Reduction of Uncertainty for Source Term using Stress Drop Deviation

Hiroshi Kawase [(1)] and Kenichi Nakano[(2)]

(1) DPRI Kyoto University, kawase@zeisei.dpri.Kyoto-u.ac.jp; (2)HAZAMA-ANDO CORP.

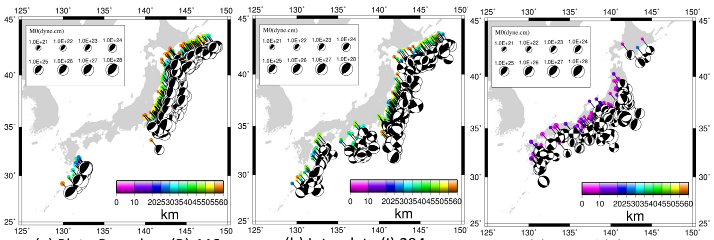
1. BACKGROUND AND PURPOSE OF THE STUDY

Under usual PSHA representation of strong motions, we use GMPEs for PGA, PGV, and SA (Response Spectra of Acceleration) derived from the regression analyses for observed strong ground motions. To represent source terms in GMPEs we usually use magnitude with some coefficients depending on source mechanisms. However, to reduce its uncertainty it would be better to investigate physical parameters that would have some impact to the spectral amplitudes.

In this study we first investigated the characteristics of strong ground motions separated from acceleration Fourier spectra and acceleration response spectra of 5% damping calculated from weak and moderate ground motions observed by K-NET, KiK-net, and the JMA Shindokei Network in Japan using the generalized spectral inversion method. Then based on the separated source spectra of individual earthquakes we obtain a linear formula to represent source terms as a function of magnitude and estimated stress drop.

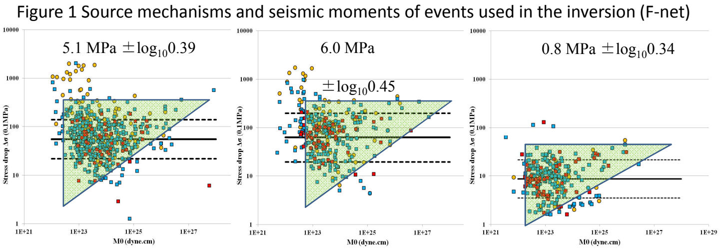
2. GENERALIZED INVERSION WITH A FIXED REFERENCE SITE

As a reference for the separation method we use the outcrop motions at a rock site, YMGH01, where we extracted the site response due to shallow weathered layers. We include events with JMA magnitude≧4.5 observed from 1996 to 2011. From corner frequencies of Fourier source spectra and CMT seismic moment values, we calculate Brune's stress drops and find a clear magnitude dependence, in which smaller events tend to spread over a wider range while maintaining the same maximum value. We confirm that this is exactly the case for several mainshock-aftershock sequences. The average stress parameters for crustal earthquakes, ~0.8MPa, are much smaller than those of subduction zone, either interplate or intraplate, ~5MPa, which can be explained by their depth dependence.



(a) Plate-Boundary (B) 446 (b) Intraplate (I) 294 (c) Crustal (C) 227

Figure 1 Source mechanisms and seismic moments of events used in the inversion (F-net)



(a) Plate-Boundary (B) 446 (b) Intraplate (I) 294 (c) Crustal (C) 227

Figure 2 Brune's stress drop with respect to the seismic moment for three types

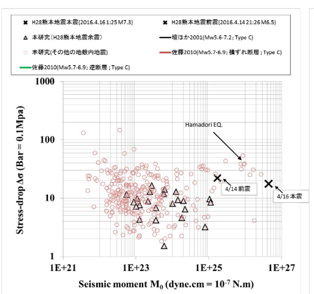


Figure 3 2016 Kumamoto Earthquake

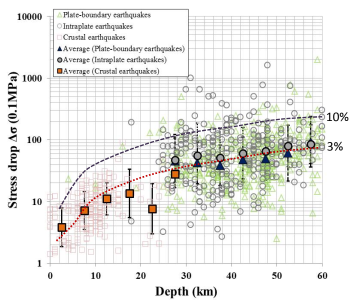


Figure 4 Depth dependence of stress drop

3. DIFFERENCE OF RESPONSE SEPCTRA FROM FOURIER SPECTRA

Next we compare the strong motion characteristics based on the 5% damping acceleration response spectra RS and find that the separated characteristics of strong ground motions are different, especially in the lower frequency range less than 1Hz. These differences comes from the difference between Fourier spectra and response spectra in the observed data. However, gross features of both spectra are quite similar.

4. REGRESSION OF SOURCE TERM WITH MOMENT MAGNITUDE

After we obtained SA source terms of for each event, we do a linear regression with respect to the moment magnitude, as GMPE analysis. Irrespective of the frequency we can see remarkably good correlation with linear lines, for all three types together.

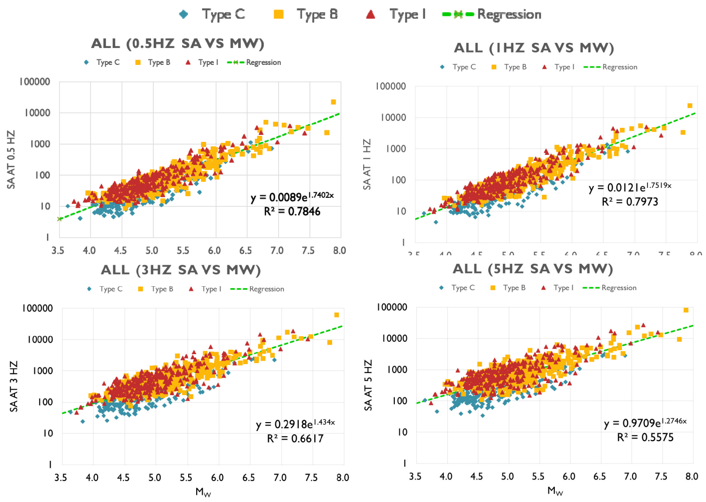


Figure 5 Linear regression of SA with moment magnitude for four different frequencies

5. STRESS DROP CORRECTION AND REDUCTION OF VARIATION

After the extraction of linear trend with magnitude we can obtain residuals for individual events and then correlate those residuals log-linearly with stress drops. Correlation with stress drops R^2 is quite high, more than 0.7 for most of the frequency. Coefficient is quite stable so that we may not need to make it frequency dependent.

After correction of stress drop we may see significant variation reduction for source term representation, about 60% for almost all the frequency ranges.

However, residuals show magnitude dependence because of high stress drop for large events. We need different correction factors for better modeling.

Prediction of ground motion for an event not yet occurred requires prediction of stress drop; its magnitude and depth dependence should be considered.

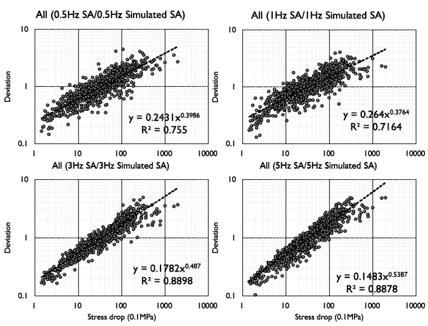


Figure 6 Linear regression for residuals with stress drop

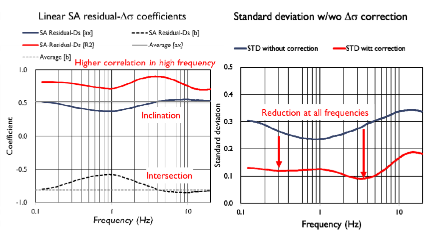


Figure 7 Regression coeff., correlation, and variance

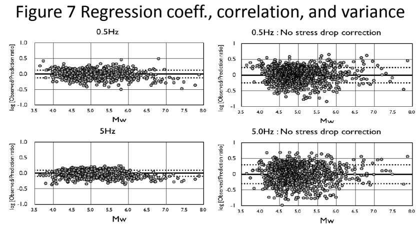


Figure 8 Residuals w/wo stress drop correction