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Interplate coupling model for the NE Japan arc inferred from 3D displacement field

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NE Japan is located at a typical subduction zone, and is seismically very active region where large interplate earthquakes have occurred repeatedly. The nation-wide network of GPS observation recently constructed enables us to investigate the crustal deformation in a detail and with high accuracy, and interplate coupling has been studied by inverse methods (e.g. Nishimura et al., 2000). Because of relatively poor accuracy in the vertical component of displacements, however, they estimated model parameters by weighting the horizontal components largely, and sometimes encountered the inconsistency between theoretical vertical displacements and observed ones. In this study, we devise a new model for interplate coupling so as to explain not only the horizontal components but the vertical ones.

We use data of continuous GPS stations operated by GSI and Tohoku University from 1997 to 2000, and analyze the data using the Precise Point Positioning (PPP) technique of GIPSY/OASIS-II. We regarded each displacement component as a linear function of time to estimate the velocity (Sato et al., 2002). Obtained result shows that vertical displacements near the Japan Sea coast are around zero, while those near the Pacific Ocean coast show subsidence. This specific pattern of vertical deformation is in good agreement with the result of leveling survey operated by GSI, which indicates that vertical components of the velocity derived by GPS can be used as the data to constrain the model.

In NE Japan, the depth of the aseismic front is estimated to be 50-60km, and the region shallower than this depth is regarded as the cohesive zone of the plate boundary (e.g. Hasegawa et al., 1994). According to Savage (1983), the deformation due to the suducting plate can be expressed by steady slip on the whole area of the plate interface and by normal slip (back-slip) on the coupling area. Usually, the effect of the steady slip is ignored because it should be small, and only the deformation due to the back-slip is evaluated. Displacement calculated from the dislocation theory at the deeper extension of the back-slip area becomes almost zero. In the actual situation, however, there should remain some displacements decreasing with depth along the plate boundary on the hanging wall side. A new model with additional normal faults whose slip rates decrease gradually with depth can roughly explain the subsidence near the Pacific Ocean coast. Though the calculated eastward displacement near the Japan Sea coast is much larger than the observed one, we can account for it if we assume the back-slip on the nascent plate boundary (Nakamura, 1983; Kobayashi, 1983) at the eastern margin of the Japan Sea. We will combine this model with a geodetic inversion method.