Response to Referee 5 (Dr. Reza Amouzgar)

Thank you for providing us with comments and suggestions on our manuscript. In this response, the referee's comments are shown with bold letters to distinguish from our point-by-point responses. In the revised manuscript, all changes are highlighted with yellow.

Q5-1: Page 8, Line 230-231 Authors: The reference elevation of the bathymetry and terrain data is the standard altitude in Japan (Tokyo Peil), and no variation of sea levels is taken into account in the tsunami simulations. Is this reference equivalent to mean high water level? (Does it assume the tsunami arrival times coincide with high water mean tide? or it is relative to the mean sea level). If the mean sea level is assumed for the simulations, based on the bathymetry/topography of the region, if the tsunami occurs at a higher tide, how it may affect the physics of the wave and inundation?

R5-1: We assumed mean sea level for simulations as usual tsunami simulations. As the tsunami length is quite long having smaller wave steepness, there is less nonlinear effects on wave deformation in a high-tide situation. The close-to-linear effect on the inundation can be expected. To clarify this point in the manuscript, the following sentence is added: '*However, the effects of tidal variations (e.g. mean high water level) are not considered in the simulations.*'

Q5-2: Page 12, Line 250-252 Authors: The numerical tsunami calculation is performed for a 3-hour duration which is sufficient to model the most critical phase of tsunami waves for the Nankai-Tonankai scenarios. Comment: That is fine to carry out the simulations with 3 hour duration. But I wanted to know for the area of your study, have you attempted one/or more of the simulations for a longer duration to see the wave interactions with the coast and the effect on local inundation. Sometimes, depending on the location, the amplification of the wave is possible.

R5-2: Longer simulations do not cause significant differences in maximum tsunami height nor tsunami inundation except for small height tsunami regions. As initial tsunami heights are quite large, edge waves and other effects become minor for the considered scenarios. We also know that 3 hours duration is enough for megathrust tsunami simulations based on the 2011 Tohoku tsunami.

Q5-3: Page 14, Line 430-431 Authors: Since the exceedance of the critical inundation depths was rare (i.e. 5 and 1 out of 1,000 cases for the towers in the Ogata and Saga districts, respectively), the exiting two vertical evacuation towers were judged to be satisfactory. Comment: That is outstanding outcome from this approach to show the towers are in a safe elevation except for very rare events. In deterministic approach usually a safety factor of 50% maybe recommended as a

typical engineering value, for example, to the tsunami wave heights value because of the uncertainties. How do you relate that in the probabilistic approach? (comparison of deterministic approach with inclusion of a safety factor with the probabilistic approach)

R5-3: This is good point to discuss. Applications of the current tsunami simulation results for a full PTHA and engineering design issues are not yet discussed. The safety factor can be considered in several stages of designing a structure. For example, the primary uncertainty involves the estimation of tsunami height (and this was the main focus of this study). The estimation of tsunami force for a given tsunami height is another important aspect (which is not considered in this study). Additionally, structural design also considers the uncertainty associated with material and others. We think that existing studies like Chock (2016) and Chock et al. (2016) would be suitable for answering Referee 5's inquiry, however, we don't have clear answers to this question.

References:

Chock, G.Y.K. (2016). Design for tsunami loads and effects in the ASCE 7-16 Standard. Journal of Structural Engineering, 142, 04016093.

Chock, G.Y.K., Yu, G., Thio, H.K., and Lynett, P.J. (2016). Target structural reliability analysis for tsunami hydrodynamic loads of the ASCE 7-16 Standard. Journal of Structural Engineering, 142, 04016092.

Q5-4: Page 21, Figure 5 and Page 22, Figure 6: Comment: In these two figures, at what grid resolution are you presenting the wave profiles and maximum tsunami heights? Is it 10m, 30m, 90m? We know at shallower depth and closer to the coast finer resolutions will better present the wave profile. Have you tried a sensitivity test, to see how the resolution may affect the wave amplitude and phase?

R5-4: The results shown in Figures 5 and 6 are based on 90-m grids. We agree with Referee 5 that at shallow depths, using finer grids will be able to capture more accurate wave profiles. We have not compared offshore wave profiles based on different grid resolutions. To indicate that the results shown in Section 4.1 are based on 90-m grids, the following sentence is added in the revised manuscript: '*The temporal surface wave profile results shown in Figure 5 are based on 90-m resolution*' and '*The extracted near-shore maximum tsunami height results shown in Figure 6 are based on 90-m resolution*.'

Q5-5: Page 24, Figure 8: Comment: In Figure 8 (a), in legend part, the horizontal red dash line (Average of 2012 CDMC models) is intersecting with the histogram. If possible, try to edit that in the final edition.

R5-5: Agreed. In the revised manuscript, we avoid this intersection in Figure 8.

Q5-6: Page 24, Caption of Figure 8: Authors: Figure 8: Histograms of tsunami inundation area in Shikoku and Kuroshio Town for the two magnitude ranges M8.9-9.1 (a,c) and M8.7-8.9 (b,d) (left: Shikoku Island and right: Kuroshio Town). Comment: It might be easier for the reader if as follows: Figure 8: Histograms of tsunami inundation area in Shikoku (a,c) and Kuroshio Town (b,d) for the two magnitude ranges M8.9-9.1 and M8.7-8.9 (left: Shikoku Island and right: Kuroshio Town).

R5-6: Agreed. We made changes to the figure caption to make the figure more understandable.

Q5-7: Page 25, Line 550, Caption of Figure 9: Authors: Figure 9: Scatter plots of slip ratios in segments Z (Hyuga-nada), A-B (Nankai), and C-E (Tonankai-Tokai) versus tsunami inundation area in Shikoku and Kuroshio Town for the two magnitude ranges M8.9-9.1 (a,c,e) and M8.7-8.9 (b,d,f). Comment: It might be easier for the reader if as follows: Figure 9: Scatter plots of slip ratios in segments Z (Hyuga-nada), A-B (Nankai), and C-E (Tonankai-Tokai) versus tsunami inundation area in Shikoku (a,c,e) and Kuroshio Town (b,d,f) for the two magnitude ranges M8.9-9.1 and M8.7-8.9.

R5-7: Agreed. We made changes to the figure caption to make the figure more understandable.

Q5-8: Do you have any comments about the computational time, parallelization, and computer resources for this study? For example, for one hour of simulation considering one scenario what would be the estimated time? There are 1000 of simulations for the regional scale and local resolution which will require significant resources and time. I didn't find in the manuscript, as I understand it is not the scope of this study. TUNAMI code or any model which solves the shallow water equation (SWEs) is computationally more efficient compared to other wave models with more complex physics. This is more important in probabilistic methods which need lots of simulations. Therefore, a code which require less computer resources/time (as used in this work) maybe more practical for this purpose compared to the alternative ones, for example Boussinesq models.

R5-8: We did not discuss the computational aspects of the Monte Carlo tsunami simulations in the paper because this was not the main focus of this study. We are willing to mention some details of these computational aspects in this interactive review communication (not in the main manuscript), partly because it may be difficult to 'generalize' our experience in a way that is useful to readers.

The Monte Carlo tsunami simulations for 90-m resolution (1000 scenarios) can be performed using several recent PCs by running multiple cases at a time. The simulations for 10-m resolution were much more demanding partly because of larger spatial domains to evaluate and finer time integration steps (0.1 s). For our calculations, we used BlueCrystal Phase 3 at the University of Bristol (https://www.acrc.bris.ac.uk/acrc/phase3.htm). Using a single node per tsunami simulation, it took about 7-10 days; we run many simulations simultaneously using multiple nodes. Because of queuing wait times, various communication failures and limitations in usage, which were specific to the BlueCrystal system, it took approximately 4 months to complete all simulations.

The TUNAMI code we used was developed by C. Goto and the original development was dated in 1997, as indicated in the accompanying TUNAMI code manual (in Japanese).

As mentioned by Referee 5, for large-scale tsunami simulations, using well-tested nonlinear shallow water equation codes, such as TUNAMI and COMCOT, is a practical approach. Having said that, it would be desirable to use more advanced numerical solvers of the governing equations for tsunami wave propagation and inundation.