A controlled-source electromagnetic investigation using new developed EM-ACROSS signal at Kusatsu-Shirane volcano

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Abstract

A controlled-source electromagnetic (CSEM) investigation operated with an accurately controlled, routinely operated signal system (EM-ACROSS) in 2018 was new developed in accordance with an initial experiment at Kusatsu-Shirane volcano in 2017. The initial experiment afforded observed signal with good anti-noise ability and high signal-to-noise ratio in the frequency range above 0.5 Hz by a one-day-observation. Based on the result from initial experiment, we adjusted the operation of transmitter system with new designed waveform. A CSEM investigation with the new developed EM-ACROSS signal was made at the same location for at least 2 months.

The major alternation of the new transmitter system is the parallel current injection in two perpendicular direction by two amplifiers. We made a continuous current injection for east-west and north-south dipole at the same time instead of by turns. Two specially designed waveforms had specifically chosen amplitudes and frequencies which based on the observed data from initial experiment and random phase shift for each frequency. A function generator, which synchronized with a 10MHz signal from GPS clock, stored the waveforms and send them to the amplifiers. The amplifiers increased the signals 80 times and injected current to the ground by two sets of electrode array. The output of amplifiers is monitored and recorded by a digital data logger. The observed data was recorded by MTU-5 magnetotelluric instrument from Phoenix Geophysics with 15 Hz sampling rate.

We used frequency domain data stacking method with a procedure of noise reduction in the data processing. The time series data was divided into many data frames with a fixed length of time segments. The data in time domain was processed by a detrending method and a Tukey window function for eliminating the effect from long-period noise. For every grouped 10 data frames, the time domain data was converted to frequency domain by Fast Fourier Transform with 1 data frame overlapping. An outlier detection and elimination procedure according to the distance-based detection was applied to either the raw or the normalized electric field and magnetic field data.

The frequency spectrum presents the new observed electric and magnetic fields with obviously enhanced accuracy and precision. The data error of observed EM-ACROSS signal visibly decreases in the frequency range below 0.5 Hz. A comparison between the data stacking with and without additional noise reduction procedure confirm the difficulty of noise reduction by simple stacking with an extending survey. This issue is caused by the non-stationary noise which could be removed in the outlier detection and elimination procedure. As a result of the acceptable error in observed EM-ACROSS signal, the normalized electric field data will be used as modeling parameter in the future.