Noise reduction of horizontal components of magnetic field by means of Independent Component Analysis and its application to the Magnetotelluric survey in Boso peninsula

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We carried out a MT survey in the Boso peninsula (Chiba, Central Japan) to investigate the resistivity structure of the area where the slow slip events have occurred at least five times within 20 years. Large artificial noise contaminated in the MT data and the resistivity and phase showed near field effect at the frequency band below 1Hz. To avoid the local noise, we attempted to apply the independent component analysis (ICA).

ICA is one of the multivariate analysis methods and in which complicated data sets can be separated into all underlying sources without knowing these sources or the way that they are mixed. It assumes that the mixing is liner, and yields the relation $x(t)=As(t)$, where input signals $x(t)$, mixing matrix A and source signal $s(t)$. The matrix $W(=A^{-1})$ is computed in the ICA. In this study, we used the frequency domain ICA program for complex signals to deal with the phase part. This is an extension of FastICA algorithm which was introduced by Aapo and Hyvärinen (2001) and is based on a fixed-point iteration scheme for complex valued signals.

We applied the ICA method to improve horizontal magnetic components in MT data. Two components of ICA using both the data observed in Boso area and the noise free magnetic data observed in Esashi, Sawauchi or Kakioka Magnetic Observatory was applied for each magnetic component. The magnitude of magnetic intensity varies over large ranges in wide frequency band. To work ICA effectively, we needed to divide into narrow frequency bands and applied the ICA at each band. After applying ICA, in order to extract noise free component which showed high correlation with data in noise free site, we kept the noise free component and set to 0 in other noise component. Then we applied inverse matrix of W to obtain original x, i.e. $x(t)=W^{-1}u'(t)$, where $u'(t)$: components vector after ICA, $x(t)$: the original data vector. Finally, we used the BIRRP processing to calculate the apparent resistivity using improved horizontal magnetic components.

After the ICA processing, the apparent resistivity showed gentle change and the phases take non-zero values. This result meant that some parts of the noise components such as near field noise were removed. These results revealed that ICA has a potential to handle noisy data. But, the ICA processing not every frequency band worked effectively and the horizontal magnetic components were well improved by the conventional remote reference method. Finally, the most suitable apparent resistivity and phases were chosen for each frequency band from the results of both methods.

We estimated the resistivity structure using the improved data and discussed the structures in relation to geological structure and the presence of fluid.

Keywords: MT methods, Magnetotelluric, independent component analysis