Reduction of ULF external source origin signals (periods T< 1,000 s) using of interstation transfer function method

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Electromagnetic phenomena preceding large earthquakes have been reported in various frequency ranges. Ground-based observation of ULF geomagnetic field change is one of the most promising methods to monitor the seismic and volcanic activities due to the skin depth.

The observed ULF magnetic and electric potential fields are considered to be superposition of some possible signals. In the periods of 1 – 1000 sec, the most intense signal is the external source field associated with the solar-terrestrial interactions such as the geomagnetic pulsations and geomagnetic storms, and their inductive field, which appear simultaneously in the global (hundreds km) scale. The next intense signal in Japan is cultural noises from DC driven train system and factories, of which effective spatial distance is considered to be regional by several tens km. The third one is local one such as move of magnetized objects at one site. The signals associated with the crustal activity are very weak in general and are considered as the regional one. Therefore, the signal separation is significant. As for ULF geomagnetic data, we have already developed effective methods for signal discrimination such as polarization analysis, principal component analysis, and fractal analysis. They are based on the detection of the characteristics of signal. Also it is very important to identify the waveform of earthquake-related signals. In this paper, we will present the effective time series analysis for reducing the field variations originated from the external source. In this approach, the reference geomagnetic data are used, so it is called the interstation transfer function (ISTF) method. We also adopted the wavelet transform using Morlet wavelet for the ISTF approach. We applied the proposed ISTF method to the actual data at the ULF electromagnetic sensor array with inter-sensor distance of about 5 km in Boso and Izu Peninsula, Japan. Both regions locate at one of the most active seismic zones in Japan. Torsion-type magnetometers with three components are in operation and two horizontal electric potential differences are measured by pairs of electrodes with distance of 50 – 100 m. All of equipments are synchronized using GPS clock. The sampling rate is 50 Hz, but we use the data resampled down to 1 Hz in this study. As a remote reference data, The geomagnetic data observed at Kakioka Magnetic Observatory, Japan Meteorology Agency are used.

We estimate ISTF under the condition of high multiple coherency and the performance of the designed filter based on the ISTF approach is found to be quite well and variations originated from geomagnetic pulsations are effectively reduced both magnetic and electric fields.

In order to verify the effectiveness of the global electromagnetic field reduction, we examined the detection of simulated VAN type Seismic electromagnetic signals (SES) for geoelectric fields and possible electromagnetic data related with the 2002 Boso slow slip event. Results indicate that the proposed ISTF method is effective to reduce the signals originated from the external source field variation in the periods t < 1000 sec and to enhance the other signals. Both model computation of SES detection and application to the 2002 Boso slip show the capacity of the proposed method.