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ASSESSMENT OF FINITE FAULT PLANE GEOMETRY IN MEGATHRUST EARTHQUAKE

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The treatment of uncertainties is a key aspect of any probabilistic seismic hazard analysis (PSHA). Ground motion prediction equations (GMPEs) are used to estimate the ground motion at a given location as a function of earthquake magnitude, distance from the earthquake source, and other source, path, and site characteristic (Kaklamanos et al., 2010). The main predictive variables employed in GMPEs are earthquake magnitude and source to site distance and other parameters are not as influential as two mentioned predictive variables (Atkinson and Morrison, 2009). Source-to-site distance is fundamental variable in seismic hazard and risk analysis evaluation and have prominent effects on developed GMPEs results (McGuire, 2004).

Relations between the dimensions of the ruptured zone of earthquake and the amount of energy released, are of great practical use in seismology engineering. This manner introduces seismic moment, M0, or equivalently magnitude, MW (Hanks and Kanamori, 1979) as magnitude scale in functional forms of GMPEs. M_w can be expressed from the relations developed by different researchers in last decades such as Wells and Coppersmith (1994), Mai and Berroza (2000) and Strasser et al. (2010). Generally, the area of the fault that ruptures increases with magnitude (Strasser et al., 2010).

As a result, Mw is not an empirical estimation of earthquake size. However, empirical magnitude scaling relations which relate earthquake magnitude to the rupture length (L), the rupture width (W), and the rupture area (A) are used to develop GMPEs. In fact, magnitude scaling relations provide the opportunity to estimate extended-source distance metrics (e.g., Rjb or Rrup) as an explanatory variable in GMPE development. According to the result of Goda and Atkinson (2014), predicted ground motion amplitudes for very large events may vary significantly depending on the manner of defining the fault plane. Goda and Atkinson (2014) suggest that the effect of alternative definitions of the rupture plane is most pronounced for mega thrust events. This is an important source of uncertainty and variability and should be considered in seismic hazard assessment. As a result, it is required to perform comprehensive study regarding how to define the appropriate fault plane to derive GMPEs. The foregoing discussion implies that source model selection is of particular significance in seismic hazard assessment. In the present study, the issue under scrutiny is to provide a persuasive trend in fault plane model selection. Accordingly as a mega thrust subduction earthquake 2011 M9.0 Tohoku with different finite fault source models considered and this source of uncertainty addressed. Existence of different fault plane model for this event propounds the view that, Do all of these models lead to the same result? To portray mentioned issue in Tohoku event as empirical benchmark we taken two GMPE, Zhao et al. (2006) and Kanno et al. into account. In light of estimated values by mentioned GMPEs for all models, we attempt to assess models efficiency. For this purpose two statistical tests, likelihood and log-likelihood, employed. Further details of these two methods will be presented in the following sections. The result of these methods presented in Table 1.

Table 1. The result of models efficiency assessment.

Model	Kanno et al.		Zhao et al.	
	LLH	**LH**	**LLH**	**LH**
Kamae and Kawabe	1.83	C	1.76	C
Gsi	1.93	C	1.89	B
Asano and Iwata	2.01	C	2.03	C
Irrikura and Kurahashi	2.02	C	1.96	C
Koketsu	2.44	D	2.50	D
Shao	2.57	D	2.65	D
Yagi	2.93	D	3.13	D
Suzuki	3.03	D	3.29	D

Results of Table 1 reveal different efficiency of these eight model. Therefore it is very important to propose a logical manner in source model selection and choose the most applicable source model in this case.

Initially 2011 M9.0 Tohoku strong motion dataset and available finite fault source models for this event compiled. Then we divide dataset into two categories and using largest portion of data event specific GMPEs for each of eight finite fault source models developed. Firstly, for each of eight fault plane model event specific GMPE with optimized coefficient by genetic algorithm developed. Then model regarding with less uncertainties that lead to better estimation of observed data in Tohoku earthquake determined. Implementing the Nash – Sutcliffe, likelihood (LH) and log-likelihood methods, as modern LH-based ranking assessment techniques, available finite fault source models for 2011 M9.0 Tohoku have been ranked. Available finite fault source model for Tohoku are classified into two categorize: SMGA-based and non-SMGA-based. Results reveal that in shorter distance from rupture plane (pronounced at short period) SMGA-based models, consisting of multiple asperities, may be useful for defining source models that produce less uncertainties. As distance increase these models efficiency decrease but in non-SMGA-models trend is not clear. Increasing the closest distance from rupture plane non-SMGA models show better efficiency in predicting observed data. Another important issue is that there is no distinct difference between models in same class. Ultimately for selection of attenuation relation in Japan based on consistency of estimated data with observed data in 2011 m9.0 we offer Irikura and Kurahashi model in shorter distance and Yagi model in larger distance.

REFERENCES

Kaklamanos, J., et al. (2011). Estimating unknown input parameters when implementing the NGA ground-motion prediction equations in engineering practice. Earthquake Spectra, *27*(4), 1219-1235.

Atkinson, G.M. and Morrison, M. (2009). Observations on regional variability in ground-motion amplitudes for small-to-moderate earthquakes in North America. *Bulletin of the Seismological Society of America*, *99*(4), 2393-2409.

McGuire, R.K. (2004). *Seismic Hazard and Risk Analysis*. Earthquake Engineering Research Institute.

Strasser, F.O., Arango, M., and Bommer, J.J. (2010). Scaling of the source dimensions of interface and intraslab subduction-zone earthquakes with moment magnitude. *Seismological Research Letters*, *81*, 941-950.

Goda, K. and Atkinson, G.M. (2014). Variation of source-to-site distance for megathrust subduction earthquakes: effects on ground motion prediction equations. *Earthquake Spectra*, *30*(2), 845-866.