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Data processing and analyzing of magnetotellurics survey data in time domain

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Data processing is one of essential techniques to obtain optimum response function of the earth. The processing of magnetotelluric survey (MT) has been based on the Fast Fourier Transform (FFT) since the response function of the earth is the function of the frequency. FFT processing gives us spectrums of time series easily. In addition, FFT gives us optimum response function of the earth when S/N ration is high or the length of the time-series is long enough. However, the error of the response function is very large when we apply FFT processing to the low S/N data or short time-series. We suppose that applying FFT processing to MT data may not be optimum. MT survey data is in general non-stationary since the source of MT is the transient electromagnetic fluctuation in the ionosphere. On the other hand, FFT assumes time series to be stationary so that we develop the novel data processing of non-stationary data without FFT.

Here, we focus on a digital filter called pole on pedestal that extracts the signal at specific frequency. This filter defines Z transform. We can calculate the phase of the electromagnetic using the filter and Hilbert transform. In addition, it is important to select the segment included in the signal. We calculate cross correlations between filtered magnetic data at different sites, and chose some segment in which the coherence among the sites has high values. In this way, we can select the segment included in the signal objectively. On the other hand, we must remove the segments contaminated by strong noise. We apply the Maximum Entropy Method (MEM) to select low S/N segments. We include robust and jackknife method in our processing and developed the data processing in time domain without FFT. We applied time domain processing to real MT survey data acquired at the Nankai trough. The data acquired at Nankai trough is low S/N ratio or short term when the signal penetrated to the earth. We obtain optimum response functions using novel data processing successfully. We conclude that the processing and analysis in time domain is important and effective.

In addition, as an example of efficiency of time-domain data analysis, we demonstrate the plane wave decomposition to the MT. The observed wave is decomposed into up-going and down-going wave. The up-going wave contains of the information of the earth. We calculate the wave from synthetic data and apply the plane wave decomposition. The calculated result matches the theoretical solution, so we can apply the plane wave decomposition to the array-like MT data. We again confirmed the future availability of the analysis and processing of the MT data in time domain.

Keywords: magnetotelluric, data processing, time domain, plane wave decomposition