Natural Hazards and Earth System Sciences Discussions

Nat. Hazards Earth Syst. Sci. Discuss., author comment AC1
https://doi.org/10.5194/nhess-2021-375-AC1, 2022

Reply on RC1

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Author comment on "Tsunami scenario triggered by a submarine landslide offshore of northern Sumatra Island and its hazard assessment" by Haekal A. Haridhi et al., Nat. Hazards Earth Syst. Sci. Discuss., https://doi.org/10.5194/nhess-2021-375-AC1, 2022

Answer to RC1

We highly appreciate your time in reviewing the manuscript as well as your valuable comments. Following please find the responses in detail:Overall evaluation

Comment:

I think this is a good work and is helpful for tsunami hazards in Sumatra region. I recommend publication after the following revisions.

Answer:

We are glad that you are interested in our work as well as your positive feedback. Please find our corrections and responses to your comments and suggestions. The corrections are indicated in this response and shown in the marked-up manuscript version highlighting the changes (track changes in Word).

Comments:

- Figure 1: Some text is Figure 1a cannot be read. Please increase fontsize.

Answer:

Thank you for your suggestion, we have revised by modifying Fig. 1a to increase the font size on some text.

- L25-28; what is meant by this: “In an extreme case, an earthquake of Mw 7 or more occurred, and the strong ground shaking triggered a submarine landslide off the northern shore of Sumatra.”? Is this about a real event? Or hypothetical?

Answer:

Thank you for your question. We apologize that our explanation lacked clarity. It is a hypothetical event. We have provided clearer explanation. Following is the revised related text in the manuscript:

L25-28; “In an extreme hypothetical case, an earthquake of Mw 7 or more occurred, and the strong ground shaking triggered a submarine landslide off the northern shore of Sumatra.” (see L26 of new revised MS)

- Abstract: make your abstract more specific by adding some numbers and values from your modelling, like wave heights and etc.

Answer:

Thank you for your suggestion. We have revised the abstract and add the necessary information resulted from the modelling, such as wave heights. We revised the abstract as follow:

Abstract. Near the northern border of Sumatra, the right-lateral strike-slip Sumatran Fault Zone splits into two branches and extends into the offshore, as revealed by seismic sounding surveys. However, due to its strike-slip faulting characteristics, the Sumatran Fault Zone’s activity is rarely believed to cause tsunami hazards in this region. According to two reprocessed reflection seismic profiles, the extended Sumatran Fault Zone is strongly associated with chaotic facies, indicating that large submarine landslides have been triggered. Coastal steep slopes and new subsurface characteristics of submarine landslide deposits were mapped using recently acquired high-resolution shallow bathymetry data. Slope stability analysis revealed some targets with steep morphology to be close to failure. In an extreme hypothetical case, an earthquake of M_w 7 or more occurred, and the strong ground shaking triggered a submarine landslide off the northern shore of Sumatra. Based on a simulation of tsunami wave propagation in shallow water, the results of this study indicate a potential tsunami hazard from several submarine landslide sources triggered by the strike-slip fault system can generate a tsunami as high as 4 - 8 m at several locations along the northern coast of Aceh. The landslide tsunami hazard assessment and early warning systems in this study area can be improved on the basis of this proposed scenario. (see L28-30 of new revised MS)

- L43-55: Another good example of tsunami from strike-slip event from this region is the event of March 2016. See reference below. You could add something like this: “Heidarzadeh et al. (2017) showed potential tsunami hazards from strike-slip events by analysing the tsunami from the Mw 7.8 strike-slip earthquake in the Wharton Basin”.

Answer:

Thank you for your suggestion. We have add on the manuscript as your suggestion. We revised the concerned paragraph as follow:

Analysis of the M_w 7.0 Haiti earthquake on 12 January 2010 revealed that an earthquake with strike-slip faulting can produce a significant tsunami. Typically, a strike-slip fault movement is not associated with uplift of the sea floor or tsunami generation. However, a combination of other factors can trigger a tsunami. For the Haiti earthquake, the tsunami waves seem to have been caused by coastal failure landslides (Poupardin et al., 2020 and references therein). Satellite images and ground photos reveal changes in the coastline following the earthquake (Hornbach et al., 2010). The Haiti earthquake is not unique. On 28 September 2018, a large tsunami hit the city of Palu following the M_w 7.5 Sulawesi earthquake in Indonesia. This event also occurred along a strike-slip fault. A tsunami of that size is unlikely to have been generated through earthquake rupturing alone. The tsunami is thought to have been caused by underwater and subaerial landslides triggered by the earthquake (Gusman et al., 2019). The complex bathymetry of the Palu Bay may have also contributed to the generation of the tsunami (Socquet et al., 2019). Another evaluation of strike-slip earthquakes that have caused tsunami is the Mw 7.6, 1999 Izmit earthquake, where slumping resulted from the gravitative instability of active gliding masses as the source of tsunami generation are observed as the chaotic deposit in the basin of the Sea of Marmara (Gasperini et al., 2022; Zitter et al., 2012). Heidarzadeh et al. (2017) showed potential tsunami hazards from strike-slip events by analyzing the tsunami from the Mw 7.8 strike-slip earthquake in the Wharton Basin. Other well-known tsunamis, such as the 1998 Papua New Guinea abnormal tsunami (Heinrich et al., 2001; Kawata et al., 1999; Tappin et al., 1999) and the 22 December 2018 tsunami at Sunda Strait caused by a flank collapse of the Anak Krakatau Volcano (Heidarzadeh et al., 2020; Muhari et al., 2019; Patton et al., 2018; Syamsidik et al., 2020), were also induced by earthquake-triggered submarine landslides (Ye et al., 2020). (see L54-57 of new revised MS)

- Figures 2 & 3: here we have two issues: the fonts are small; and please write the owner of the data in the caption; is that from Malod and Kemal, 1996? Please also write that they are digitized from paper versions. These two figures are key figures of the paper and you need to be very clear about them.

Answer:

Thank you for your question. We apologize that our explanation lacked clarity in the caption, although we have clearly indicate this data on L89-91. As it is in the caption of Figs. 2 and 3, Yes, the seismic profiles are from Malod and Kemal, 1996. We revised the concerned caption as follow:

Figure 2. Seismic section of SUMII-32 that have been collected from 1991 to 1992 by Malod and Kemal (1996). This dataset are digitized from paper recording that were scanned and converted to digital images. All seismic traces were digitized and converted into the SEG-Y format for reprocessing. Please see section 3.1 for detailed processing of this dataset. (a) The reprocess uninterpreted seismic profile with direction, shot point (SP), and offset (in meters) presented at the top of the profile. (b) Possible location of the Seulimeum fault. (c) Fan-shaped sediments.

Figure 3. Same as Fig. 2 but for SUMII-33. (a) The reprocess uninterpreted seismic profile with direction, shot point (SP), and offset (in meters) presented at the top of the profile. (b) Possible compression. (c) Mass transport deposits.

- L93: what type of reprocessing? Please clarify.

Answer:

Thank you for your question. We apologize that our explanation lacked clarity. The reprocessing of these seismic sections is explained as follows:

Due to digital conversion, the original seismic data has uneven trace amplitude with low-frequency noise artifacts clearly seen on some parts of the profile, so the main purpose of reprocessing is to attenuate those noises, while some post-stack image enhancement methods was also applied to further improve the seismic image. The processing detail is as follows: after SEG-Y input, a low-cut filter (4-8Hz) was applied to attenuate the low frequency artifact. To remove the noise outside the data range, seafloor mute and bottom trace mute were picked and applied, followed by amplitude balancing and signal enhancement in both frequency domain (FXDECON) and FK domain (FKPOWER). After that, post-stack predictive gap deconvolution was applied to remove the reverberation and compress the wavelet. Finally, seafloor mute and bottom trace mute were reapplied before SEG-Y output.

In the manuscript we add:

L92: Those paper recordings were scanned and converted to digital images. All seismic traces were digitized and converted into the SEG-Y format for reprocessing. In the absence of any velocity information, these data were migrated using a water velocity of 1500 m s^{-1} to remove the effects of seafloor scattering. Due to digital conversion, the original seismic data has uneven trace amplitude with low-frequency noise artifacts clearly seen on some parts of the profile, so the main purpose of reprocessing is to attenuate those noises, while some post-stack image enhancement methods was also applied to further improve the seismic image. The processing detail is as follows: after SEG-Y input, a low-cut filter (4-8Hz) was applied to attenuate the low frequency artifact. To remove the noise outside the data range, seafloor mute and bottom trace mute were picked and applied, followed by amplitude balancing and signal enhancement in both frequency domain (FXDECON) and FK domain (FKPOWER). After that, post-stack predictive gap deconvolution was applied to remove the reverberation and compress the wavelet. Finally, seafloor mute and bottom trace mute were reapplied before SEG-Y output. The reprocessed seismic profiles are presented in Figs. 2 and 3. (see L105-112 of new revised MS)

- L295: Another good ref here: Tsuji et al. (2011):

Answer:

Thank you for your suggestion. We added the suggested reference and revised the paragraph as follows:

Tsunamis induced by giant megathrust earthquakes, such as the 2004 Sumatra–Andaman earthquake or the 2011 Tohoku earthquake in Japan, and their mechanisms have been investigated (Araki et al., 2006; Liu and Zhao, 2018; Romano et al., 2014; Sibuet et al., 2007; Tsuji et al., 2011; Wang and Liu, 2006). (see L316 of new revised MS and the same as in references)

- L170: Yes, it is true that COMCOT can model landslide tsunamis as well. Would be useful to add another reference here of other people who used COMCOT for landslide tsunamis. I recommend Heidarzadeh and Satake (2015):

Answer:

Thank you for your suggestion. We added the suggested reference and revised the concerned line as follows:

COMCOT can also be used to simulate tsunamis caused by landslides (Heidarzadeh and Satake, 2015; Liu et al., 1995; Wang, 2009) (see L187 of new revised MS and the same as in references)

- L316: I think here you could cite one more article; I suggest Heidarzadeh et al. (2019):

Answer:

Thank you for your suggestion. We added the suggested reference and revised the concerned line as follows:

Furthermore, multiple submarine landslides can be triggered by one event at failure sites on the continental slope, enhancing tsunami hazards. The 2018 Palu earthquake is a real example of this phenomenon (Gusman et al., 2019; Heidarzadeh et al., 2019) (see L337 of new revised MS and the same as in references)

Please also note the supplement to this comment:
https://nhess.copernicus.org/preprints/nhess-2021-375/nhess-2021-375-AC1-supplement.pdf