Spatiotemporal characteristics of the displacement field in Kanto-Tokai district revealed with principal component analysis

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Principal component analysis (PCA) is applied to the displacement field recorded by 147 GPS stations in the Kanto-Tokai district of Japan for the period from January 1999 to February 2003. There are many researches on modeling spatiotemporal characteristics of major geophysical events in the district based on inverting GPS displacement data (e.g. Ito and Yoshioka, 2002; Nishimura et. al., 2001; Ozawa et. al., 2002). In order to quantitatively extract and model primary geophysical processes which have caused rapid crustal deformation in this region with no assumption on the sources of the processes, we attempt to decompose the displacement field into some representative spatial modes and their corresponding temporal modes using PCA and further rotations of some principal axes obtained with PCA.

The displacement field includes the following three major events. (1) The Miyake-Kozu volcanic event in 2000 to the south of Tokyo, which includes large-scale dyke intrusion and intensive earthquake swarm between Miyake and Kozu Islands (e.g. Toda et. al., 2002). (2) The Tokai slow slip event, which looks like starting at almost the same time as the Miyake-Kozu volcanic event and is still ongoing. It occurred on the boundary between the subducting Philippine Sea plate and the overriding Eurasian (Amurian) plate in the Tokai district (Ozawa et. al., 2002). (3) The Boso slow slip event, which lasted for nearly two weeks in October 2002. It also occurred on the boundary between the subducting Pacific plate and the overriding North American plate near the Boso Peninsula (Ozawa et. al., 2003; Sagiya, 2004). Such events have been detected as displacement at GPS stations around their sources.

Although application of PCA results in decomposing the displacement field into the modes corresponding to the above-described three major events to some extent, there are some problems because some signal (e.g. a stair-like step) representing a geophysical process included in one mode also exists in other modes. For example, the spatial and temporal modes corresponding to the Miyake-Kozu volcanic event are found in other modes.

For the purpose of removing such contamination, we try a further procedure, in which the principal axes obtained with PCA are rotated so as to minimize the correlation coefficient for each pair of temporal modes during a specified period when some geophysical process is occurring. The algorithm for this operation is as follows.

(1)PCA is applied.

(2)Correlation coefficients during a specified interval are calculated for all pairs of temporal modes making some contributions to the total displacement field.

(3)The principal axes for the pair of modes with the highest correlation coefficient are rotated so that the correlation coefficient is below a definite lower limit.

(4)The 1st mode obtained after process (3) is subtracted.

These four procedures are iterated until there are no pairs of modes with correlation coefficients higher than the lower limit.

Rotations of principal axes obtained with PCA lead to improve the separation of the above-mentioned three primary events. This implies that further rotations of principal axes obtained with PCA can improve the separation level of major geophysical processes.

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