RC 2

P: Page
L: Line

Reviewer comments	**Author response**
1- The used catalog is not subjected to completeness analysis, therefore, the authors consider the earthquakes are complete for the entire magnitude range (4-9.1) along the catalog period (1907- 2016). I am highly skeptic about this. Please provide, at least, a completeness analysis showing that earthquakes of magnitude 4.0 are complete along the entire period.	The use of the entire magnitude range (4.0 – 9.1) was initially considered based on the observation that earthquakes causing felt ground motion in the peninsula starts at M_w 4.0. We, therefore, assumed that the catalog is complete. However, taking into account that both Reviewer #2 and Reviewer #3 have noted that the completeness analysis is essential for PSHA, we have re-performed a completeness analyses using the Stepp (1972) method and will be included in the revised manuscript.
The catalog shows no earthquakes generated by the local intraplate faults. Really I do not know if these faults are active or inactive one to be included or excluded from the calculations. Please follow the following points: *a- Provide evidences for the activity of all mapped major intraplate faults.* *b- Define their dimension and rate of slip along each of them.* *c- Define the associated maximum magnitude and recurrence interval based upon the above data. If these faults are active, then the seismic hazard will change dramatically. Using the maximum recorded PGA values is not the proper way for seismic hazard assessment.*	The local intraplate earthquakes have been inactive in the past, but Shuib (2009) noted that due to the massive 2004 Aceh earthquake, some of the local intraplate faults may have been reactivated. This was evident in a series of mini earthquakes felt between 2008 and 2009 at Bukit Tinggi and several other areas within the peninsula. These events were recorded by the MMD and are tabulated in Table 2 (nos. 45-50). Therefore, while these faults are not completely active, they are also not absolutely inactive. Due to their relative inactiveness, limited information (slip rate etc.) is available to date from past literature, the Malaysian Meteorological Department (MMD) and Department of Mineral of Geosciences on the definition of the activity rates within the local intraplate. Amongst the local intraplate faults, only the Bukit Tinggi fault has been studied more closely by local researchers (Shuib, 2009; Shuib et al., 2017) revealing that there are several likely active faults in Peninsular Malaysia based on earthquake epicenter distribution. These geomorphologic studies, however, did not indicate how "active" these intraplate faults are. The mapping of major and minor faults lines were digitized from the Geological Map by MMD (2014). As mentioned above in 2a, this is not possible with limited information. Apart from the Bukit Tinggi event that we have modelled at a high magnitude of 6.0 (Mw) due to concerns raised by Looi et al. (2003) – P14, L13, the maximum magnitude for all the remaining 5 local intraplate earthquakes were based on the records provided by MMD. Only DSHA was performed for these events, PSHA was NOT

	conducted as we were not able to calculate the recurrence interval based on the limited available information. The maximum recorded PGA values were not utilized in the SHA but shown for comparison of suitability of the GMPEs to be used in the SHA. *Note: It should be noted that due to the limited geological information available and the relative inactiveness of the faults, PSHA for the local intraplate faults was NOT conducted. Only DSHA was conducted using point sources. This has been highlighted in P12, L13. Nevertheless, we will make it clearer in the revision.*
3- Bases for subdividing SSZ into 7 areas and line seismic source zones are unclear and very confusing. Sumatra earthquake 2004 initiated at latitude near 3.2 degree N and extended for about 1200 km northward till about 14 degree N, rupturing at least zones 3, 2 and 1. These zone were ruptured in one earthquake, therefore, I found it strange to subdivide it into three different seismic zones. Segments 4, 5, and 6 have almost the same slip rate, thus their segmentation is questionable for me. Generally segmentation along SSZ is unclear, therefore, geological, tectonic, seismological evidences should be provide to support the current segmentation.	We are aware that various researchers have segmented the SSZ differently using different geological and tectonic methods of segmentation in the past. For example, Hanus (1996) demarcated 30 zones across the Sumatran subduction and fault zones based on earthquake foci, Franke et al. (2008) performed digital imaging based on the 2004 to 2005 massive Sumatra earthquake, and Petersen et al. (2007) conducted SHA based on deep and shallow events. However, we are not aware that there is a clear segmentation that defines the whole of 4000+ km long SSZ that can be precisely defined/segmented/modelled for PSHA. Therefore, we have modelled the SSZ based on the seismological evidence in the subduction zone by dividing them into various subdivisions at 2-3° latitudinal intervals to avoid overlap of zones when PSHA analyses is conducted. With earthquake rupture dimension being different for each independent event, there is no exact methodology to segment the length of each sub-division. We have, therefore, modelled the individual zones of SSZ at 2-3° intervals as rupture length of large earthquakes from past events approximately within this range, as shown in Subarya et al. (2006) - 2005 earthquake (Mw 8.6) – appox. 2.5°N to 0° - 2007 earthquake (Mw 8.4) – appox. 3.0°S to 5.0°S - 1833 earthquake (Mw 9.0)- approx. 2.5°S to 5.6°S As for the question raised by Reviewer #2 on what happens during an exceptional event such as the 2004 earthquake which ruptured for an extensive length, we have considered another model that takes into account the entire subduction length as

	part of the logic tree, and this will be added in the revised manuscript.
4- According to Wells and Coppersmith, 1994, Strasser et al., 2010, and Blaser et al., 2010, all the provided fault lengths cannot produce the expected magnitudes in Table 3.	Expected M_wMAx was not based on calculation of the fault length and depth for SSZ, rather consideration that an earthquake of such a high magnitude is possible (P10, L9-12). As for SFZ, these values were extracted from literature in Table 2, with an upper boundary assigned. – (P8, L23-30). As the word "expected" may be confusing, we will revise it to "modelled."
5- Gutenberg-Richter (1944) approach to define b-values imposes the unrealistic assumption that the maximum potential earthquake is unbounded and unrelated to the seismotectonic setting. Therefore, I prefer to use the truncated exponential model instead of G-R (1944) model, which contradicts the idea of maximum magnitude as it is open from its both ends.	We appreciate the Reviewer's comments on the model choice. We may point out that the G-R method has been used in other recent published work also (e.g., Ullah et al. 2015, Wang et al. 2016). We have conducted our analysis based on what we understand best and believe that we have obtained sensible results using the G-R method.
6- Figure 5 shows a very strange piece of data, where the logarithm of the cumulative annual frequency for earthquakes with magnitude 9.1 is Zero, meaning that the annual frequency of this range of magnitude is 1.0. Actually we do not have an earthquake with magnitude 9.1 or larger every years in this area. A great mistake is committed and should be reconsidered. Authors seem to use the same recurrence parameters for both area and line sources.	We thank the Reviewer for pointing out this mistake. The label was supposed to be "cumulative frequency" instead of "cumulative annual frequency". The label in Figure 5 will be corrected accordingly.
Please use rate of slip to define the recurrence parameters for the fault sources. But first authors should show how did they calculate the slip rate and show whether their calculations contain creep components or not and show whether the time span for calculation the slip rate is representative or not. *Comparison of the results using the area and line sources should be provided.*	The slip rates for both the SSZ and SFZ were not calculated. They were obtained from literature as mentioned in Section 3 (see P5, L4-7). We are hence unable to comment on the creep component calculation. It should be noted that different slip rates for the SSZ have been reported in the literature. However, majority of the literature agrees that the slip rate increases from north to south along the subduction line.
7- According to Figure 5, the maximum observed magnitude at zones 1, 2 is less than 7.6 (1.5 magnitude unit less than the maximum magnitude assigned for these seismic zones). Please comment. Such inconsistency is observed at many other regions. The solution is to combined the provided segmented seismic sources into proper larger ones.	While Figure 5 does show the observed magnitude at various zones to be lower than the maximum magnitude assigned, the expected M_wMax utilized for the PSHA was once again not based solely on the historical values. The expected MwMax values for zones in both the SSZ and SFZ were modelled to be as high as 9.5 and 8.0, respectively, because we intended to model them as the worst-possible case scenario. Considering that the 2004 earthquake was able rupture >1200 km and produce an earthquake of 9.1M_w, we wonder why is it not possible for it produce a similar magnitude rupture again in the future?

	The upper boundary of the expected M_wMax though differs from zone to zone. The modelled values are explained on P10, L8-14.
8- Local intraplate faults and the seismic activity at Sabah are not included in the PSHA.	Sabah does not fall within the scope of the current study; only peninsular Malaysia is only considered. We will revise Fig. 1 to give a clearer representation of our study area.
9- The distances employed in the Ground Motion Prediction Equations (GMPE) is the hypocentral distance as indicated in figure 6. This kind of distances considers the earthquake as a point and cannot be used for earthquakes that cause ruptures up to 1200 km. Even it cannot be used for local source that can produce earthquakes of magnitude 5.0. Recent GMPE avoid using the hypocentral distance as it overestimates the distance. Although the authors used local GMPE, but it is not appropriate for the current use. I suggest to use Rrup or Rjb within appropriate GMPE for the studied area.	We appreciate the Reviewer's suggestion for use of alternative parameters. However, the available information on the rupture plane is limited. Therefore, we would prefer to stick with hypocentral distances. Moreover, with distances as long as 1200 km, the effects of using various distance parameters (Repi, Rhyp, Rrup, or Rjb) for this region are not huge, as also noted by Van et al. (2016). The GMPEs utilized for DSHA and PSHA (SSZL18, SFZL18, S16 and SM00) were mainly derived based on the hypocentral distances, and therefore, we have conducted the analyses based on Rhyp.
Please always provide more details about the used GMPE (e.g. minimum amd maximum distance for applicability, type of horizontal ground motion used, tectonic environment, magnitude used, shear-wave velocity, etc.). Of most important is to define the standard deviation for the used GMPE.	More details regarding the GMPEs including the standard deviations of the parameters that have were used for the DSHA and PSHA in this work will be provided in the form of a Table in the revised manuscript.
10- GMPE used seems not to calculate the ground motion in terms of response spectra, which are the most important input parameters for engineers, especially if they are asked to use the IBC codes. PGA is OK if the Euro code is to be applied, but it is just an isolated value on the time history and neither represents the ground motion nor correlates well with the damage potential of shaking. I highly recommend to provide hazard maps in terms of short period and 1.0 sec spectral period for the two return periods (475 and 2475 years) in addition to the PGA maps.	We appreciate the Reviewer's recommendation and acknowledge that the response spectra are an important input parameter for engineers. We have already acknowledged the limitation of the present work. Some of the GMPEs (LSSZ18, LSFZ18 and SM00) used in this work do not include the coefficients required to calculate the response spectra. Hence, we have omitted them from the current work. The reason why we have focused our work on the PGA at bedrock is because as recently as 2016, the Department of Standards Malaysia have drafted a seismic resistance design code based on the Eurocode 8 which specify the notional design of PGA at bedrock.
11- The main advantage of the PSHA is the combination of all magnitudes, distances, and effects. Thus all seismic sources that might affect the area of interest should be included in each single run. Separation of SSZ and SFZ in the logic tree is an mistake as it underestimate the seismic hazard. of course, different seismic source models can be used, but in each model all the seismic sources should be used in each single run. For example authors may consider each of SSz and STZ as single or more in one branch of the logic tree while the their preferable source model is on the other branch. Segmentation of the seismic zone into area and lines zones is acceptable.	We thank the Reviewer for picking up this mistake. It was an oversight from us in separating the two different source models in the logic tree. We have already repeated the analyses by combining all the related seismic sources in a single run. The logic tree branch in Figure 7 will also be redrawn with the new results.

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