Variability in ETAS parameters depending on estimation algorithms

*Yuta Mitsui[1], Jun Kataoka[2]

1.Department of Geosciences, Shizuoka University, 2.Faculty of Science, Shizuoka University

The ETAS model (Ogata, 1988) allows us to estimate background seismicity \mu without aftershock effects from an earthquake sequence. As an interesting example, Llenos et al. (2009) showed that slow tectonic deformation truly increased the background seismicity \mu but did not correlate with the other ETAS parameters about aftershock productivity. Several studies such as Ide et al. (2013) expanded in application Kataoka and Mitsui (2015, JpGU) tested this concept for some regions around Japan, and obtained implications for magma intrusion beneath Mt. Fuji after the 2011 Tohoku Earthquake, slow slip events at subduction zones, and attenuation of slow slips after large earthquakes.

For the above parameter estimation, we used SASeis2006 by Ogata (2006). SASeis2006 adopted the DFP method, a kind of quasi-Newton method. However, Kasahara and Yagi (2015, SSJ) constructed a new estimation algorithm based on Newton method and showed a margin for improvement in SASeis2006 especially in terms of initial value dependence.

On the basis of this situation, this study introduce four estimation methods and examine the variability in the estimation results. Namely, we compare the estimation results from the same initial values: (1) downhill simplex method (2) conjugate gradient method (3) quasi-Newton method (BFGS method) with parameter constraints (all parameters are limited in a range of 0.01~10) (4) Newton method. We use earthquakes around Japan (M>2) in the JMA hypocenter catalogue. The time range is every one year in 1998~2014. The spatial range is around the source region of the 1993 southwest-off Hokkaido earthquake and the 2003 Tokachi-oki earthquake.

We find that the solutions do not converge in some cases, especially of SASeis2006 or the Newton method. Moreover, we obtain the following results: [1] Variability in the estimated value of \mu is relatively smaller. The ratio of the maximum value to the minimum value is at most 1.8 times. [2] Variability in the estimated values other than \mu are far larger. The ratio of the maximum value to the minimum value often reaches 10 times, or greater. [3] When comparing among the log-likelihood functions for the estimated parameters, the Newton method accounts for approximately 65% of the maximum likelihood. The conjugate gradient method and the downhill simplex method follows.

Keywords: Seismicity, ETAS model, Parameter estimation

