Reply to the Editor

By Duruo Huang, Wenqi Du and Hong Zhu

Comments to the Author:
Dear Authors,
Regarding your revisions, I feel you have mostly well replied on the reviewer´s concerns, but many of the additional information given in the reply letter is not provided in the revised manuscript. Please reorganize your paper incorporating all of your reply at appropriate positions in the text.

Referee #1 pointed out the high similarity between RS of site b and c, and in your reply you´ve indicated a mistake in the DSHA calculations for site b that should have been fixed in the revised manuscript. However, when comparing Figures 4 of the revised and original submissions I can see no difference in the RS of the sites. Please clarify this, together with a more in-depth explanation on the criteria used to assign specific earthquake locations, the general similarity of the RS, and more discussion why a source model developed for PSHA is suitable for DSHA. It should be explained why specific RS for sites a-e are required and not only one because of their similarity. Additionally, more explanation on the specific seismotectonic site characteristics of the six locations is required in the manuscript. Moreover, it is important to explain properly in the manuscript why local earthquake records were not exclusively used for this study. Adding a paragraph on this in the discussion is not sufficient, a justification why global earthquake records have been searched and why these are applicable to the Taiwan case (and site characteristics) using RS based on a local GMM should be provided in Section 3 of the manuscript.

The authors thank for the valuable comments and discussions on this manuscript. The paper has been reorganized to incorporate responses to the editor and reviewers, with changes highlighted as red fonts. The replies are provided point-by-point as follows.

Why a source model developed for PSHA is suitable for DSHA?

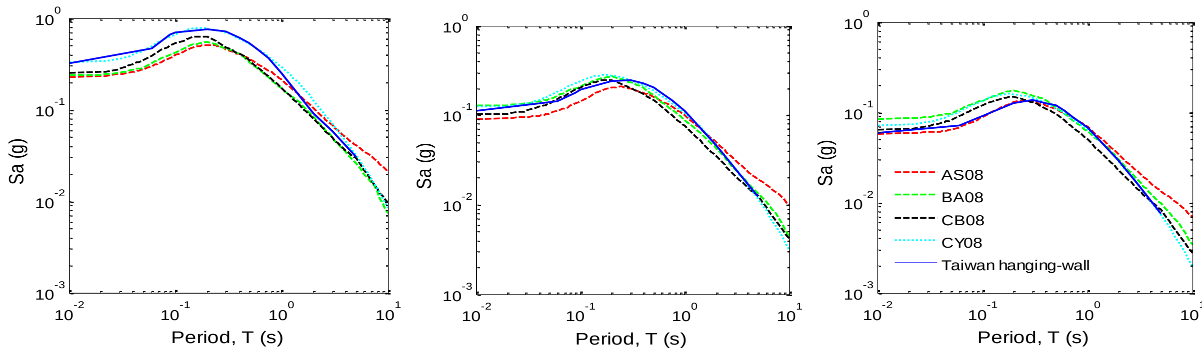
DSHA and PSHA, are commonly used methods for evaluating seismic hazard. DSHA adopts "deterministic" information during analysis, while PSHA accounts for the "probabilistic" characteristics of earthquake size, location, and ground-motion models. The seismic zonation used in this study follows previous researchers' work (i.e., Tsai 1986; Cheng 2002; Cheng et al. 2007). For example, Tsai (1986) reviewed historic seismicity data and proposed the zonation which accounts for complex local seismotectonics. The source model was developed based on historic data, site investigation and local tectonic setting. Although it has been used in the PSHA framework, it is not limited to probabilistic analysis, given that the MCE for multiple sources have been clearly specified.

Besides, tectonic setting of the six study sites are provided in Page 5, Lines 125-134: "As is well know that Taiwan is located at the boundary between the Philippine Sea Plate to the East and the Eurasian Plate to the West, the six study sites are intentionally selected to represent different geological units of the island: site (a) Taipei, site (c) Taichung and site (d) Chiayi are located at the Western Foothills, where syn-orogenic sediments of the foreland basin have been accreted and deformed.; site (b) Kaohsiung is located at the Coastal Plain as a part of the foreland basin of Taiwan; site (e) Pingtung is located within the West Central Range (or Backbone Range) with mostly Miocene to Eocene slates, corresponding to the area of highest altitudes in Taiwan; site (f) Hualien is located at the Longitudinal Valley which is believe as the suture zone between the Luzon arc and the Chinese continental margin."

Why local earthquake records have not been exclusively used?

The mean square error (MSE) for each single selected record has been added in Table 4 in the revised manuscript. It can be seen that the MSEs range from 0.023-0.046 for different study sites. The ground-motion waveforms have been recommended in this study based on their compatibility with the target response spectrum, and such compatibility is parametrized as the MSE.

Regarding selection of local earthquake records, we need to also look at Figure R.1, which compares spectral accelerations predicted using the local GMPE (Lin et al. 2011) with those computed using other four widely used NGA global GMPEs, namely, AS08, BA08, CB08 and CY08, for several earthquake scenarios (Abrahamson and Silva 2008; Boore and Atkinson 2008; Campbell and Bozorgnia 2008; Chiou and Youngs 2008). It can be seen that under the scenario M=7, Rrup=30 km, Vs_{30} = 760m/s, the spectral accelerations predicted by local attenuation agree well with the BA08 and CY08 models across a wide range of periods (i.e. from 0.01 s to 5 s). As for the scenarios M=7, Rrup=10 km, Vs_{30} = 760m/s, the spectral accelerations predicted by local GMPE again corresponds well with those computed using the CY08 model, as demonstrated in Figure R.1 (a). Apart from the consistency with global GMPE, it is also worth mentioning that the functional form of the local model is based on Campbell (1981), which is a quite generic and widely adopted one. Therefore, the target RS in this study is not exclusive but generalized in a way. Ground motions selected from the comprehensive NGA database based on compatibility with the target RS can be either local records or global ones, but not necessarily local motions, given the "generic target GMPE". A justification on why local earthquake records have not been exclusively used for this study is provided in the revised manuscript Page 10-11, Line 271-303.



(a) (b) (c)

Figure R.1. Comparison of spectral acceleration predicted using the local model and NGA global ground motion prediction equations (GMPE) under earthquake scenarios (a) M=7, Rrup=10 km, Vs_{30} = 760m/s, (b) M=7, Rrup=30 km, Vs_{30} = 760m/s; (c) M=7, Rrup=50 km, Vs_{30} = 760m/s

The criteria used to assign specific earthquake locations?

Reply: The principle of deterministic seismic hazard assessment is to incorporate the worst-case earthquake scenario, that is, the maximum considered earthquake (MCE) occurred at the closest source-to-site distance. This worst-case scenario 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 in the calculation. As can be seen from Table 3 in the revised manuscript, several studies sites are governed by similarly large MCE, which can result in similar spectra shape for different study sites.

The respective controlling seismic sources for the six sites are listed in Table 3. For each site, we assumed the earthquake rupture occurred at the same site location, with a depth of 2 km. Therefore, the closest source-to-site distances are 2 km accordingly. For the earthquake scenarios considered for these sites, the only differences are the maximum magnitude assigned. For these near-fault scenarios (i.e., different Mw but the same Rrup), the resulting RSs obtained by the same local GMPE are therefore similar.

General similarity of the RS and why specific RS for sites a-e are required and not only one because of their similarity

Thanks for pointing out the error. The RSs for site b (Kaohsiung) in Figures 4 and 7 have been revised in the updated submission.

In this study, the response spectra for sites a-e have been developed following the framework of DSHA, which adopts the worst-case scenario accounting for historical data and focal mechanism in a region. Since several sites are governed by similar MCE, the computed response spectra are similar in such a case. However, the RS cannot be represented by a single one because of their similarity. For the site such as Hualien governed by relatively large MCE, its RS is significantly (around 30%) larger than those for other sites. On the other hand, for sites Taipei and Taichung that has quite similar MCEs as 7.1 and 7.3, respectively, Table R.1 summarizes spectral accelerations for the two sites along with their relative difference. Generally, the difference in spectral acceleration is larger than 5%, and can approach 20% at long period (i.e. 3s). Thus, specific RS for each city is required instead of using a single one to represent all cases.

Table R.1. Comparison of spectral accelerations at study sites Taipei and Taichung

Spectral period (s)	Sa in g (Taipei)	Sa in g (Taichung)	Relative difference
0.06	1.10	1.13	2.7%
0.09	1.92	2.02	5.2%
0.10	1.95	2.05	5.1%
0.30	1.63	1.70	4.3%
0.50	1.10	1.16	5.5%
1.0	0.46	0.49	6.5%
2.0	0.14	0.16	14.2%
3.0	0.10	0.12	20%

In addition to the above general observations on your revisions in the light of the referee comments, I have some additional specific comments on the presentation listed below. Please revise your paper following these and the general comments above and resubmit your paper together with a detailed point-per-point reply and a manuscript version highlighting the applied changes. After resubmission, your paper will be reviewed again by the editor.

P5L110: Here you should also refer to Figure 2 where the sites are plotted as stars (although not indicated in the Figure caption). Please also denote site letters a-f for easy identification throughout the manuscript.

Reply: Comments appreciated. We refer to “Figure 2” in Page 5 Line 124 in the revised manuscript and highlight the six study sites in the caption of Figure 2. Also, we refer study sites from (a) to (f) throughout the revised manuscript.

P5L118: If for all sites the area source is the controlling source, why do you provide the line sources and their parameters? Please explain.

Reply: We first considered and listed all possible seismic sources (i.e., area and line sources) in this region for these city sites. The worst-case scenario was then identified for each city (area source is the controlling one).

P5L120: Isn´t the source-to-site distance zero in all cases since the sites are located in the specific controlling source areas? Please explain.

Reply: Not exactly. For an area source, the upper and lower seismogenic depths are important source parameters. As the upper depth of these source areas are assumed as 2 km, the source-to-site distance is then set as 2 km accordingly.

P7L181: In Figure 6, it cannot be observed that something is highlighted. Do you refer to the red rectangle in the Figure? This is not indicated in the caption.

Reply: Comments appreciated. "MSE" (mean squared error) is indicated it in the caption of revised Figure 6. And we also added detailed description of the DGML searching interface (ref. to Figure 6) and specified functionality of the major components in Page 6 Lines 166-170 in the revised manuscript.

P8L200-P9L222: Section 4.1: I am not sure whether a general discussion on pros and cons of PSHA vs. DSHA is really required here. It would be better to argue why DSHA have been chosen for this study and how it can be developed further in the Taiwan case.

Reply: Thanks for the comment. Because in the manuscript several pervious PSHA studies for Taiwan have been referred to, it tends to be comprehensive to give a brief comparison between the two widely adopted methods. Regarding using DSHA in this study, we have following discussion in the revised manuscript Lines 241-247: "… it should come to a logical understanding that both the deterministic and probabilistic analyses are needed and useful in engineering applications. The use of the DSHA approach in this study is primarily due to its analytical simplicity and transparency. Since it has been reported that DSHA rather than PSHA is more appropriate for design of critical structures (Bommer et al., 2000), the selected ground motion suites, with a representative seismic hazard analysis and a reputable earthquake database, are then recommended for such applications."

Figure 1: This map has no scale. Reference to plotted stars (sites) is missing in the caption. Maybe you can plot more information from Table 1 in this Figure (e.g., source areas colored with max. magnitude classes).

Reply: Comments appreciated. Reference to the plotted star is added in the caption. Since Figure 1 is a schematic diagram to illustrate general computation framework of DSHA, we do not intended to refer a specific case, such as the information listed in Table 1.

Figure 2: Map has no scale. Is it needed since your DSHA only requires area sources? Please check.

Reply: Comments appreciated. We added scales in the revised Figure 2 and Figure 3. The DSHA requires both area and line sources in the computation framework. The controlling source for each site (i.e. area source in this study) was identified after the computation flow, instead of being recognized before the assessment.

Figure 6: The screenshot of the search engine is of very bad quality. Specifically, the search criteria are not visible, and the red box (probably highlighting MSE-ranges) is not indicated in the caption.

Reply: Thanks for the comments. We actually specified selection criteria in terms of magnitude bound, distance bound, Vs30, range of scale factor and weight factor, etc, in Page 7, Lines 171-188 in the revised manuscript. In addition, we added detailed description of the DGML searching interface (ref. to Figure 6) and specified functionality of the major components (Lines 166-170): "The DGML Search Engine window is shown in Figure 6. It contains the following major parts: (1) Inputs for searching criteria; (2) Prescribed range of scale factor; (3) Prescribed weight factor for spectral period; (4) Spectrum plot of selected motions; (5) MSE of each individual selected ground-motion record; (6) Scale factor of each record; (7) Event name and (8) station name of each record."

Table 1: Is it necessary to provide the parameters of the line sources?

Reply: Yes, I think it is necessary.

References:

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