Seismicity anomalies measured by the ETAS model and stress changes

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I am concerned with precise prediction of time- and history-dependent occurrence rate of an earthquake sequence, particularly, of aftershock sequence, in order to test the hypothesis that abrupt stress-change due to a seismic or an aseismic slip triggers seismicity-rate-change in the surrounding area. In principle, it could be always expected that seismic activity is enhanced in the zones where increment of the Coulomb failure stress (CFS) is positive, and also that the activity is reduced (seismic quiescence) in the stress-shadow zones. In fact, however, the stress changes in a region are very frequently affected by the nearby events, which trigger further aftershock clusters. Unfortunately, such stress transfers are too complex to be computed precisely due to a fractural feature.

In order to extract a regional stress-change transferred from a far-field fault, we have to remove the effect of such complex, proximate triggering mechanics occurring within aftershock clusters. As a practical solution, we rely on the statistical empirical laws of aftershock activity. That is to say, the statistical model, such as the modified Omori formula and its extension, the epidemic-type aftershock sequence (ETAS) model, is fitted to the sequence of events from the region in order to precisely mimic the normal activity there. Then, I am concerned with seismicity-rate-changes (enhancement and reduction) relative to the predicted rate by the model, and explore matching them for the pattern of Coulomb's stress-changes due to a rupture or a silent slip suspected somewhere.

I will show a number of such examples from the recent seismic activities in Japan. These lead us to a summarized observation that even a small size of the CFS increment of the order of millibars can trigger such seismicity-rate-change, which is also supported by the Dieterich's seismicity-rate-equation. Thus, I expect that the anomalous seismic activity relative to the ETAS rates is sensitive enough to detect and measure a slight stress-change.

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