Principal component analysis of differential ULF geomagnetic data associated with earthquakes

Aya Serita[1]; Katsumi Hattori[2]; Chie Yoshino[3]; Masashi Hayakawa[4]; Nobuhiro Isezaki[5]

[1] Sci., Chiba Univ.; [2] MBRC, Chiba University; [3] MBRC, Chiba Univ.; [4] Univ. Electro-Comms.; [5] Dep. Earth Sci,Chiba Univ.

We investigate the anomalous ULF geomagnetic changes associated with 2000 Izu Islands Earthquake swarm with using principal component analysis (PCA) and singular spectrum analysis (SSA).On June 26, 2000, the swarm earthquakes beneath the summit suddenly became active. Then, migration of magma and a small-scale sea floor eruption started. After a while, earthquake epicenters also migrated from the island first westward and then northward. During the swarm 4 large earthquakes (7/1:M6.4, 7/9:M6.1, 7/15:M6.3, 8/18:M6.0) occurred within 100km from our stations, where we measured three component ULF geomagnetic fields and two horizontal geoelectrical potential differences. There are three stations with intersensor distance of 5 km. Observed ULF geomagnetic fields are considered 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 methods are required. In this paper, we applied principle component analysis (PCA) and singular spectral analysis (SSA) to the observed data Bx at the arrays to investigate the signal discrimination. The analyzed period is from February 2000 to December 2003. The ULF waveform data at Seikoshi(SKS), Mochikoshi(MCK), and Kamo(KAM) stations are down to 12.5Hz, and then all data are fed to narrow-band pass filters without delay, of which center frequency is0.01 Hz. Let us consider the time series data (30min) observed at each station is given by Xn=[xn(t1), xn(t2),..,xn(tN)], where n is the number of the site and N is the number of the data. The data matrix X=[x1,x2,x3]* is obtained, where * means transpose and the variance matrix R=XX*/N is computed. The eigenvalue decomposition of R=VPV* has been performed. We investigate the variations of eigenvaluses Pi and eigenvectors vi. In addition, we perform the PCA for differential data set; that is we apply PCA to SKS-KAM and MCK-KAM data as X1 and X2 to remove the coherent influence at the array.

The results of PCA with three station data show the variation of eigenvalue of the 1st principal component is similar to that of Ap index. These facts suggest that the dominant origin of the 1st principle component may be solar-terrestrial interaction. The variation of eigenvalue of the 2nd principal component seems to be related to that of electricity consumption power around stations. The variation of eigenvalue of the 3rd principal component shows the peak values before a few days before the earthquakes with M greater than 6. It is also found that about two week before the swarm activity, there is also local maximum. However, the contribution of 3rd component is small. In order to improve this and remove the most intense signal like the 1st principal component, we make the differential data sets of SKS-MCK and MCK-KAM in NS component. The behavior of the 2nd sprincipal component resembles to that of the 3rd component using three station data and the contribution is improved. SSA results indicate the signal observed at stations is generally composed of three component in 0.01 Hz band. This shows that PCA with the use of closely distributed three geomagnetic station data has a capacity to detect weak earthquake-related ULF geomagnetic changes. The results of Izu array, demonstrate the possibility of monitoring the crustal activity.