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Principal Component Analysis of Geomagnetic Field Data Associated with Earthquakes

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Many studies on electromagnetic phenomena associated with earthquakes have been reported. Among them, one of the most probable studies is to investigate the relationship between ULF (Ultra Low Frequency, <10Hz) geomagnetic anomalous changes and earthquake. In comparison with other higher frequency ranges, ULF has an advantage in propagation in the crust due to skin depth. Therefore, we investigate the anomalous ULF geomagnetic changes associated with 2000 Izu Islands Earthquake Swarm with using principal component analysis.

The swarm activity started from June 26 and lasted about three months. During this period, we measured three components of ULF geomagnetic fields at Izu and Boso Peninsula, Japan. The array observation system consist of three stations with intersensor distance of 5 km is in operation. Generally, observed ULF geomagnetic fields are superposition of solar origin signal, artificial noise, and other noises propagated in the crust. The signal associated with crustal activity is very week and sophisticated signal classification is important. Therefore, the principle component analysis (PCA) has been performed to the data observed at each peninsula. At station far from the hypocenter, they are grater than the signal associated with earthquakes. Accordingly, we perform principal component analysis (PCA) to discriminate small signals. The square roots of eigenvalues have the average of each power. The eigenbectors have the information of each source.

The results of Izu stations are as follows. The variation of eigenvalue of the first principal component is very similar to that of Ap index. The corresponding eigenvector found to be stable. This suggests that the dominant origin may be solar-terrestrial interaction. The variation of eigenvalue of the second principal component seems to be related to that of electricity consumption power around stations. This shows the variation of origin may be artificial noise. The variation of eigenvalue of the third principal component shows the peak values before a few days before the earthquakes with M greater than 6. Also, the level of the third eigenvalue is slightly enhanced 4 month before the swarm. Corresponding the third eigenvectors found to be scattered. Furthermore, the level is recovered the original one after the swarm activity. The results of Boso Peninsula are different from those of Izu. Because, there are differences in hypocenter distance and electromagnetic environment. In this paper, we will show you the results of PCA after removing the first principal components from the original time series data.