Development of time-domain noise reduction method using MSSA (Multi-channel Singular Spectrum Analysis) for Boso MT data (3)

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There is a triple junction of three plates (the North American plate, the Philippine Sea plate, and the Pacific plate) near the Boso peninsula, Japan, located in central Japan. Thus, the area around the peninsula is high crustal activity. The epicentral regions of the past large earthquake are estimated in the southwest of the peninsula, and Slow Slip Events (SSE) sometimes occur within some years. Thus, we conducted the magnetotelluric (MT) method survey in 2014 ~2016.

However, the human activity in the area is also high, and the observed electromagnetic data contains not only the MT signal from a natural source but also artificial signal by the effects of the leak current from DC-driven trains and the effects of a power line. The effects of the artificial noise influence the wide band because both the MT signal and artificial noise are correlated, and the noise has a rectangular-like waveform. Thus, we can not obtain the reasonable MT response function to use subsurface resistivity structure analysis by a conventional method that processes outliers caused by the noise and estimates in the frequency domain. Thus, we introduce the Multi-channel Singular Spectrum Analysis (MSSA) based signal noise discrimination method to reduce the effects of the noise before the MT response estimation in the frequency domain.

MSSA can decompose from C-ch time series to WL×C principal components (PCs) in descending order of large amplitude. The summary of the scheme is as follows: Tapering the observed time series with window length WL, then creating a trajectory matrix with shifting 1 data point. Performing Singular Value Decomposition (SVD) to the covariance matrix of the trajectory matrix, then reconstruct PCs from the eigenvalue and eigenvector of SVD. By choosing the PCs based on the property, such as contribution and correlation coefficient, and summating the selected PCs, we can divide the observed time series into signal and noise components. Compared with other methods, such as wavelet transforms, it is suitable for processing non-stationary signals, such as natural electromagnetic fields, because it does not require basis functions.

In the MSSA-based new method, 7ch data (target site 5 components (horizontal magnetic field 2ch (Hx and Hy), vertical magnetic field 1ch (Hz), and horizontal electric field 2ch (Ex and Ey)) and reference site 2ch (magnetic field 2ch (Rx and Ry))) are used. First, apply MSSA to 7ch, then eliminate the trend. Second, apply MSSA to 4ch (Hx, Hy, Rx, and Ry) to extract solar-origin magnetic field fluctuation. Finally, apply MSSA to 7ch (extracted magnetic field by step 2, Hz, Ex, and Ey) to obtain the MT signal in Hz, Ex, and Ey.

In practice, by applying this method to the Boso MT data, which contains the rectangular rectangular-like noise by the artificial noise, we can reduce the effect of the noise. In this presentation, we will introduce the result mainly.

Keywords: MT method, Multi-channel Singular Spectrum Analysis, Noise reduction, Boso peninsula, ULF band

