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Contribution of Coulomb stress changes by the 2011 Tohoku-oki earthquake on seismicity rate change in the Kanto region

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Abrupt changes in seismicity rate after the 2011 off the Pacific coast of Tohoku earthquake (MJMA 9.0) on March 11, 2011 are basically well explained by the static changes in the Coulomb Failure Function (dCFF) imparted by the gigantic thrusting. This suggests that changes in seismicity rate are sensitive for small changes of Coulomb stress (dCFF $<$ 1.0 bar), and accurate evaluation of Coulomb stress changes may improve the performance of earthquake forecasting after large earthquakes.

In the source region of gigantic event and its neighboring regions, the drastic changes in both hypocentral distributions and focal mechanism solutions were clearly observed. For example, in Tohoku region, focal mechanisms of earthquakes after the megathrust event are dominantly strike-slip type in the region where the thrust-type was dominant before the mainshock.

We examined a relationship between the dCFF due to the Tohoku earthquake and the seismicity rate change in Tokyo Metropolitan area following March 11. Because various types of earthquakes with different focal mechanisms occur in the Kanto region, the receiver faults for the calculation of dCFF were assumed to be two nodal planes of small earthquakes.

The computed dCFF shows positive values, which predicts seismicity rate increase, at intermediate depth in southwestern Ibaraki and northern Chiba prefectures and in shallow crust of the Izu-Oshima and Hakone regions. In these regions, the seismicity rate has actually increased since March 2011 with respect to the Epidemic Type Aftershock Sequence (ETAS) model, suggesting that the rate change was due to the stress increase by the Tohoku earthquake. The activated seismicity in the Izu and Hakone regions rapidly decayed following the Omori-Utsu formula, while the seismicity rate in the southwestern Ibaraki and northern Chiba prefectures is still increasing.

The observed temporal changes in focal mechanism distributions are well correlated with calculated dCFF. For example, thrust-type focal mechanisms (typical dCFF values ˜ +1-2 bars) relatively increased in an earthquake cluster in southwestern Ibaraki after March 11, whereas normal-fault type earthquakes (typical dCFF values ˜ -0.5 bars) relatively decreased compared to before March 11. The dCFF values calculated for focal mechanisms of the earthquakes after March 11 show more positive values than those before March 2011, supporting a hypothesis that the 2011 Tohoku earthquake triggered the seismicity changes in the Kanto region, whereas some other possible factors (e.g., dynamic stress changes, excess of fluid dehydration, post-seismic slip, large aftershocks, or viscosity) may also contribute the rate changes.

Keywords: seismicity rate change, Kanto region, Coulomb stress change, focal mechanism