Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SSS30-P05 Room:Convention Hall Time:May 24 17:15-18:30

Statistical analysis of seismicity by discretized triggering model

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[Introduction]

To quantify interactions between earthquakes, earthquake triggering, we can regard an earthquake sequence as a point process and analyze seismicity statistically. A probability of an event occurrence at a given time depends on the history of event occurrences up to that time. To quantify the frequency of earthquake occurrences, we can explain it by stationary activities (background term) and triggering effects (triggering term) and the form of the triggering term is not unique.

[Method]

The Epidemic-Type Aftershock Sequence (ETAS) model is a well-known point process model and widely used [Ogata, 1988]. The ETAS model explain the triggering term using a specific form of function following the Omori-Utsu law which is an empirical law on aftershock sequences, so we can consider that the ETAS model is developed for modeling of aftershock sequences. Though the ETAS model explains the triggering term with a continuous function depending on time and magnitude, the discretized triggering model developed by this study explains it discretely which enables us to explain a complex dependencies of the triggering term on time and magnitude and gives us a simple way to model more general earthquake sequences other than aftershock sequences. Moreover, we used a maximum-likelihood estimation (MLE) to estimate model parameters and compared the results of the ETAS models and several discretized triggering models which are different in discretization using AICs.

[Data]

We apply the ETAS model and several discretized triggering models to two types of earthquake catalogs. One is a relocated catalog in southern California by Shearer et al. [2005] as an example of ordinary seismicity (an aftershock sequence), and the other is three low-frequency earthquake (LFE) catalogs in Japan detected by Aso et al. [2012 (this meeting)] as an example of extraordinary seismicity.

[Results and Discussion]

When we apply models to the SHLK catalog and compare results, we get a better AIC value than the ETAS model with a model in which we assume a separation of time and magnitude dependences of the triggering term. The result by this model shows a magnitude dependence of the corner of the triggering term which is corresponding to the c-value of the Omori-Utsu law, and we can say that the discretized triggering models are useful tools to enable us to quantify the c-value and its physical meanings.

For three LFE catalogs, estimated p-values of the Omori-Utsu law by the ETAS model are 1.2-2.2 which are larger than ordinary seismicity. Moreover, results by the discretized triggering models show a mountain of the triggering term in a time range shorter than 100-1000 seconds, and we can quantify a characteristic time scale and successive properties of LFEs. The difference between forms of the triggering terms of ordinary seismicity and LFE activities can imply the difference of physical processes.

Keywords: Discretized Triggering Model, ETAS model, forecast of seismicity, low-frequency earthquake