信号源の空間不均質性が地磁気変換関数に与える歪み

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Disturbance of geomagnetic transfer functions by spatial heterogeneity of source field

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It is well known that the heterogeneity of source field strongly affects the magnetotelluric (MT) responses and geomagnetic transfer functions (TF). These electromagnetic responses are used for visualization of subsurface structure, and recently time-lapse MT has been conducted for monitoring the subsurface environment, especially around geothermal area. Therefore, understanding of behavior of the heterogeneous source field to the MT responses and TFs becomes a key for accurate imagining of subsurface structures and their monitoring since the false temporal changes can be triggered if the geomagnetic variation is not homogeneous (e.g., Egbert et al., 2000; Romano et al., 2014). In the conventional methods, the TFs of horizontal magnetic field between two sites have been used to evaluate the spatial characteristics of geomagnetic variation since the horizontal magnetic field basically reflects the strength of source field. However, the TF-based evaluation of source field characteristics requires long time-series data for accurate estimation of TF at both sites. In this study, we focus on the raw spectrograms (i.e., time-frequency domain) of geomagnetic data, which have huge information and will be suitable for accurate and detailed discussion on the source field. We applied the Non-negative Matrix Factorization (NMF) (Lee and Seung 2000; Kameoka et al., 2009), which can extract the independent components from the spectrogram, and expanded the NMF to the Multi-Channel NMF (MC-NMF) in order to extract the common components from several geomagnetic spectrograms. We applied MC-NMF to the horizontal geomagnetic data obtained at several geomagnetic observatories, and extracted the independent components. We found north-south heterogeneities of some components in horizontal geomagnetic spectrograms. Then, we calculated the temporal stability of TFs during 2000-2010, and found that the low stabilities of TFs are obvious if the components in geomagnetic spectrograms have large spatial heterogeneities. We also found that the horizontal-vertical geomagnetic transfer functions (so called as tipper) indicate instabilities in case of larger spatial heterogeneities of geomagnetic spectrograms. As a result, we conclude a successful evaluation of the spatial characteristics of geomagnetic variation based on our method. In further studies, we expect that our method will reduce the unwanted effect due to the heterogeneous source field, and derive the TFs and MT responses with higher accuracy.