Stress loading on crustal source faults due to megathrust coupling: the Nankai Trough and the Kuril trench

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As observed in the seismicity change due to the 2011 Tohoku-oki earthquake, Japan, stress loading in the plate interior is controlled by the interplate process, particularly, megathrust coupling. Thus, the probability of crustal earthquake occurrence can change on decadal scales. Relatively short-term change of this kind is not yet incorporated in the long-term seismic risk assessment based on longer time-scale records from paleoseismology.

This study proposes a deterministic approach to calculate stress loading rates in the plate interior due to the interplate process and examine the consistency with the occurrence of the crustal earthquakes. We use geodetic data from the dense observation network in the Japanese islands to constrain the model. We apply this approach to the Nankai trough and the Kuril trench.

We construct 3-D finite element model including the Japanese islands. This model consists of the Eurasia, Pacific and Philippine Sea plates. The plate boundaries are determined by the previous studies based on distribution of the interplate earthquakes. The plate boundary shallower than depth of 80 km is divided into ~700 subfaults to generate Green’s functions. The model includes viscoelastic property in the asthenosphere to treat the long-term process. As the source fault geometry, we revised the geometry model by Headquaters for the Earthquake Research Promotion and added the source faults under the Sea of Japan based on the recent geophysical surveys.

Using our model, we invert geodetic data to obtain the slip-deficit rates (locking rates) on the plate boundary. Then, we compute Coulomb stress rates on the crustal source faults due to the locking. We obtained positive Coulomb stress rates on the source faults of the 2016 Mw7.0 Kumamoto and the other ~M7 earthquakes due to the Nankai trough locking. As for the Kuril trench, we also obtained positive Coulomb stress rates for the 2018 Mw6.7 Iburi (Hokkaido) earthquake. These results imply that crustal earthquakes occur to release the stress loaded by the megathrust coulpling.

Keywords: Stress loading, Nankai trough, Kuril trench, Source fault, Finite element method, Crustal deformation

