Japan Geoscience Union Meeting 2010
(May 23-28 2010 at Makuhari, Chiba, Japan)
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HDS023-04 Room: 304 Time: May 27 09:48-10:02

Estimating on-going fault rupture extent for large earthquakes from strong motion records

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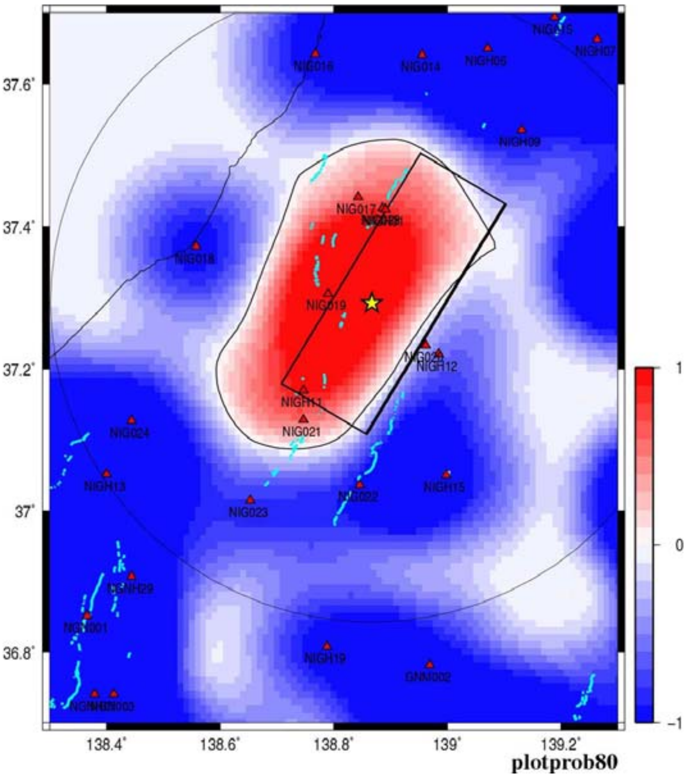
Current earthquake early warning systems assume point source models for the rupture. However, for large earthquakes, the fault rupture length can be of the order of tens to hundreds of kilometers, and the prediction of ground motion at a site requires the approximated knowledge of the rupture geometry. Early warning information based on a point source model may underestimate the ground motion at a site, if a station is close to the fault but distant from the epicenter.



This research estimates an on-going rupture extent from near-source ground motions (Yamada et al., 2007; BSSA). Assuming the station locations are dense enough in the near-source region, each station can be classified into near-source or far-source based on its observed record, and then we can estimate the on-going fault rupture extent. Since it is difficult to predict rupture direction and rupture extent, we try to trace the on-going rupture from strong motion records and update the result every second. To approach this problem, we take the following steps:

1. Peak ground motions recorded in past earthquakes are analyzed to determine whether a station recording ground motion is close to the earthquake fault area.
2. A discriminant function of the ground motion is constructed to provide the best performance in terms of near-source/far-source classification.
3. Using the interpolated probability that a station is near source, we develop a method using a weighting function to obtain the 2-dimensional fault surface.
4. Waveform data are included to improve the methodology for better estimating the fault geometry

We applied this methodology to near-source records of recent large earthquakes around Japan and estimated fault surface in off-line simulations. For this simulation, the amplitudes of the records available at each second are used and the estimated rupture extent is updated every second. The fault rupture surface can be estimated reasonably well for most of the earthquakes. With advance knowledge of local surface soil amplification, the waveform data can be used to obtain a better estimate of the fault model. The Figure shows the estimated fault rupture area for the 2004 Niigata-ken Chuetsu earthquake. The square box shows the fault model from the waveform inversion. Although our estimate did not use any information from the aftershock distribution, it agrees well with the fault model for the waveform inversion.