3D spatial models for seismicity beneath Kanto region

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Development of point-process models for the seismicity in 3D space (longitude, latitude and depth) beneath Kanto area down to 100km depth is more required than for seismicity in the rest of the world. This is because the three tectonic plates meet beneath Kanto plain; and interactions among the interplate and intraplate earthquakes are too complex to make detailed analysis and forecasts in 2D space that ignores the depths.

We consider the 3D hierarchical space-time ETAS (epidemic-type aftershock sequence) model. Among the characterizing parameters, the background seismicity rate μ and aftershock productivity K are highly sensitive to the locations, so that these parameters should be location-dependent. Furthermore, the impact of the 2011 Tohoku-Oki earthquake of M9.0 to the seismicity beneath the Kanto region has been so large that we need a space-time function for representing the amount of the induced seismicity beneath Kanto by this giant earthquake. Specifically, we adopt the Omori-Utsu function as the effect of induced earthquakes, started after the occurrence time of the Tohoku-Oki earthquake, where we assume that the aftershock productivity parameter K_{M9} of the Omori-Utsu function is also location-dependent. For forecasting future large earthquakes, we further need to estimate the location-dependent *b*-value of the Gutenberg-Richter law.

The spatial variations of the characteristic parameters $\mu(x,y,z)$, $K(x,y,z)$, $K_{M9}(x,y,z)$ and $b(x,y,z)$ of our model are inverted to visualize the regional changes of the seismic activity. For this objective, we make 3D Delaunay tessellation of the Kanto volume, where every earthquake belongs to vertices of a tetrahedron. Each of the above mentioned parameter function is a 3-dimensional piecewise linear function defined by the values at the four Delaunay tetrahedral vertices.

The estimates of the focal parameter functions are obtained by an optimal trade-off between the goodness of fit to the earthquake data and the smoothness constraints (or roughness penalties) of the variations of parameter values. Strengths of the constraints of or the penalties to respective parameter functions can be simultaneously adjusted from the data by means of an empirical Bayesian method using the Akaike’s Bayesian information criterion (ABIC).

Keywords: ABIC, aftershock productivity, background seismicity rate, b-values, Delaunay function, Omori-Utsu function for induced seismicity

