点過程モデルによる熊本地震の余震活動の解析

Monitoring of the Seismicity before and after the 2016 Kumamoto Earthquake with Point Process Models

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It is expected that the probability gain prediction of a large aftershock or of an event larger than a main shock near the aftershock region can be elevated by analyzing the presence or the absence of the quiescence in seismicity sequence (Ogata 2001). We applied the ETAS model to the aftershock sequence of M6.5 event (foreshocks) which precedes the M7.3 Kumamoto main shock, to reveal that there was relative quiescence. It is also seen that the sequence migrated deeper and closer to the M7.3 hypocenter.

We then applied the ETAS model, non-stationary ETAS model (Kumazawa and Ogata 2013) and b-value estimate to the entire sequence of the M7.3 aftershocks for the period of one year together with the foreshock sequence. It is shown that the aftershocks have more rapidly decaying than what is normally expected, with regional variations. The parameter $K_0(t)$ and the background seismicity rate $\mu(t)$ of the nonstationary ETAS model stayed high for short period after the M7.3 main shock, then they gradually decayed. The estimated b-value showed stepwise changes at major events (M6.5, M6.4, M7.3).

We also analysed the seismicity in and around the aftershock region since 2010 before the occurrence of M6.5 foreshocks. Quiescence is detected only near the region of Futagawa fault (where M7.3 occurred), with some seismic swarm activities characteristic to fault weakening in small area. In the rest of the regions, the seismicity was stable.

ETAS model

$$\lambda_\theta(t|H_t) = \mu + \sum_{\{i:S\le t_i<t\}} K_0 e^{\alpha(M_i-M_c)}/(t-t_i+c)^p$$

Non-stationary ETAS model

$$\lambda_\theta(t|H_t) = \mu(t) + \sum_{\{i:S\le t_i<t\}} K_0(t) e^{\alpha(M_i-M_c)}/(t-t_i+c)^p$$