Monitoring and prediction of terrestrial and space environments using natural and man-made electromagnetic noises

Yasuhide Hobara
*Graduate School of Informatics and Engineering, University of Electro-Communications
**Center for Space Science and Radio Engineering, University of Electro-Communications
Chofugaoka, Chofu 182-8585, Japan
Email: hobara@ee.uec.ac.jp

In this invited lecture, I would like to briefly introduce how observations of both natural and man-made electromagnetic (EM) noise contribute to monitoring terrestrial environments and mitigating natural disasters. I will focus on three different topics such as (1) lightning discharges, (2) electromagnetic phenomena associated with seismic activities, and (3) space weather. An interdisciplinary approach is highly required to tackle the above-mentioned problems, and so we should closely collaborate with various URSI scientific commissions.

(1) Lightning discharges

Recent global climate change causes more hazardous meteorological events worldwide. Most of these events are associated with active thunderstorms with significant lightning discharges. Lightning discharges generate strong electromagnetic pulses known as sferics in wide frequency ranges and the pulses propagate a long distance. I am going to demonstrate two practical applications of lightning discharges.

The first application of lightning is to monitor and short-term forecast extreme meteorological events such as Tornadoes, wind gusts, and heavy rainfall causing flash floods, etc. by using so-called Total Lightning (TL), which is a sum of the Cloud to Ground lightning discharges (CGs) and In-Cloud lightning discharges (ICs). Analyzed results of the TL data from the Japanese Total Lightning Network (JTLN) will be presented.

The second application is related to mitigating the damage to the power grid systems from very energetic lightning characterized by a large lightning charge Q. Extremely Low Frequency (ELF) range EM radiation from lightning are utilized to derive the proxy of Q. Both regional and seasonal dependences in Qds and Ip of CGs provide the basic information to prevent/mitigate potential damages to the power grid systems and renewable power generating systems. Such examples in Japan and Malaysia will be demonstrated.

Lightning observations from space such as satellites and International Space Station (ISS) can provide electrical properties of lightning on the ground with uniform and high sensitivity. Such examples from EM/optical observations will be presented.

(2) Electromagnetic phenomena associated with seismic activities

Significant progress has been made in this new scientific field, exploring the possibility of earthquake (EQ) prediction with EM effects in the last few decades. In this talk, recent results of the various types of EM phenomena such as lower ionospheric perturbation observed by VLF/LF transmitter signals, ULF/ELF anomalies, atmospheric electric field, etc. around EQs will be presented.

(3) Space weather

Prediction of physical parameters in the space environment is extremely important not only for space weather but also for seismo-electromagnetics. Here machine learning techniques are applied to build spatio-temporal models to predict energetic electrons flux in the radiation belt (various external space weather parameters including ground-based ULF geomagnetic field data), VLF/LF transmitter amplitude, and F2 layer critical frequency (foF2). The prediction accuracy of proposed models is quite high and is proved to be useful.