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Seismicity rate change estimated by a numerical simulation of the Tokai earthquake

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We have been trying to simulate the recurring great earthquakes as well as the long-term slow slip events in the Tokai region [Hirose et al. (2007)] using the numerical method based on the rate- and state- friction law [Dieterich (1979, 1981) and Ruina (1983)]. The performance of our latest model, however, is not still good enough to reproduce the actually observed data. To measure the goodness of simulation performance, we, so far, have mainly employed the recurrence pattern of large earthquakes and crustal deformation estimated by GPS data. The seismicity data can possibly be one of the measures of performance if the seismicity is well estimated by a simulation. However, it is very difficult to predict seismicity by a numerical simulation because seismicity may be affected by many unknown factors, and the theoretical model to combine seismicity and stress (or strain) is not well established. In this study, we adopt the Dieterich (1994) model as an attempt to estimate seismicity change related to the earthquake cycle simulation.

The seismicity pattern predicted by the Dieterich (1994) model basically resembles the pattern of Coulomb stress change. But the phase and amplitude of stress change and seismicity differ each other depending on the model parameters. A large value of the product of friction parameter A and effective normal stress, for example, makes phase difference large; the larger the background stressing rate, the smaller the amplitude of seismicity rate change; and the shorter the period of cyclic stress, the larger the phase difference.

We estimate the seismicity rate change in the shallow crust region and in the slab of the Philippine Sea plate basing on the results of our earthquake cycle simulation. The mechanism assumed for the crust earthquakes is pure strike slip type with P-axis of EW direction, and that for the slab events is pure strike slip type with P-axis of NS direction. The result predicts that the area with high seismic activity moves eastward from the long-term slow slip area to the center of assumed source region of the Tokai earthquake before the occurrence of the earthquake. As for the seismicity in relation to a long-term slow slip event, the predicted seismicity indicates a low activity in the western half of the slab area just below the slow slip area, whereas the observed seismicity shows the rate decreases in all of the slab area just below the slow slip area. The mismatch may be caused by the reasons that the other factors we do not take into account may affect the seismicity, that the Dieterich (1994) model is not good enough for this seismicity, or that the slip area estimated by the simulation or the GPS data is not so accurate to compare it with a very local seismicity.