Real-time Estimation of Fault Rupture Extent for Large Earthquakes

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An earthquake early warning (EEW) system can tell you about the occurrence of a large earthquake before large ground motions arrive at a site. Using this system effectively, we can mitigate the damage of structures and lifelines during large earthquakes. In Japan, EEW has been issued to the public via TV, radio, and commercial instruments since October 2007.

The current system operated by Japan Meteorological Agency (JMA) has two important issues which require improvement. Firstly, the predicted ground motions may be underestimated for large earthquakes (M>8). Secondly, the warning may not be issued with enough time before the arrival of large shaking in the near-source region. Here, we would like to discuss the first issue.

Figure 1 shows the ground motion distribution for the expected Nankai earthquake estimated by the current JMA method. The current system assumes a point source model for all earthquakes, so the ground motion distribution essentially scales with station distance. However, for large earthquakes, the fault rupture length can be of the order of tens to hundreds of kilometers, and the prediction of ground motion at a site requires the approximated knowledge of the rupture geometry. The estimated ground motion in the South-Western area of Japan for the Nankai earthquake is 3 to 4 in JMA intensity (Figure 1a), but the actual ground motion could be 5+ to 6+ in JMA intensity, if we consider a finite source (Figure 1b). Therefore, it is essential to estimate the rupture dimension in real-time in order to provide more accurate ground motion estimation. The current system does not provide any

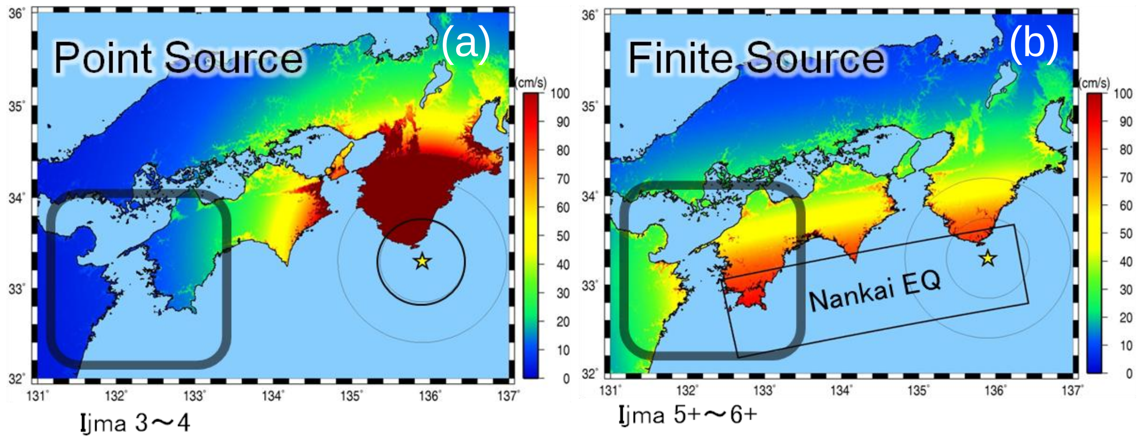

Figure 1: Ground motion distribution for the Nankai earthquake.

information on the rupture dimension, so a methodology to estimate the fault rupture in real time is required.

Yamada et al. (2007) proposed a methodology to estimate the rupture dimension from strong motion records which are assumed to be available in real time. We developed an empirical function to classify seismic records into near-source (NS) or far-source (FS) records based on past strong motion records. Here, we defined the near-source region as an area within 10 km of the surface projection of the rupture. If we have ground motion records at a station, the probability that the station is located in the near-source region is;

$$P = 1/(1+\exp(-f))$$

$$f = 6.046\log_{10}(Za) + 7.885\log_{10}(Hv) - 27.1$$

where Za and Hv denote the peak values of the vertical acceleration and horizontal velocity, respectively.

Each observation provides the probability that the station is located in near-source region, so the resolution of the proposed method depends on the station density. We apply a cosine-shaped smoothing function to the probability distribution of near-source stations, and convert the point fault location to 2-dimensional fault information.

The estimated rupture geometry for the 2007 Niigata-ken Chuetsu-oki earthquake 10 seconds after the origin time is shown in Figure 2. We will illustrate our method with strong motion data of recent large earthquakes. The on-going rupture extent can be estimated for all datasets as the rupture propagates. For earthquakes with magnitude about 7.0, the determination of the fault parameters converges to the final geometry within 10 seconds.

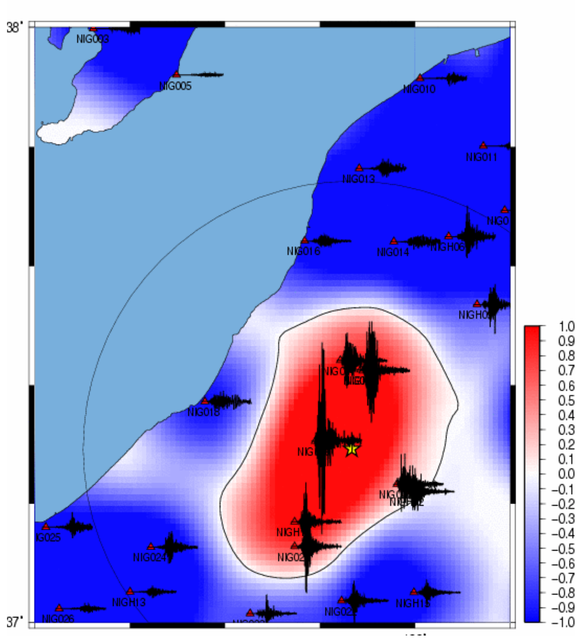

Figure 2: Eestimated rupture geometry for the 2007 Niigata-ken Chuetsu-oki earthquake. The red area is the near-source region.