Principal Component Analysis of ULF geomagnetic data associated with 2000 Izu Islands earthquake swarm

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The purpose of the paper is to detect ULF geomagnetic changes associated with 2000 Izu Islands Earthquakes swarm, especially over magnitude 6.0, Serita et al.,(2005), presented an effective method to extract unusual fluctuations preceding large earthquakes over M6.0 a few days before earthquakes by applying the principal component analysis (PCA) using H components of three closely distributed observation points. In this paper, we examine if we can extract the information on anomalous changes of layer earthquakes using less observations.

ULF waveform data were obtained by 3 components torsion magnetometers buried at Kamo(KAM), Mochikoshi(MCK) and Seikoshi(SKS) stations in Izu peninsula. Intersensor distance is about 5km. The swarm began on June 26, 2000, and lasted about three months. During the swarm period, there were 5 large earthquakes over M6.0 within 150km radius from our stations. (7/1:M6.4, 7/9:M6.1, 7/15:M6.3, 7/30:6.4, 8/18:6.0)

Before applying PCA, we resamples 50Hz data for all stations to 12.5Hz data, and then all data are fed to narrow-band pass filter of which center frequency is 0.01Hz. Next, we extract every 30 minute data, and make a data matrix X whose row is N=22500(30m$*$60s$*$12.5Hz), and column is K=2(h,d) or 3(h,d,z). From the matrix X, we compute a covariance matrix, and we can obtain eigenvalues and eigenvectors with the use of SVD.

First, we applied PCA to h,d,z components observed at the single station. We used data at UT15˜19 (JST0˜4 because of less artificial noises). We applied PCA to 3 observations, and results were almost same. Eigenvalues corresponding to any principal components resemble to ap index, These facts suggest that any eigenvalues affected by solar-terrestrial interaction. Then, we calculated differential data sets of SKS-KAM,MCK-KAM,MCK-SKS to remove the coherent variation at the stations. In this analysis we used h, d components for differential data sets.

The results show three important facts, (1) any principal components don't correlate with ap index. This shows that we can remove the coherent influence by using differential data sets,(2) because both 1st and 2nd principal components are stable on Sunday than weekdays, and during night time than day time, we can consider that both components contain artificial noises. (3)There are simultaneous increases of the second component at three data sets in only June and July. That is safe to say, simultaneous increases of the second component except June and July are effect from regional artificial noises, but simultaneous increases of the second component at three data sets in June and July are not originated from the solar-terrestrial interaction, in other words, it's geomagnetic fluctuation.

From above results, in the case that we apply PCA in Izu region, we need at least 3 stations. Because PCA depends on surrounding electromagnetic environment, we need to apply the similar investigation to the another observation points, and investigate the adequate number of sensors.