Tectonics and Earthquake Generation in the Kanto Region: Coseismic Slip at the Kanto Earthquake and Interseismic Slip Deficits

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In the south Kanto region, Japan, the Pacific and the Philippine Sea plates are descending beneath the North American plate, and the Philippine Sea plate is running on the Pacific plate at the eastern margin. Furthermore, the Philippine Sea plate is colliding with the Mainland of Japan at the north of the Izu Peninsula. In order to understand tectonic processes and earthquake generation in the south Kanto region, it is important to analyze various time-scale crustal movements due to mechanical interaction at plate interfaces in a unified framework. In the present study we focus on the coseismic and interseismic crustal deformation associated with the 1923 Kanto earthquake.

From the inversion analyses of coseismic surface displacement data, several fault slip models of the 1923 Kanto earthquake have been obtained. For example, assuming a uniform slip on a planar rectangular fault, Matsu'ura et al. (1980) have determined the location, dimension, dip-angle, slip-direction, and average slip of the fault. Wald and Somerville (1995) and Kobayashi and Koketsu (2005) have estimated the spatial slip distribution on an assumed planar fault from a joint inversion of geodetic data and seismic wave data. However, since the actual geometry of plate interfaces in the south Kanto region are very complex, the assumption of planar fault might lead to biased inversion results. To avoid such a defect, in the present analysis, we use a realistic 3-D model of plate interface geometry (CAMP standard model; Hashimoto et al., 2004). With this 3-D model we estimated the spatial distribution of coseismic fault slip on the interface between the North American and the Philippine Sea plates. We used the surface displacement data obtained from the comparison of the pre- and post-seismic geodetic measurements (Military Land Survey, 1930).

In the case of elastic half-space, the surface displacements due to a fault slip distribution on a plate interface can be expressed by the superposition of the responses to subunit slip distributions. So, to discretize the problem, we represent the fault slip distribution by the superposition of normalized bi-cubic B-splines. In this formulation, the coefficients of superposition are the model parameter to be determined. Then, we obtain a set of linear equations that relate the observed surface displacement data with the model parameters. In addition to observed data, we impose the prior constraints on fault slip distribution that the spatial variation of slip must be smooth in some degree, because the fracture strength of rocks must be finite. Combining the prior constraints with the observation equations by Bayes' rule, we can construct a Bayesian model with a hyperparameter that prescribes a relative weight between the observed data and the prior constraints. In order to select the optimum model, we use Akaike Bayesian Information Criterion (ABIC).

The inverted slip distribution of the 1923 Kanto earthquake has two main peaks around Odawara (about 6 m) and the Miura Peninsula (about 8 m) and one sub-peak off the Boso Peninsula (about 4 m). The gross feature of this coseismic slip distribution is in accord with the inversion results of Wald and Somerville (1995) and Kobayashi and Koketsu (2005). After the arrest of coseismic slip, some parts of plate interface will be locked. Interseismic crustal deformation can be ascribed to the increase of slip deficits at the locked portions on the plate interface. So, with the same plate interface model, we estimate the slip-deficit distribution from the inversion analysis of geodetic data for an interseismic period, and reveal the relation between the coseismic slip distribution and the interseismic slip-deficit distribution.