A numerical simulation of an aftershock activity with the rate-and-state friction model and secondary aftershock effect

Takaki Iwata[1]*

[1]The Institute of Statistical Mathematics

The model of seismicity rate with rate- and state-dependent constitutive law suggested by Dieterich [1994, JGR] (hereafter referred to as Dieterich model) successfully explains the decay rate of an aftershock activity following an inverse power law (Omori-Utsu law [Utsu, 1961, Geophys. Mag.]). The temporal decay of an earthquake sequence derived from the Dieterich model is asymptotically the same as the particular case of the Omori-Utsu law with the p-value equal to 1, but real aftershock sequences has a variety of the p-value. Some studies have already attempted to resolve this consistency, but it is difficult to reproduce the case of $p > 1$. For this issue, Dieterich [1994] suggests his model including secondary aftershock effect. In this framework, Marsan [2006, JGR] shows the variation on the decay of an aftershock activity with his numerical simulation, but did not discuss how the p-value changes.

This study clarifies the effect of secondary aftershocks on the variety of aftershock decay through a numerical simulation. The approach used in this study is similar to that of Marsan [2006]. Probability distributions of stress changes caused by a mainshock and each aftershock are assumed, and random stress changes which follow the assumed probability distributions are given to a huge number of subfaults. Then, on the basis of the Dieterich model, we compute the seismicity rate with the given stress changes. While Marsan [2006] shows the expected decay of a seismicity rate, in this study earthquake sequences are generated from the computed seismicity rate and the p-values are estimated by fitting the Omori-Utsu formula to each of the generated sequences. The numerical simulation reveals that the p-value depends on the assumed probability distributions of stress changes and that in particular p-value is greater than 1 if the mean of the stress changes caused by aftershocks is positive.

Keywords: aftershock activity, Omori-Utsu law, p-value, rate- and state-dependent friction law, point process analysis, statistical seismology