Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS35-P04 Room:Convention Hall Time:May 23 18:15-19:30

Constraining the extent of an earthquake source fault with seismic intensity distribution

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The 2011 Tohoku-Oki earthquake has provided us with important lessons. One of them is that we should pay more attention to knowledge in the fields of paleoseismology in considering giant earthquakes. Concerning prediction of strong ground motion, finite fault models are usually considered. However, such finite fault models have been estimated mainly for recent earthquakes for which seismic, geodetic, and tsunami data are available. Studies to estimate finite fault models for historical earthquakes began recently [e.g. Kanda et al. (2003), Tokumitsu et al. (2006), and Sugawara and Uetake (2009)]. In this study, we try to image finite fault models from spatial distribution of seismic intensity using a backprojection-like method. Our final target is historical earthquakes. But in this study, we try to validate a method using two modern earthquakes: The 1944 Tonankai earthquake (M7.9) and the 1946 Nankai earthquake (M8.0).

An attenuation relation of seismic intensity on the Japan Meteorological Agency scale used in this study is the same as one used in 'the national seismic hazard maps for Japan'. Given the magnitude, depth, and fault type of an earthquake, the nearest distance to a finite source fault is estimated at a site from intensity there using the attenuation relation. The crossing points between the plate boundary and spheres with the nearest distances to the fault from the sites are candidate points of the fault edges. The intensity distributions for the two earthquakes estimated by Kanda et al. (2003) are used. Concerning the fault geometry, we follow the source models estimated by Ando (1975) mainly using geodetic data. Node points are set on the fault planes with a spacing of 1km x 1km. In using the attenuation relation, we set depths of the two earthquakes to be 20km. So far, Vs30 is assumed to be 600m/s without making correction of site conditions. For the two earthquakes, the number of data for intensity 6 is too small to image the extent of source faults. Data of intensity 4 cannot constrain the fault extent. Using data of intensity 5, the extent of source faults can be estimated. However, the shallow end and horizontal ends of the faults are not imaged, because data are limited on land. Only the deep end of the faults can be estimated, which are roughly consistent with the fault models of Ando (1975). However, estimation error in this study is probably at least 10km. This may suggest that we need to incorporate the site correction and more realistic shape of the plate boundary in the analysis.

In conclusion, we have tried to image the extent of finite source faults for the 1944 Tonankai and the 1946 Nankai earthquakes from the spatial distributions of seismic intensity data using a backprojection-like method. Data of intensity 5 can constrain the deep end of the source faults. But the shallow end and horizontal ends are not well constrained because data are limited on land. The deep end of a source fault is important for seismic hazard estimates. We plan to apply the method to historical earthquakes.

Keywords: Seismic intensity distribution, finite fault, historical earthquakes