A Robust Method for Imaging Asperities of Large Earthquakes

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There is no doubt that the major target of the EEW system in Japan is M>8 subduction-zone events such as Nankai, Tonankai, and Tokai earthquakes. However it is pointed out accurate estimation of expected seismic intensity for those earthquakes is not very feasible, because finiteness of the rupture plane should be included as essential information for the accurate estimation. To help improve estimation accuracy in those cases, we have developed a robust method to image asperity regions in real-time using an attenuation relation of seismic intensity magnitude, *MI* (Yamamoto et al., 2007) and the seismic network data.

Here we assume that seismic intensity is generally determined from the maximum amplitude of incoherent high-frequency waves and those waves generated from different regions are accumulated inefficiently at an observation site, i.e. waves from the most influential source region for the site determine seismic intensity. Under this assumption, a basic flow of this method is described as follows;

1) Separate observation stations into neighboring groups (sub-network, $j=1, L$) and set grid points (candidates of asperity regions, $k=1, N$) around the hypocenter.
2) Search the best grid point and the best *MI* (MI_j^{opt}) to minimize averaged estimation residual R of intensity from observed intensity data of the sub-network j by using the attenuation relation of *MI*. *MI* can be calculated from P-wave or S-wave.
3) Plot R distribution (R_j^k) for the sub-network j by constraining *MI* to be MI_j^{opt}. -> produce L plots of raw R images
4) Smooth the raw R image by using other raw images of the neighboring sub-network analyses. -> produce L plots of smoothed R images
5) Pick the lowest R value at every grid point from all the smoothed R images and re-plot R distribution. -> produce single plot of the final R image

It is obvious the regions with lower estimation residuals correspond to asperities often including directivity effects. By analyzing the real records (Hi-net data, 119 earthquakes, 10145 records), we found the ranges of estimation residuals are 0.436-0.584 (92-10 stations) with station correction, 0.622-0.855 (92-10 stations) without station correction, and estimation residuals increase as numbers of stations decrease. When we assume 15 stations are used for each sub-network analysis, estimation residuals of less than 0.7 are possible values for real asperities. After asperity regions and their *MIs* are determined, seismic intensities at sites can be estimated without difficulty.

We applied this method to the future Nankai-Tonankai earthquake, for which the Central Disaster Prevention Council (CDPC) of Japan published a possible fault model with its calculated intensity distribution. We carry out a blind test of our method by using the intensity data as input to investigate the method's ability to reconstruct the fault model. The result is shown in Fig.1 in which the regions with estimation residuals less than 0.7 are imaged with a grayscale. From the figure we found that the regions with lower estimation residuals roughly correspond to the asperity regions by CDPC. Considering its simplicity and robustness, this method could be very effective in an EEW to estimate realistic seismic intensity distribution of future large earthquakes.

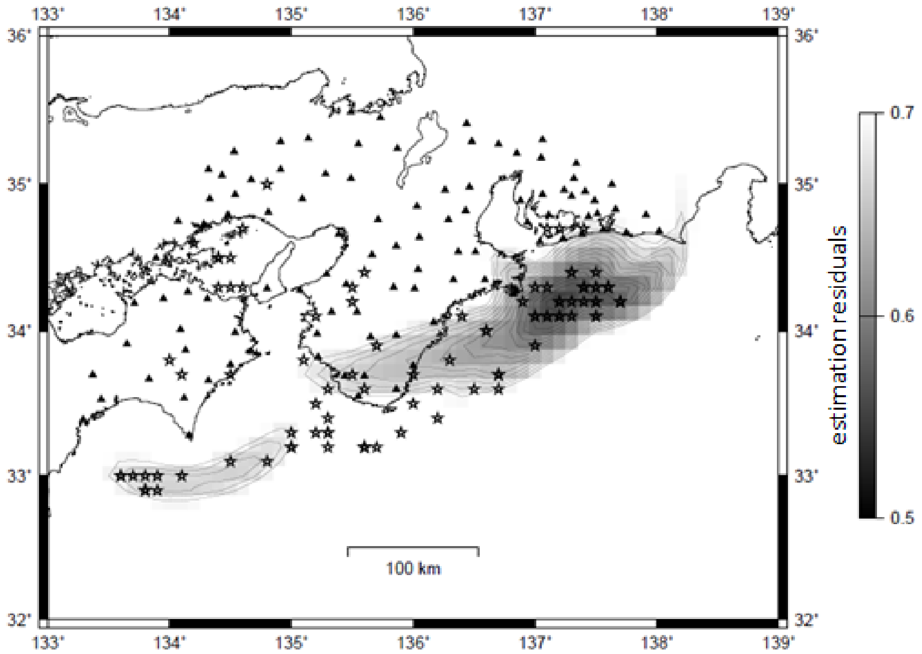

Fig.1 Distribution of estimation residuals for the Nankai-Tonankai earthquake.

98 stations and 98 sub-networks are used for this analysis. 15 neighboring stations are grouped as "sub-netwok"

▲:observation point, ☆:optimized source point for each sub-network data