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Correlation between Coulomb Stress Changes Imparted by Large Historical Earthquakes and Current Seismicity in Japan

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We investigated the correlation between current seismicity in Japan and the static changes in the Coulomb Failure Function (dCFF) due to eight large historical earthquakes (since 1923, magnitude (M) 6.5 or above) with a strike-slip fault mechanism in two ways. The one is a previously-used method that the dCFF calculated on the mainshock receiver fault mechanism is compared with the epicentral distribution of recent seismicity. The other calculates the dCFF on two nodal planes of focal mechanism solutions and investigates the probability distribution. We found that recent seismicity for the mainshock receiver fault is concentrated in the positive dCFF regions of four earthquakes (i.e. the 1927 Tango, 1943 Tottori, 1948 Fukui, and 2000 Tottori-Ken Seibu earthquakes), while no such correlations are recognized for the other four earthquakes (i.e. the 1931 Nishi-Saitama, 1963 Wakasa Bay, 1969 Gifu-Ken Chubu, and 1984 Nagano-Ken Seibu earthquakes). However, the probability distribution of the dCFF calculated on nodal planes of the focal mechanism solutions clearly indicates that recent earthquakes concentrate on positive dCFF regions. That is to say, current seismicity is possibly correlated with the positive dCFF due to large historical earthquakes. Furthermore, it is revealed that specified receiver fault mechanisms sometimes accompany large uncertainty and fail to obtain fair conclusion.

Though seismicity rate changes (aftershocks) can continue for a long period, few studies have investigated the correlation between the dCFF due to large historical earthquakes and recent seismicity. Many studies have focused on earthquake triggering and seismicity rate changes due to changes in the dCFF resulting from large earthquakes (e.g. Harris and Simpson, 1992; Stein et al., 1992; Toda et al., 1998). Based on the dCFF, Mueller et al. (2004) investigated focal regions and focal mechanisms of four earthquakes (M~7) that occurred from 1811 to 1812 in New Madrid, MO, USA. If recent seismicity represents aftershocks of these earthquakes, aftershock activity has continued for 200 years. Furthermore, Utsu et al. (1995) reported that the number of felt earthquakes in Gifu, central Japan, have obeyed the Omori formula for a century after the 1891 Nobi earthquake.

In this study, we investigated the correlation between the dCFF due to eight large historical earthquakes with a strike-slip fault mechanism and current seismicity using the unified Japan Meteorological Agency (JMA) catalog from October 1997 to May 2010. We also calculated the dCFF on two nodal planes of the F-net focal mechanism solutions by the National Research Institute for Earth Science and Disaster Prevention (NIED). The dCFF assuming specified receiver fault mechanisms may generate large errors under a complex stress field in which various types of earthquakes occur, and this uncertainty can be substantially reduced by using focal mechanisms as receiver faults (e.g. Toda, 2008).

The results strongly suggest that the background seismicity rate estimated from earthquake catalogs is possibly affected by large historical earthquakes that occurred prior to the start of the catalog. The proposed correlation between the dCFF and recent seismicity may be affected by multiple factors controlling aftershock activity or decay time.

Acknowledgments

We used the unified JMA catalog and F-net focal mechanism solutions determined by NIED. We also used the program by Okada (1992) for calculating dCFF. We thank all of these organizations and individuals. This study is supported by the Special Project for Earthquake Disaster Mitigation in the Tokyo Metropolitan Area from the Ministry of Education, Culture, Sports, Science, and Technology of Japan.

Keywords: Coulomb stress change, Seismicity, Focal mechanism