Nat. Hazards Earth Syst. Sci. Discuss.,
doi:10.5194/nhess-2017-33-AC1, 2017

Natural Hazards and Earth System Sciences Discussions
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Interactive comment on "A Procedure to Select Earthquake Time Histories for Deterministic Seismic Hazard Analysis: Case Studies of Major Cities in Taiwan" *by* Duruo Huang and Wenqi Du

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Received and published: 17 April 2017

The authors thank for the feedback. We appreciate the comments and valuable discussions on this manuscript. The comments and replies are provided as follows.

1. The common procedures for DSHA and GM-selection were applied in the case studies for six Taiwan sites (cities). The review comments are listed as followings: 1. Based on the DSHA results, all the controlling seismic sources of the six study sites are the area sources. However, the criteria for assigning the locations (hypocenter or the rupture plane) of the earthquake scenarios of the area sources were not provided. For example, the controlling magnitudes of the study sites b and c (Kaohsiung city and Taichung city) are Mw6.5 and Mw7.3, respectively, but, the RSs are similar to

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Discussion paper

each other as shown in Figures 4. It means that a shorter source-to-site distance was assigned to the site b than that to the site c. What are the criteria for assigning the locations (hypocenter or the rupture plane) of the earthquake scenarios (the worst-case?)? It should be noted that the area source models (Cheng et al., 2007) were developed for PSHA, and might not be adequate for the DSHA. In this paper, the upper-bound magnitude of area-source zone C, Mw7.1, was used for the DSHA scenario, however, the magnitude of Mw7.1 came from a historical event occurred in the subduction zone with a focus depth more than 70km. This paper may not assign a more likely earthquake scenario for the DSHA, even for the worst-case. Similar questions can be found on the other study sites.

Reply: There was indeed a mistake about the DSHA calculation of Kaohsiung city, which has a controlling source Zone G with a maximum considered earthquake of M6.5. Therefore, the response spectra based on DSHA computation scheme for Kaohsiung city should be smaller than that of Taichung city, instead of the similar trend as pointed by the reviewer. The updated computation of DSHA-based response spectrum and recommended ground-motion waveforms for Kaohsiung city will be provided in the revised manuscript.

Also thanks for pointing out that the maximum magnitude Mw 7.1 of area source C came from a historical subduction event. Nonetheless, the seismic zonation used in this study (from Zone A to Zone T) is categorized as shallow crustal regional source following previous researchers' work (i.e., Tsai 1986; Cheng et al. 2007). The maximum earthquake magnitude reflects a combined effect of regional seismology regarding historical earthquakes, focal mechanism, and source zonation, etc. Thus, the maximum magnitude of these seismogenic zones (e.g. M7.1 for source C) is adopted as the worst-case scenario during DSHA calculations. The worst-case scenario was used for identifying the earthquake scenario considered in DSHA analysis; for each area source considered, the closest source-to-site distance is assigned accordingly. More discussions on the worst-case scenario for each study city will also be provided in the revised manuscript.

2. The DSHA spectra are similar to each other for most of the study sites; however, the earthquake records from the GM-selection are quite different (I was surprised by these results). For example, the RSs of the Taichung and Chiayi cities are the same. But, the GM-selection results are different. More discussions on this or providing of other detail conditions of the GM-selection would be helpful.

Reply: Thanks for this valuable comment. In the procedure described in this study, ground-motion time histories are selected according to a quantitative measure, the mean squared error (MSE), which evaluates how well a time history conforms to the target spectrum. The DGML search engine used in this study searches the NGA database for ground-motion waveforms that satisfy the general criteria (i.e. 5.5<Mw<8, 0<Rrup<30 km) and then ranks theses records in an order of increasing MSE. It means that the ground-motion waveform that matches the target RS best has the lowest MSE and will be ranked No. 1. To be more specific, the MSE is defined using the following Equation 1 (Wang et al. 2015), where Ti denotes considered spectral periods, w(Ti) denotes a weight function that allows for assigning weights to different period ranges so that the periods of more interest can be emphasized in the ground-motion selection process, f represents a scale factor to linearly scale the whole ground-motion time history. More detailed condition on how ground motions are selected will be added in the revised manuscript. It should be also noted that the MSE does not vary too much in some cases. For example, as highlighted in the following Figure 1, the MSE ranges from 0.023-0.032, indicating that the selected scaled ground motions are almost equally good and compatible with the target response spectrum. Therefore, in this study, we intentionally select some other ground-motion waveforms if some of them have been recommended in the other study cities. As a result, different GM selection results are recommended for the Taichung and Chiayi cities although they have the similar target response spectra. We expect, by doing so, more flexibility and options could be provided for time-history analyses in engineering practice. It should be also mentioned that although different ground motions are selected for various sites, they are statically consistent and compatible with the corresponding DSHA spectrum.

3. Furthermore, it seems that the RSs (as shown in Figures 4) of the study sites were generated from the "attenuations for the hanging-wall and rock sites (Lin et al. 2011)", not the ones shown in Table 2 (for hanging-wall and soil sites). I suppose that this minor mistake is not important, but a correction of Table 2 will be better and appreciated. And, do you think the specific hanging-wall attenuations are good for the area sources? It's questionable for the cases with very short distance.

Reply: Thanks for pointing out the typo and meaningful discussion. The attenuation adopted in this study is indeed for the hanging-wall and rock sites, and thus Table 2 will be corrected in the revised manuscript. For the second concern, we agree that the worst-case scenarios considered in this manuscript may not be the hanging wall case. However, since the Lin et al. (2011) model is the only available regional-specific response spectral attenuation model for shallow crustal earthquakes to the authors' best knowledge, this hanging-wall attenuation model is then adopted in the current study with reasonably conservative results provided. Besides, to avoid possible saturation at short distance in the attenuation model, each seismogenic area source was defined with assumed depth as 2 km.

References:

Cheng, C. T., Chiou, S. J., Lee, C. T., and Tsai, Y. B.: Study on probabilistic seismic hazard maps of Taiwan after Chi-Chi earthquake, J. GeoEngineering, 2, 19-28, 2007.

Lin, P. S., Lee, C. T., Cheng, C. T., and Sung, C. H.: Response spectral attenuation relations for shallow crustal earthquakes in Taiwan, Eng. Geol., 121, 150-164, 2011.

Tsai, Y. B.: Seismotectonics of Taiwan, Tectonophysics, 125, 17-37, 1986.

Wang, G., Youngs, R., Power, M., and Li, Z.: Design ground motion library: an interactive tool for selecting earthquake ground motions, Earthq. Spectra, 31, 617-635,

2015.

Best regards,

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Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., doi:10.5194/nhess-2017-33, 2017.

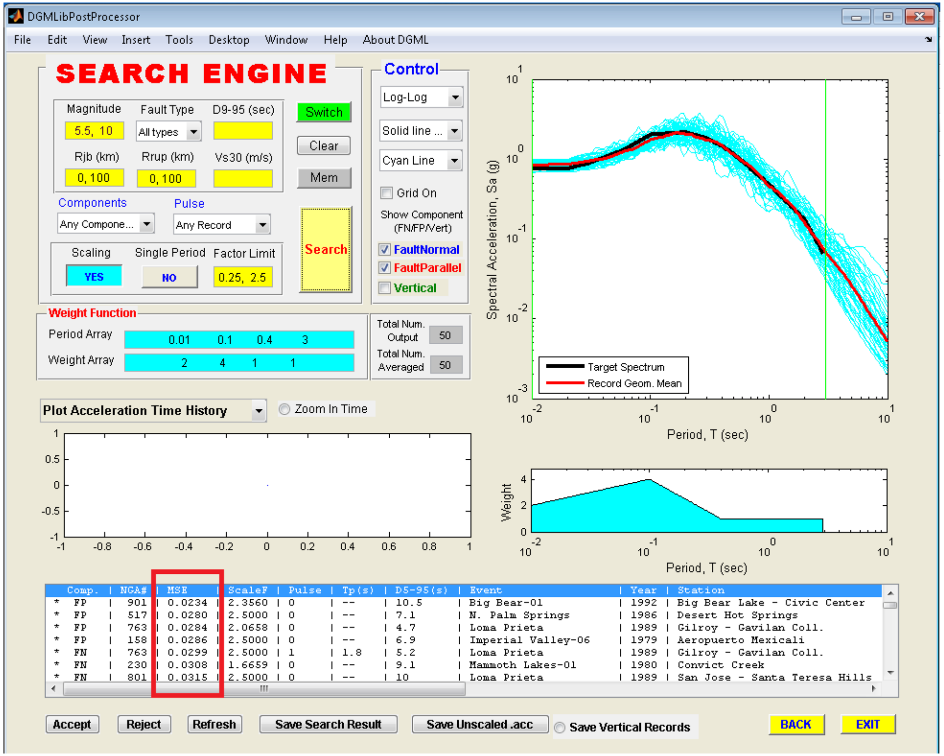

Fig. 1. The screenshot of the database's interface. The red box highlights the column that reports the computed MSEs of selected ground-motion records.

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$$\mathrm{MSE} = \frac{\sum_i w(T_i)\{\ln[Sa^{target}(T_i)] - \ln[f \times Sa^{record}(T_i)]\}^2}{\sum_i w(T_i)}$$

Fig. 2. Equation 1

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