Testing the Coulomb stress triggering hypothesis for great subduction earthquakes using abundant focal mechanisms

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We quantitatively investigate the correlation between the static Coulomb stress changes transferred from the recent three megathrust earthquakes (i.e., the 2004 Sumatra-Andaman, 2010 Maule, and 2011 Tohoku-Oki earthquakes) and changes in seismicity using abundant focal mechanism solutions, and show that the post-seismicity is strongly affected by the stress perturbations due to the mainshocks.
To reduce the uncertainty in the ΔCFF values due to variability in receiver faults, we calculated the ΔCFF on the two nodal planes of the focal mechanism solutions for actual earthquakes. We used variable fault slip models inverted from tsunami waveforms for the source fault of the 2004 Sumatra-Andaman [Fujii and Satake, 2007], 2010 Maule [Fujii and Satake, 2013], and 2011 Tohoku-Oki [Satake *et al*., 2013] earthquakes. For receiver faults, we used the focal mechanism solutions of earthquakes between January 1, 1976 and September 31, 2015 among the Global Centroid Moment Tensor (GCMT) catalog [Dziwonski *et al*., 1981].
In evaluating the contribution of ΔCFF transferred from the megathrust earthquakes to seismicity changes, we used median of ΔCFF values of the 200 receiver faults in moving time window. As a result, the time series of the medians show significant positive ΔCFF values for a while after the occurrence of megathrust earthquakes and decayed in time, while those are neutral before them for the all megathrust earthquakes. The increased median ΔCFF values rapidly decayed to background level in case of the 2004 Sumatra-Andaman earthquake, whereas they are still elevated after 4 years in case of the 2011 Tohoku-Oki earthquake. Furthermore, the Coulomb index, a percentage of receiver faults with stress increases, at least, for one nodal plane [e.g., Hardebeck *et al*., 1998], showed higher values in the post-seismic period than those in the pre-seismic period for the all of three cases. Our result supports the stress triggering hypothesis that the static stress changes imparted by megathrust earthquakes played a significant role in triggering seismicity changes. The conclusion is opposite from a previous study using optimally-orientated receiver faults. Hence, the present results clearly suggest the importance of considering spatio-temporal heterogeneity of receiver faults.
We repeated our analyses for three different apparent coefficients of friction (*i.e.*, μ' = 0.0, 0.4, and 0.8) as well as different fault slip models (*i.e.*, slip models by Rhie *et al*. (2007) for the 2004 Sumatra-Andaman, Delouis *et al*. (2010) for the 2010 Maule, and Yokota *et al*. (2011) for the 2011 Tohoku-Oki) in order to verify how these differences affect our conclusion. While the higher apparent coefficients of friction were more consistent with static stress triggering hypothesis, the time series of the median of ΔCFF values showed similar patterns in most cases. The catalog dependency was also tested for the case of the 2011 Tohoku-Oki earthquake by using the F-net focal mechanisms as receiver faults.
We only considered the static stress changes transferred from co-seismic fault slips of the mainshock, while other possible factors such as the dynamic stress triggering, decreases in failure strength due to increase of pore-fluid pressure changes, postseismic slips, acceleration of plate

slip rates, static stress changes from indirectly triggered earthquakes by numerous aftershocks, and/or viscoelastic relaxation have been suggested.

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