masaki[2]

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It's well known that high energy particles precipitate into the ionosphere caused by interactions between lightning generated whistler waves in the atmosphere and the energetic particles in the magnetosphere. Perturbation of the lower ionosphere due to the precipitating particles are monitored by the ground-based VLF measurement as a space trimpi event.In this study, the spatio-temporal dependence of precipitating particle energy flux were calculated by numerical simulations. In particular, we focus on the source spectrum of lightning discharges as one of the simulation inputs. The results from different types of source spectra such as TLE-producing and conventional discharges will be presented.

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MIS02-09 Room:203 Time:May 22 11:45-12:15

# Lightning Applications in Severe Weather Research

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The study of lightning and thunderstorms is important for many practical and scientific reasons. Although lightning is a direct hazard to aviation, power companies, and the public, while igniting many forest fires around the globe, lightning activity within thunderstorms is also related to different types of severe weather. Due to the relationship between cloud electrification and the microphysical and dynamic structure of these storms, changes in lightning characteristics in storms can tell us a lot about the inner workings of thunderstorms. Lightning activity has been related to the likelihood that storms will produce hail, flash floods, tornadoes and other wind damage. In addition, it has been shown that lightning is related to the intensification of typhoons. With regional and global VLF lightning detection networks today supplying data in real time, while in the near future we will have real time lightning data from geostationary satellites, lightning observations provide a useful tool to help in the forecasting of severe weather, and the possibility to provide early warnings for the public in advance of these damaging storms.

Keywords: lightning, severe weather, natural hazard

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MIS02-10 Room:203 Time:May 22 13:45-14:00

# Measurements of the properties of ions generated in ambient air

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Gaseous ions are ubiquitous in the lower atmosphere, mainly produced by galactic cosmic rays. Other ion sources such as radioactive decay, lightning, power transmission lines and combustion can enhance the ion concentration locally. Atmospheric ions are essentially important in Atmospheric Electricity because they provide electrical conductivity to the atmosphere.

Ions are involved in aerosol formation. Ions may grow sufficiently to become stable aerosol particles. Ion growth requires the presence of atmospheric trace gas molecules which have the ability to attach to ions. The ion growth speed which increases with the concentration of such trace gas molecules must be sufficiently large to allow ion growth within the relatively short ion lifetime. However such conditions are met only in certain atmospheric conditions. Whether ion induced aerosol formation makes a significant contribution to the atmospheric aerosol budget therefore remains an open question.

In addition, artificially produced ions have been reported to reduce the levels of particulates, air-borne microbes, odors and volatile organic compounds in indoor air. Because of these effects of ions, commercial electrical appliances with ionizers (mainly corona discharge type) are widely used in indoor environment. However, the detailed mechanisms by which the ions contribute to improving indoor air quality are not clearly understood.

To access the role of ions in atmospheric environment in more detail, obtaining information on ion properties such as composition and mobility (diameter) under variety conditions is important. In this paper, we present experimental results of measuring ions formed by corona discharge in ambient air using an ion mobility/mass spectrometer (IMS/MS).

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MIS02-11 Room:203 Time:May 22 14:00-14:15

# Global electric circuit affected by Fukushima power plant accident

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Radioactive contamination occurred due to Fukushima power plant accidents on March 11, 2011. In this study, we investigate atmospheric electric field variation associated with radioactive material which affected global electric circuit. The observed data of atmospheric electric field, air-earth current, and radiation agree with global electric circuit model through the circuit simulation.

Keywords: Global electric circuit, Fukushima nuclear power plant accident, Atmosphere

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MIS02-12 Room:203 Time:May 22 14:15-14:30

# Observational study of the Lithosphere-Atmosphere-Ionosphere Coupling (Chemical cannel)

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Recently, Ionospheric anomalies possibly associated with large earthquakes have been reported by many researchers. These reports suggest the existence of ”Lithosphere- Atmosphere-Ionosphere Coupling (LAI coupling)”, For the LAI coupling, 3 cannels have been proposed; they are ”acoustic”, ”chemical”, and ”electromagnetic” channel. In this study, the chemical cannel is considered to be dominant and in order to understand basic characteristics of the chemical cannel, we observe ion content concentration, atmospheric electric fields, and meteorological parameters in the southern part of Boso Peninsula. We have installed COM-3700, produced by Com System Inc., to measure ion content concentration at Akishima (Tokyo), Kiyosumi (the southern part of Boso Peninsula) and Uchiura (the southern part of Boso Peninsula). Atmospheric electric field and weather conditions (temperature, humidity, air-pressure and window conditions) have also been measured simultaneously at Kiyosumi station. We are now collecting fundamental data to understand variations.

After the 2011 off the Pacific coast of Tohoku Earthquake(M9.0), We observed anomalous variations of ion content concentration and atmospheric electric field. It may results from atmospheric radioactive material released by the Fukushima Daiichi Nuclear Power Plant accident. We think this variation of atmospheric electricity parameters is response to increase of radioactive material in the atmosphere.

In our presentation, we will show you details.

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MIS02-13 Room:203 Time:May 22 14:30-14:45

# Magnetic Storm Free ULF Analysis in Relation with Earthquakes in Taiwan

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Despite early optimism, pre-earthquake anomalous phenomena can be determined by using enhanced amplitude at the ultra-low-frequency range from geomagnetic data via the Fourier transform. In reality, accuracy of the enhanced amplitude in relation to earthquakes deduced from time-varied geomagnetic data would be damaged by magnetic storms and/or other unwanted influence resulted from solar activity and/or variations in the ionosphere, respectively. We substitute values of the cross correlation between amplitudes summarized from the earthquake-related (0.1-0.01 Hz) and the comparable (0.01-0.001 Hz) frequency bands for amplitude enhancements as an index of determination associated with seismo-magnetic anomalies to mitigate disturbance caused by magnetic storms. A station located about 300 km away from the others is taken into account to further examine whether changes of the cross correlation values are caused by seismo-magnetic anomalies limited within local regions or not. Analytical results show that the values suddenly decrease near epicenters few days before and after 67% (=6/9) earthquakes (M>=5) in Taiwan between Sep. 2010 and March 2011. Seismo-magnetic signals determined by using the values of cross correlation methods partially improve results yielded from the Fourier transform alone and provide advantage information regarding forthcoming earthquakes in the time and spatial domains.

Keywords: Seismo-magnetic anomaly, Ultra low frequency

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MIS02-14 Room:203 Time:May 22 14:45-15:15

# Is it possible to predict earthquakes? - There are reasons to believe

O Molchanov[1], SCHEKOTOV, Alexander[1*], E Fedorov[1], V Gladishev[1], HAYAKAWA, Masashi[2], HOBARA, Yasuhide[2]

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This report is dedicated to our friend and colleague Oleg Molchanov who passed away last year. During his last years the problem of earthquake forecast was the most important for Oleg and new approaches were developed and several interesting results were got under his leadership. Here we present only two of them, probably the most interesting and statistically significant. These seismo-electromagnetic effects due to their properties can be used for short-term earthquake prediction. The first one is the depression of the ULF magnetic field fluctuations 1-7 days before earthquakes. Contrary, the second effect is an additional emission in the atmosphere during the same time interval in the frequency range 1-50 Hz. The efficiency of both methods for the EQ forecast is verified at numerous earthquakes at Japan, Kuril Islands and Kamchatka. We also describe the measurement technique, the procedure for finding the precursors, and the methods of data processing.

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MIS02-15 Room:203 Time:May 22 15:30-15:45

# Numerical modeling of seismo-ionospheric disturbances by FDTD method and comparison with experimental results from Japan

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Recently many experimental results have been reported concerning the ionospheric perturbation associated with major earthquakes. VLF/LF transmitter signal received by network observations are used to detect seismo-ionospheric signatures such as amplitude and phase anomalies. These signatures are due to the ionospheric perturbation located around the transmitter and receivers. However the physical properties of the perturbation such as electron density, spatial scale, and location have not been understood well. In this paper we carried out the numerical simulation on the subionosperic VLF/LF signals including the various conditions of seismo-ionospheric perturbations by using a two-dimensional finite-difference time-domain (2D-FDTD) method to determine the perturbation properties. The amplitude and phase for the various cases of an ionospheric perturbation are calculated relative to the normal condition (without perturbation) as functions of distance from the transmitter and distance between the transmitter and perturbation. These numerical results are compared with our observation for several major earthquakes. As a result, we found that the received transmitter amplitude depends greatly on the distance between the transmitter and ionopsheric perturbation, on the spatial scale and height of the perturbations. Moreover results of modeled ionospheric perturbation for the recent 2011 off the pacific coast of Tohoku earthquake are compared with those from our VLF network experiment.

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MIS02-16 Room:203 Time:May 22 15:45-16:00

# Is IAR necessary for SRS? - Not always

SCHEKOTOV, Alexander[1*], E Fedorov[1], HOBARA, Yasuhide[2], HAYAKAWA, Masashi[2], NAKAMURA, Ryohei[2], SHIOKAWA, Kazuo[3], N Yagova[1]

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We analyze magnetograms for the time intervals with clear spectral resonant structures (SRS) at frequencies 0.1- 6 Hz. For this study we use the data of induction magnetometers from Moshiri (Japan) and Karimshino (Russia). The common view is that the SRS originate from excitation of the Ionospheric Alfven Resonator (IAR) by lightning discharges. However, rather frequently the typical picture in time domain includes only two pulses: the main pulse caused by a lightning discharge, and a single echo pulse following with delay from several tenths of seconds to several seconds. The secondary pulse can be explained by partial reflection of an initial wave from the steep gradient of Alfven velocity in the ionospheric F-layer. Thus, although a spectrum with the comb-shape structure is seen at IAR frequencies it can be sometimes successfully interpreted without resonance excitation.

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MIS02-17 Room:203 Time:May 22 16:00-16:30

# Possible precursors to the 2011 3/11 Japan earthquake:VLF/LF propagation anomaly and ULF depression anomaly

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The purpose of this paper is to present a possible precursor to the 2011 March 11 Japan earthquake. First of all, we present the results on subionospheric VLF/LF propagation anomaly (ionospheric perturbation) by means of Japan-Russia VLF network. It is found that the ionospheric perturbation is clearly detected on March 4, 5 and 6 on the propagation paths of NLK (Seattle, USA) to Japanese stations and on a path of JJI (Miyazaki, Kyushu) to Kamchatka. Next, we present the results on the ULF depression (horizontal component) on the same days, which is interpreted in terms of the absorption in the disturbed lower ionosphere of the downgoing magnetospheric Alfven waves. These two precursors are considered to be due to the same effect of the lower ionospheric perturbation about one week before the earthquake.

Keywords: Seismo Electromagnetics, ULF emission