Spatio-temporal clustering of successive earthquakes: analyses of global CMT and F-net catalogs

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The present study systematically examined the characteristics of successive earthquakes that are not so-called aftershocks but closely occur in space and time after the occurrence of a small, moderate or large earthquake in order to understand the triggering process. We use the Global Centroid Moment Tensor catalog for the period from 1976 to 2016. Shallow earthquakes with a moment magnitude, Mw, of larger than or equal to 5 are analyzed. We also use F-net catalog provided by NIED, Japan, for the period from 2001 to 2010 and analyze the earthquakes occurring around Japan islands with Mw<5.5. We separately analyze these two data set to clarify the characteristics of successive earthquake occurrence for a wide magnitude range of Mw>=3.5. We search the earthquakes that occur within a horizontal distance (*D*) and a lapse time (Ta) from a source event, and group them as a cluster. We then count the number of the clusters, which represents the successive earthquakes, for different *D* and Ta. To examine whether or not these successive earthquakes occur randomly, we compare the results with simulations in which earthquakes are set to randomly occur in time (but at the locations same with the estimated centroid). The results show that the number of clusters for the simulation for a given Ta and a magnitude range rapidly increase with *D* and merge with those for real data at a short distance called triggering distance. The triggering distance increases with increasing the magnitude of source event and decreases as the lapse time increases. This implies that the seismic activity turns to become the normal condition in which the occurrence time intervals of large earthquakes obey a Poisson distribution. From the analysis of both global CMT and F-net catalogs, we found that the triggering distance increases with being almost proportional to about 1/5 to 1/4 of the seismic moment of source earthquake. Such moment dependency is reconstructed from the simulated data that follow ETAS model. We further derive empirical scaling relations between the seismic moment and triggering distance from the equations in ETAS model, and the observed exponent of 1/5 to 1/4 are well predicted from the estimated ETAS parameters reported at various regions around the world. These consistencies suggest that we may evaluate the triggering probability of eartqhaukes by ETAS model.

Key words: Spatio-temporal clustering, successive occurrence, triggering distance, ETAS model.

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