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

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SUMMARY

In the magnetotelluric (MT) survey, we employ the natural signal caused in the ionosphere or by lightning discharges to estimate the subsurface resistivity structure. However, the observed data also includes an artificial noise, such as the effect of the leak current from a DC-driven train. The noise violates the assumption that the MT source is from a far field and distorts the MT response function.
To solve the problem, various noise reduction methods are introduced. Robust estimation and application of the principal component analysis or singular value decomposition are perhaps used to estimate the reasonable response if we have the amount of the observed data. However, in some cases, using lots of data is difficult due to the limitations of the survey sites and the person's and mechanical resources. Thus, we developed a noise reduction method in the time domain using Multi-channel Singular Spectrum Analysis (MSSA) to improve the signal-to-noise ratio before the conventional MT response estimation.
In the MSSA, the time series data is decomposed into several principal components (PCs) and reconstructed by selecting the PCs based on the criterion, such as correlation.
We confirmed the performance of MSSA-based preprocessing to (1) quiet data observed at KAK (Kakioka Magnetic Observatory, Japan) and (2) noisy MT data observed in Boso, Japan. MMB (Memambetsu Magnetic Observatory, Japan) data is employed as a reference in both data. The reconstructed KAK data (1) corresponded to the reference even with the low quality of the electric data. The reconstructed Boso data (2) also showed good coherence with reference data in 30 to 1000 seconds, even though the observed electric and magnetic data included correlated noise, such as the effect of a DC-driven train. As a result of the MSSA preprocessing, a more reasonable MT response function than BIRRP (Chave et al., 2004) was obtained.

Keywords: Magnetotelluric (MT) method, noisy data, MSSA, noise reduction