Response to Anonymous Referee 4

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.

Q4-1: The main comment that I have with regard to the manuscript is with regard terminology that would be confusing to most readers. "Probability" is used in the manuscript to describe tsunami inundation hazard assessment. This can be easily confused with probabilistic tsunami hazard analysis (PTHA), which is a very different method than what is performed in this study (see Grezio et al., 2017 for details). PTHA is an aggregation of tsunami rates and heights from different sources, including uncertainty (i.e., aggregate aleatory uncertainty is integrated into the rate calculations). Probability in PTHA is also given in terms of a particular exposure period. Neither of these aspects are considered in this study. I strongly recommend that this type of study be termed as "uncertainty analysis" or "uncertainty quantification".

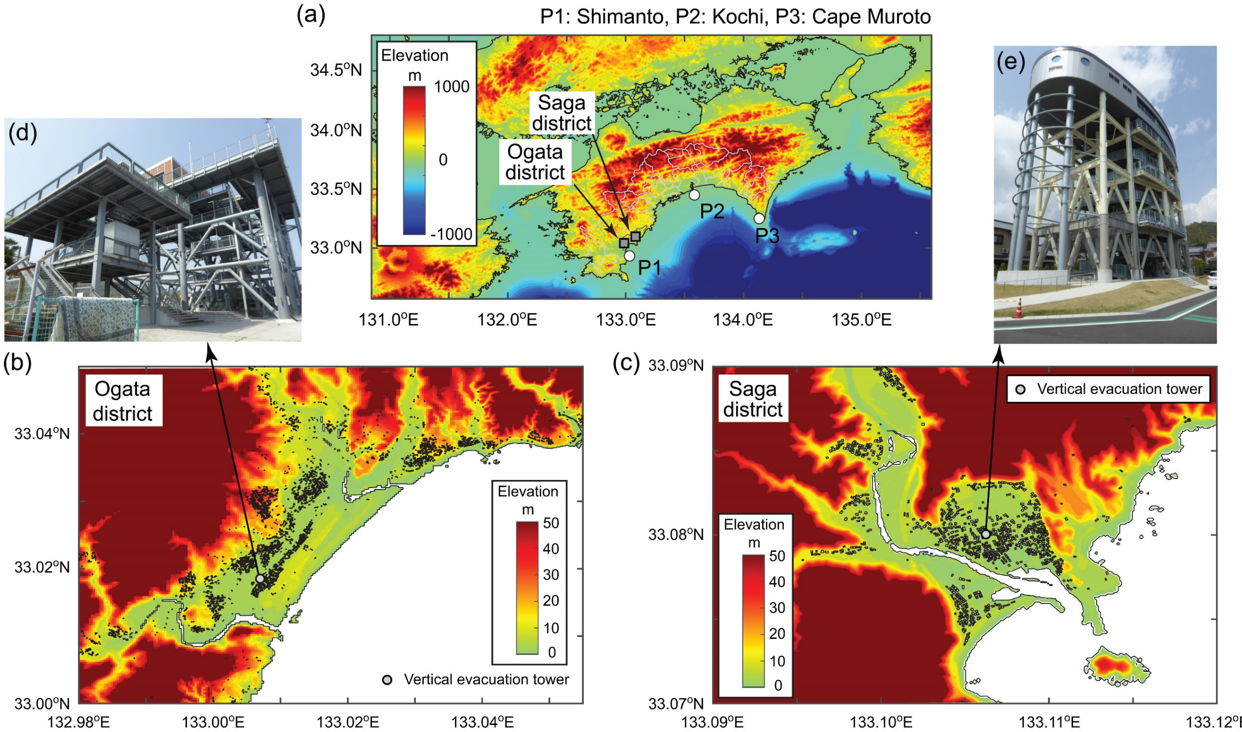
R4-1: We understand the concern by Referee 4. Our study is conditional on earthquake scenarios falling within a specific range of magnitude, and does not address on the occurrence probability of these events nor cover the entire range of the magnitude. In the revised manuscript, we change the paper title to: '*Uncertainty quantification of tsunami inundation in Kuroshio Town, Kochi Prefecture, Japan using the Nankai-Tonankai megathrust rupture scenarios*'.

Q4-2: Probability is also used to describe the scaling relationships. These are better termed as empirical or statistically derived scaling relationships. They are only probabilistic in the sense that the residuals are distributed according to some probability distribution. For example, standard linear regression assumes that the residuals are normally distributed, but this type of regression is rarely if ever called probabilistic. The same would hold if the residuals were distributed as a lognormal, Poisson, etc. distribution.

R4-2: Agreed, and as above, we understand the concern by Referee 4. Throughout the manuscript, we avoid the expressions like '*probabilistic*' tsunami hazard assessments and '*probabilistic*' scaling relationships.

Q4-3: It would be helpful for the authors to clarify the names of the study areas, especially for those unfamiliar with geography in Japan. In the title, Kuroshio Town is referred to. In Figure 4, does Kuroshio Town encompass the Ogata and Saga districts? It would be helpful if the boundaries of these districts, Kuroshio Town, and Kochi Prefecture were included in Figure 4.

R4-3: We created a figure requested by Referee 4 by showing political boundaries for Kochi Prefecture and Kuroshio Town as below. In our opinion, it is not easy to see the boundaries and these boundaries interfere with other mapped objects in the figure (and even with high resolutions, it would be difficult to see these boundaries in the properly formatted paper). Since we have indicated these political boundaries in Figure 1, it may be better to mention this in the Figure 4 caption so that readers can check the locations of Kochi Prefecture and Kuroshio Town. For this reason, we added the following sentence in the caption of Figure 4 in the revised manuscript: '*The Ogata and Saga districts are located in Kuroshio Town, Kochi Prefecture. The locations of Kuroshio Town and Kochi Prefecture are indicated in Figure 1.*'

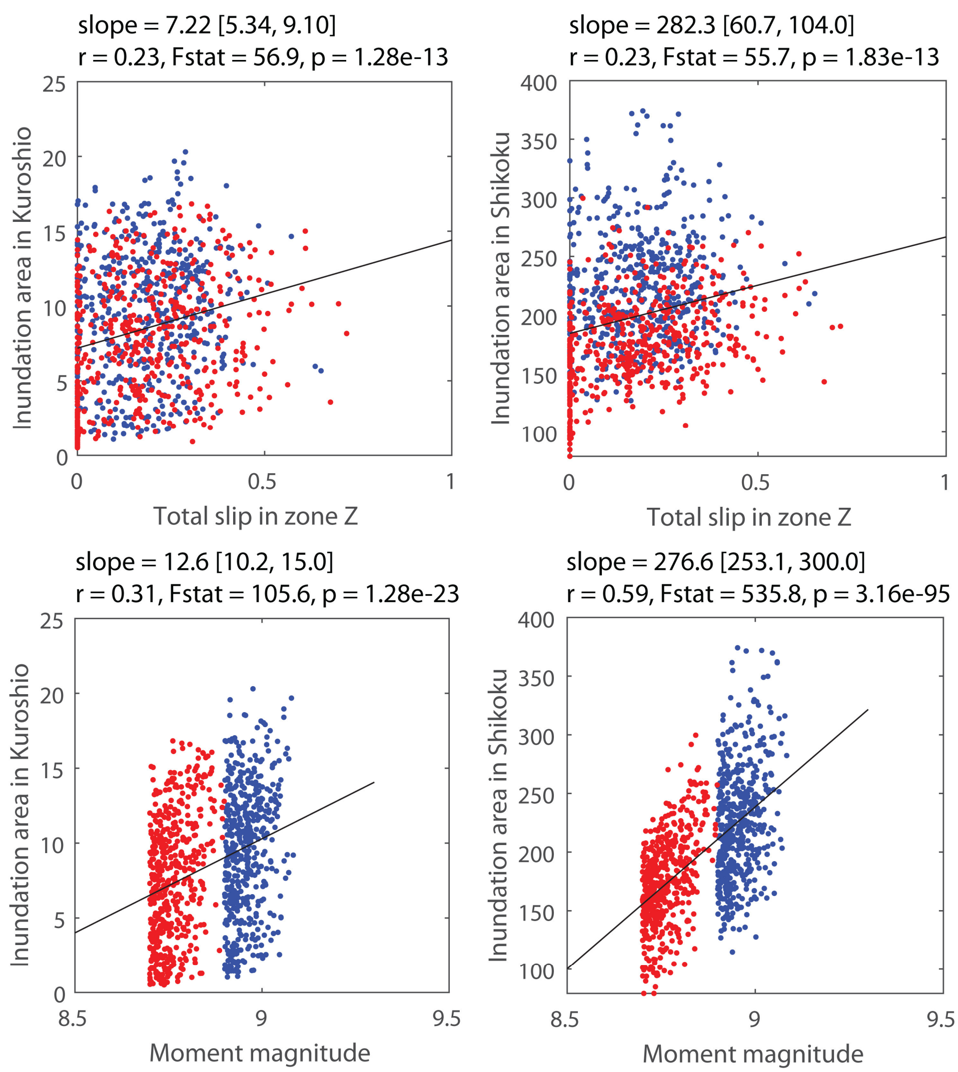


Q4-4: The scatter plots (Section 4.2) exhibit very weak correlation, likely because the effects of Green's Law have not been considered. Some discussion as to this effect would be helpful. Also, results of the regression F-test would be helpful in these cases to determine whether dependence on a particular parameter is statistically significant.

R4-4: As Referee 4 points out correctly, the scatter plots for slip ratios for segment Z (Figures 9a,b) and those for moment magnitude (Figures 10a,b) do not show strong dependency on inundation areas for Kochi (regional) or Kuroshio (local). These are consistent with r values indicated in the figures. The effects of Green's law are implicitly considered by the nonlinear shallow water modeling but is not clear in our results. This is because the we didn't compare tsunami height change from offshore to onshore, although we analyzed Mw-inundation area relation in Section 4.2.

Furthermore, as suggested by Referee 4, we checked the linear regression statistics of these scatter plots shown in Figures 9 and 10. (Note that the detailed discussions of the regression analysis results, such as developing statistical relationships for prediction purposes are not of our direct interest). We report that even for Figures 9a and 9b, the positive linear dependency is observed via linear regression analysis; the confidence interval of the slope parameter does not include zero, F-statistics is large, and the corresponding *p* value is small (less than 0.01). Nonetheless, from visual inspections, when the r value is relatively small, e.g. less than 0.2 in absolute values, the linear dependency between the hazard metric (i.e. slip ratios, magnitude, tsunami potential energy, or other parameters we tested) is not obvious and obscured by the large scatter of the data points. In the revised manuscript, we added the following sentence: '*Although some of the identified trends between the inundation areas and slip rations are weak (e.g. Figures 9a and 9b), the slope coefficients of these relationships are found to be significant (i.e. non-zero) based on the p-values.*'

Just as illustration of specific cases, we show such linear regression plots for slip ratio in segment Z and for moment magnitude below. In the figures, slope parameters (with confidence interval), r value, F statistics, and *p*-value are indicated.



Q4-5: L30, 32: Please provide references for magnitudes of historical earthquakes.

R4-5: We took magnitude values from Fujiwara et al. (2020).

Reference:

Fujiwara, O., Aoshima, A., Irizuki, T., Ono, E.,Obrochta, S. P., Sampei, Y., Sato, Y., and Takahashi, A. (2020). Tsunami deposits refine great earthquake rupture extent and recurrence over the past 1300 years along the Nankai and Tokai fault segments of the Nankai Trough, Japan. Quaternary Science Reviews, 227, 105999.

Q4-6: L35: "which occurred on a megathrust that was originally thought to only rupture in smaller segments"

R4-6: The segmented rupture model was a standard for the Tohoku region (and elsewhere in Japan) prior to the 2011 Tohoku earthquake and tsunami. This fact is indicated in the Cabinet Office's report. In the revised manuscript, we cite an opinion paper by Stein and Okal (2011), which raised issue associated with such a segmented model.

Reference:

Stein, S., and Okal, E.A. (2011). The size of the 2011 Tohoku earthquake need not have been a surprise. EOS, 92, 227–228.

Q4-7: L114: The slip models shown in Fig. 2 do not look like they are derived from a circular crack model. Is this a surface-rupturing crack? Some clarification is needed. It would also be helpful to compare CDMC models with those using the authors' stochastic slip model.

R4-7: Based on the report on the Nankai-Tonankai tsunami model by the Cabinet Office, the circular crack model was used to calculate the average slip as a function of stress drop. But the report indicates that the earthquake slip is distributed (or determined) based on the assumed asperity models as well as geodetic information on individual segments (slip rate is not uniform along the strike).

Q4-8: L138: fault -> rupture

R4-8: Agreed and this change is made in the revised manuscript.

Q4-9: L144: Not sure what "synthesis" means here.

R4-9: We change it to 'simulation'.

Q4-10: L158: "mu" is not typeset in equation.

R4-10: Thank you very much for pointing this out. We corrected this error in the revised manuscript.

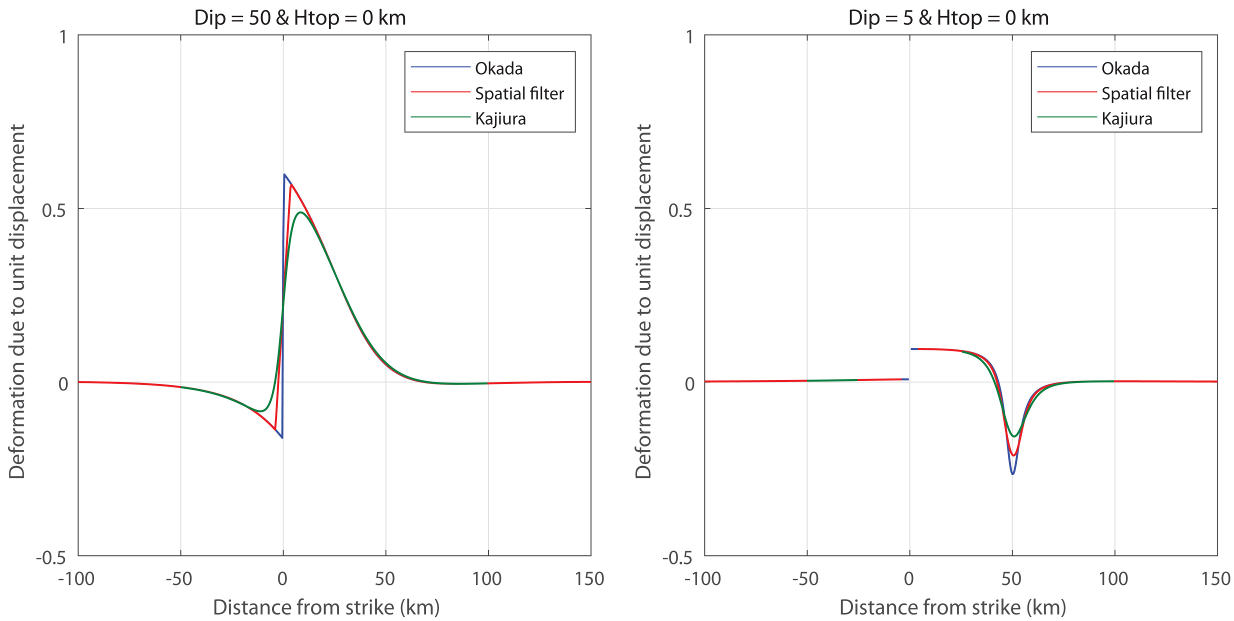
Q4-11: Section 3.2: Please indicate how displacements are calculated for surface rupturing earthquakes, compared to imbedded earthquakes.

R4-11: We used Okada equations to calculate elastic displacements (vertical and horizontal) due to the fault movement and used Tanioka-Satake equations to obtain the final vertical displacement. Subsequently, we applied the spatial smoothing filter (9 grids by 9 grids, with grid size of 810 m), as was done for the 2012 CDMC models. In the 2012 CDMC models, the top of the fault plane was assumed to reach the ocean bottom (i.e. 0 km depth in calculating the Okada displacements; as mentioned in Section 2.2). We used the same fault plane geometry as the 2012 CDMC models. Therefore, for the subfaults that are most offshore along the Nankai-Tonankai Trough, earthquake ruptures are not embedded. In other words, for these subfaults, the discontinuous rupture profiles are obtained along the trough.

Q4-12: L244: How does this filter compare to Kajiura's 1/cosh(kh) filter?

R4-12: We compare the Okada deformation (vertical only), spatial filtered deformation (15-grid size with 0.5 km grid size, which is approximately similar to 9-grid size filter with 0.81 km grid size), and Kajiura filtered deformation. To make a suitable reference to the published paper, we used the same rupture scenario as considered by Glimsdal et al. (2013). More specifically, the rupture scenario is: unit reverse displacement of a rectangular fault with L = 100 km and W = 50 km. The dip angle is set to 50 degrees and the top of the depth is set to 0 km (i.e. surface rupture). Glimsdal et al. compared the Okada-based cross-section profile with the Kajiura-based cross-sectional profile for this rupture (see Figure 2 in their paper). In addition, a comparison for dip = 5 degrees (representing a shallowly-dipping reverse fault rupture, like subduction events) is also included in the figure below.

The spatial filter that is used in this study has less significant than the Kajiura filter (red versus green). Note that when the spatial filter size is doubled, the spatial filter and the Kajiura filter become more similar in profile and amplitude. Therefore, in our calculations, sharper deformation profiles are used, compared with the Kajiura filter. We emphasize that the set-up for the spatial filter is the same as in the Cabinet Office's model and we wanted to use the same set-up for our investigations.



Reference:

Glimsdal, S., Pedersen, G.K., Harbitz, C.B., and Løvholt, F. (2013). Dispersion of tsunamis: does it really matter? Natural Hazards and Earth System Sciences, 13, 1507–1526.

Q4-13: Figure 8: Indicate that these are probability density histograms (correct?).

R4-13: We used the normalization to make summed vertical values to be equal to 1. In the revised manuscript, we added '*The sum of the vertical bin heights is 1*' in the figure captions.