PRESS RELEASE

Source: International Public Relations, University of Electro-Communications, Tokyo.

For immediate release: 28 January 2016
University of Electro-Communications research: Ionospheric anomalies – distinguishing quakes from storms

(Tokyo, 28 January 2016) **Research at the University of Electro-Communications suggests how to identify anomalies due to geomagnetic storms in low frequency signals, which may help distinguish them from seismic activity.**

A potential for earthquake prediction may lie in detecting anomalies in the propagation of very low frequency (VLF: 3-30 kHz) radio signals, as they are greatly affected by ionospheric disturbances that may originate from seismic activity. However there are several other possible causes for VLF anomalies, including terrestrial and space weather, many of which are little understood. In their latest work the UEC researchers help to shed light on how to distinguish VLF anomalies caused by geomagnetic storms that have no relation to seismic activity.

The UEC researchers, Kenshin Tatsuta and Yasuhide Hobara, in collaboration with S. Pal, also associated with the Indian Centre for Space Physics and M. Balikhin at the University of Sheffield in UK, analysed data from 16–21 independent VLF and low-frequency transmitter-receiver paths at different latitudes over 27 months. The transmitter-receiver paths ran at high-latitude (east to west), mid-latitude (east to west) and north to south. They considered statistical parameters including the average signal amplitude and variability of the signal amplitude, and compared changes in the VLF propagation characteristics with data of geomagnetic storm indicators.

The comparisons indicated that VLF propagation is far more likely to exhibit anomalies caused by geomagnetic storms at high latitude than those at mid latitude or north-south transmitter-receiver paths, where anomalies originating from other events are more commonly observed. Paths over land rather than water may be also better for revealing anomalies with seismic origins due to the difference in conductivity.

The UEC team concludes, “Although it is still uncertain that only VLF data can be used to assess the probability of future seismic activities, the characteristics of VLF signals can form a part of the set of parameters that will allow us to provide a warning of possible hazards.”

Background

Ionosphere

The ionosphere is located in the altitude between 60 km and 1000 km above sea level. Here solar radiation can ionize atoms and molecules. The density of atoms and molecules in this region is so low that although the ions and electrons created attract each other, they may still not readily recombine, giving rise to an ionic plasma.

Ionisation in the ionosphere is affected by solar intensity which varies over the course of the day and changes in seasons. As a result the composition of the ionosphere will vary diurnally and seasonally. It is also affected by space events, such as solar flares and geomagnetic storms, the Earth's atmospheric weather such as thunderstorms, as well as seismic events.

Electromagnetic waves, such as from radio transmitters, interact with the ionosphere which affects the propagation characteristics, particularly electromagnetic signals at very low frequencies. How propagation is affected depends on the conductivity changes of the ionosphere along the propagation path. The challenge is distinguishing the signature of the different events that perturb the ionosphere in VLF signals to identify the cause.

Geomagnetic storms

The region in which the Earth's magnetic field affects the paths of charged objects is described as the magnetosphere. Further away and the charged object may be more affected by the magnetic fields from other astronomical objects.

The electrically conducting plasma inside the Sun – solar wind - gives rise to its own magnetic field. A shock wave in solar wind can interact with the magnetosphere, initially compressing it and increasing its energy. This can increase electric field lines in the magnetosphere and electric currents in the magnetosphere and ionosphere.

Both the auroral electrojet and disturbance storm time indices are indicators of geomagnetic storms. The authors used measurements for both over the same time period to compare with the VLF propagation data.

The statistical parameters used

The daily average amplitude of the VLF transmitter signals used in this study was calculated by the average nighttime amplitude at a defined day. The residual so-called 'trend' at a defined day was then derived by the difference between the average nighttime amplitude at the defined day and the average amplitude over the previous 15 days .

The researchers specifically looked at the trend as well as the dispersion defined as the standard deviation of the residual each day and the nighttime fluctuation defined by the residual integrated over the whole night. These three statistical parameters considered may differ from study to study due to the different origins of perturbations and geographical configuration of the propagation paths, and the researchers will further study the effect of the VLF anomalies from different natural origins for comparison.

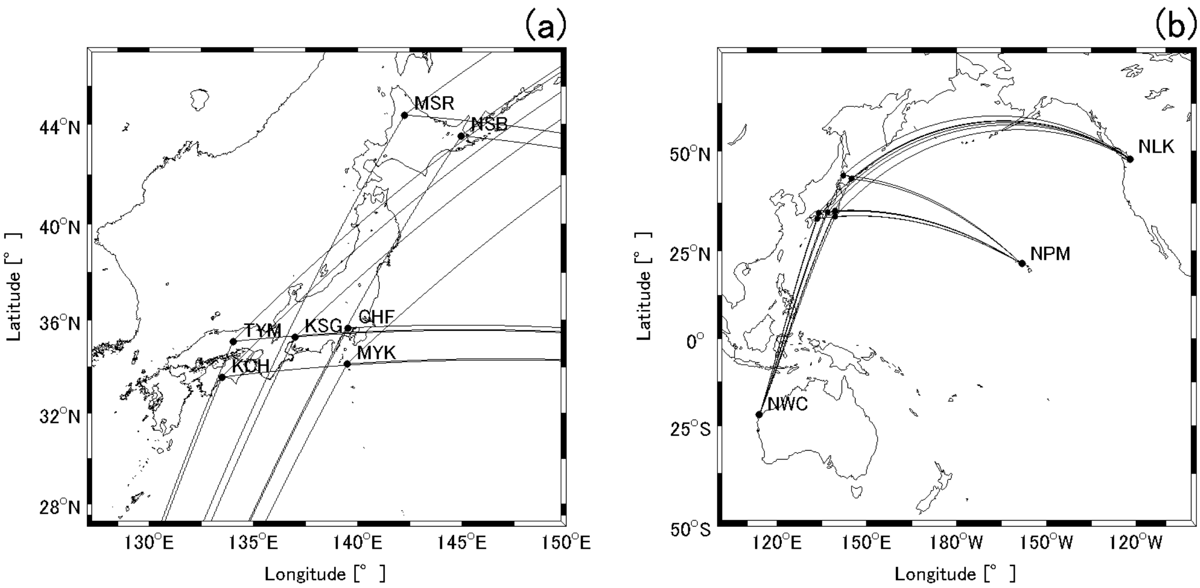
Reference

K. Tatsuta[1], Y. Hobara[1,2], S. Pal[1,3], and M. Balikhin[4], Sub-ionospheric VLF signal anomaly due to geomagnetic storms: a statistical study, *Annales Geophysicae* **33** 1457-1467 (2015).

1. Department of Communication Engineering and Informatics, The University of Electro-Communications, Tokyo, Japan
2. Earth Environment Research Station, The University of Electro-Communications, Tokyo, Japan
3. Indian Centre for Space Physics, Kolkata, India
4. Department of Automatic Control and Systems Engineering, University of Sheffield, Sheffield, UK

*Corresponding author: hobara@ee.uec.ac.jp

Figure 1



Caption

Maps showing VLF observation network operated by UEC. The geographic locations of VLF transmitters and receivers used for the data analysis are indicated. Corresponding great circle paths (GCPs) for every transmitter–receiver pair are also given. (a) Paths around Japan (indicating VLF receiving stations) and (b) entire
paths (including VLF transmitters).

Further information:

International Public Relations
The University of Electro-Communications
1-5-1 Chofugaoka, Chofu, Tokyo 182-8585
E-mail: ru-info-ml@uec.ac.jp
Website: http://www.uec.ac.jp/

About the University of Electro-Communications

The University of Electro-Communications (UEC) in Tokyo is a small, luminous university at the forefront of applied sciences, engineering, and technology research. Its roots go back to the Technical Institute for Wireless Commutations, which was established in 1918 by the Wireless Association to train so-called wireless engineers in maritime communications in response to the Titanic disaster in 1912. In 1949, the UEC was established as a national university by the Japanese Ministry of Education, and moved in 1957 from Meguro to its current Chofu campus Tokyo.

With approximately 4,000 students and 350 faculty, UEC is regarded as a small university, but with particular expertise in wireless communications, laser science, robotics, informatics, and material science, to name just a few areas of research.

The UEC was selected for the Ministry of Education, Culture, Sports, Science and Technology (MEXT) Program for Promoting the Enhancement of Research Universities as a result of its strengths in three main areas: optics and photonics research, where we are number one for the number of joint publications with foreign researchers; wireless communications, which reflects our roots; and materials-based research, particularly on fuel cells.
Website: http://www.uec.ac.jp/