An idea to extract effective fault size from a slip distribution estimated by inversion analysis

*Kazuhito Hikima[1], Akihiro Shimmura[1]

1. Tokyo Electric Power Company Holdings, Inc.

- Objective -

Fault length and width (also fault area of those multiplication) are the basic and important parameters for source information. In recent decades, these parameters are estimated by inversion analyses using observed data in most cases. When the source process inversions are performed using, for example, waveform or geodetic data, larger fault area than true area is set first. Therefore, we have to perform additional operations to extract real fault area from the derived slip distribution.
As such a method, Somerville *et al*. (1999) proposed a method in that marginal rows or columns having relatively small slips are trimmed from inverted slip distributions and rectangular main area is extracted. Mai and Beroza (2000) and Thingbaijam and Mai (2016) also proposed other methods which estimate effective source dimensions based on autocorrelation width of the spatially variable slip. Many authors have discussed source scaling relations using the parameters estimated in such a way. However, the roughness of estimated slip distributions (the amplitude of spatially variation) tends to differ depending on the analysis methods and analysts. Furthermore, it is some problem that the distinct and physically clear criteria are not determined to extract main slip area from those results.
Therefore, we considered a procedure to extract a rectangular effective fault area based on wavenumber spectra of slip distribution, considering more physical validity.

- Method -

Analyses considering wavenumber spectra of slip distributions have been already discussed by, for example, Somerville *et al*. (1999). We also calculate two-dimensional wavenumber spectrum of subject fault model as same as their procedure. The steps now adopted are follows.
First, a slip distribution at 1 km intervals for length (X-direction) and for width (Y-direction) is made from an original spatially variable slip. Then, zero values are added outside of the fault area to make 256 x 256 size data set. Amplitude wavenumber spectra of these data are calculated using two-dimensional FFT. For these spectra, we consider that the wavenumber spectrum at k_y=0 (k_y: wavenumber for Y-direction) is in length direction and the spectrum at k_x=0 (k_x: wavenumber for X-direction) is in width direction, respectively.
On the side, Fourier transform of a rectangular function having width as L is $f(\nu)=L\sin(\pi L\nu)/(\pi L\nu)$ [$\nu=1/\lambda$; λ: wavelength]. As well known, this sinc function crosses with zero line at n=n/L [n=1, 2, …], and these correspond to trough of the spectrum in the case of amplitude spectrum.
To determine fault length, we basically fit this sinc function with the spectrum at k_y=0 in length direction previously obtained. However, the calculated spectrum becomes irregular curve actually due to its slip distribution. Therefore, only lower part than first trough (it corresponds to n=1) of sinc function is used for fitting operation. And we placed emphasis on lower wavenumber part especially. Additionally, we apply the same means to the spectrum at k_x=0 in width direction to determine fault width.

- Result -

We performed preliminary analyses using the fault models in the SRCMOD (Mai and Thingbaijam, 2014). Although goodness of fitting is evaluated visually, in the current procedures, the optimal dimensions can be determined with the error lower than a few km. Thingbaijam *et al*. (2017) estimated the fault length

and width by using their ways and have listed in the paper. The lengths determined by our methods were almost comparable with their values. However, we also recognized that some models show somewhat smaller length than published one. To pursue causes of these results, we performed a model calculation using synthetic fault model having asperity. As a result, the tendency that estimated area become smaller than whole fault area was found, depending on the conditions. It is thought because proposed method estimates an equivalent rectangular fault area with considering the slip distribution.
We would like to report on the features of the method after further considerations, also including comparison with other methods.

Keywords: Fault size, Rupture area, Trimming, Scaling of fault parameters, Slip distribution

