Inversion Analysis of Geodetic Data in the Kanto Region with a 3-D Plate Interface Model: Diversity of Stress Release Modes

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The Kanto region, central Japan, is in a complex tectonic setting, where the Pacific (PAC) plate is descending beneath the North American (NAM) and Philippine Sea (PHS) plates, and the PHS plate is descending beneath the NAM plate and running on the PAC plate at its eastern margin. Furthermore, the PHS plate is colliding with the mainland of Japan at the northern end of the Izu peninsula. Because of such a complex tectonic setting, crustal movements in the Kanto region are manifold from instantaneous coseismic movements to long-term tectonic deformation. The cause of these crustal movements is essentially in mechanical interaction at the interfaces between the NAM, PAC and PHS plates. In this study, we focused on the crustal movements after the 1880s, which have been precisely measured through leveling, triangulation, trilateration and GPS, and analyzed the coseismic, interseismic and episodic movements with a realistic 3-D plate interface model to reveal diversity in tectonic stress release mode at plate interfaces beneath the Kanto region.

Applying a newly developed inversion method based on a Bayesian model with direct and indirect prior information to various time-scale geodetic data, we estimated the coseismic slip distribution of the 1923 Kanto earthquake, the interseismic slip-deficit rate distribution, and the slip distribution of the 1996 and 2002 east off-Boso slow slip events. From the analysis of coseismic vertical and horizontal displacement data, we found that the coseismic slip of the 1923 Kanto earthquake on the NAM-PHS plate interface is characterized by a bimodal distribution with the 5 km-deep western and 15 km-deep eastern peaks of about 8 m, extending to 30 km in depth. The slip vectors are almost parallel to the direction of plate convergence except for their clockwise rotation near the Sagami trough. From the analysis of GPS velocity data for the interseismic calm period of 1996-2000, we found the broad and high slip-deficit rate zone extending from the Boso peninsula to the northern end of the Izu peninsula along the Suruga trough on the NAM-PHS plate interface. This result indicates strong interplate coupling in the source region of the 1923 Kanto earthquake and the Izu-Mainland collision zone. From the analysis of daily GPS coordinate data associated with the 1996 and 2002 east off-Boso slow slip events, we found that these events have unimodal forward slip distributions with the peak of 40 mm and 80 mm, respectively, in almost the same area east off the Boso peninsula on the NAM-PHS plate interface. These slow slip events accompany earthquake swarms. The series of slow slip events occurred east off the Boso peninsula at the average interval of 2-4 years would have similar characteristics to the 1996 and 2002 events.

Putting together the interseismic slip-deficit rate distribution, the coseismic slip distribution of the 1923 Kanto earthquake, and the average slow-slip rate estimated from the slip distributions of the 1996 and 2002 off-Boso events and their recurrence intervals, we revealed that the NAM-PHS plate interface can be partitioned into the following four regions with different stress release modes: A) steady slip without stress accumulation in the northeastern part of the Boso peninsula, B) intermittent stress release by slow slip events at the interval of 2-4 years in the area east off the Boso peninsula, C) sudden stress release by the periodic occurrence of large interplate earthquakes at the interval of several hundreds years in the source region of the 1923 Kanto earthquake, and D) tectonic stress release by inelastic crustal deformation around the collision boundary at the northern end of Izu peninsula.