

REGIONAL CHARACTERISTICS OF TSUNAMI AMPLITUDES IN JAPAN WITH VARIOUS FAULT PARAMETERS

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INTRODUCTION

Future tsunami events include a variety of uncertainties. Especially on megathrust earthquake tsunamis, the tsunami hazard intensity at coastal cities highly depends on the source characteristics such as fault width, length, slip distribution, and location of the large slip area. To facilitate these statistical uncertainties, many studies on probabilistic tsunami hazard assessment (PTHA) have been conducted considering numerous source scenarios. However, these PTHA studies typically consider fixed subfault geometry. In addition, subfault depths are mostly based on geological surveys or analysis of historical earthquake events. However, the results may have some uncertainty. It is important to quantitatively estimate the effect of the uncertainty on tsunami height in coastal areas. This study aims to quantify the sensitivity of fault depth and rake to the coastal tsunami height. The target earthquake source is the subduction zone along the Nankai Trough, located southwest of Japan.

UNCERTAINTY ANALYSIS OF FAULT PARAMETERS IN THE NANKAI TROUGH SEISMIC SOURCE REGION

Possible values of fault depths and rakes are estimated. We evaluated the difference in fault depth by comparing two models: the Japanese Cabinet Office model (2012) and the Slab2 model (Hayes et al., 2018). Figure 1 shows the difference in fault depth between the Slab2 and Cabinet Office models. Slab2 model is about 5 km deeper than the Cabinet Office models in a wide area. The Cabinet Office model assumes a fault depth uniformly 5 km shallower than the estimated location of the plate boundary, so the Slab2 model is about 5 km deeper over a wide area. The rakes are estimated from a database of earthquakes of Mj4.5 or greater that have occurred in the target epicenter area in the past, and their variations are analyzed. The mean rake was about 90° with a standard deviation of about 14°.

METHOD FOR NUMERICAL TSUNAMI SIMULATION CONSIDERING THE UNCERTAINTY OF FAULT PARAMETERS

Within the fault plane of the Cabinet model, 100 cases of artificial slip distributions were generated using the random phase method, as in Mori et al. (2017). To account for the variation in fault depth, a total of 400 cases were created, consisting of 100 cases of slip distribution and four different parameters of fault depth: (i) the same as the Cabinet Office model, (ii) 2.5 km deeper than the Cabinet Office model, (iii) 5.0 km deeper than the Cabinet Office model, (iv) the same as the slab2 model. Similarly, four sets of calculations ((v)-(viii)), totaling 400 cases, were created to account for the variation of rakes, with rakes uniformly varying from the Cabinet Office model by $\pm 7.25^\circ$

and $\pm 14.5^\circ$, respectively. Numerical tsunami simulations were performed for these 800 cases using JAGURS, which is based on the nonlinear shallow water equations. The target area for the simulations was the Pacific coast of western Japan from Kochi Prefecture to Aichi Prefecture.

EFFECT OF FAULT PARAMETERS ON TSUNAMI AMPLITUDE

We evaluate the tsunami amplitudes at two points with a water depth of 20 m along the coast of Kochi Prefecture shown in Figure 2(a). Figure 2(b) shows the distribution of tsunami amplitudes for each 100 cases at four different fault depths along the coast of Kochi Prefecture. In all cases, the deeper the fault, the larger the tsunami height. The median tsunami height in case (iii) is about 1 m larger than that in case (i). The difference in median tsunami amplitudes between (iii) and (iv), which have similar fault depths, is as small as 0.1 m. Therefore, the amplitude tends to be larger as the fault depth is deep, and a similar distribution of fault depths indicates a smaller difference in tsunami heights. To support this, we examined initial tsunami distributions resulting from a simplified fault model. When a large number of low-angle dip subfaults are arranged, the range of large initial tsunami heights increases with fault depth up to a certain depth. Therefore, the initial tsunami energy increases as the fault depth increases up to about 20 km. Figure 2(c) shows the distribution of tsunami amplitudes for each 100 cases at five different rakes along the coast of Kochi Prefecture. The median tsunami height in case (viii) is about 0.5 m larger than that in case (i). Since the original values of the rakes are greater than 100°, the closer the rakes are to the vertical, the greater the tsunami height at all points. The reason is that the vertical displacement increases as the rakes approach to 90°.

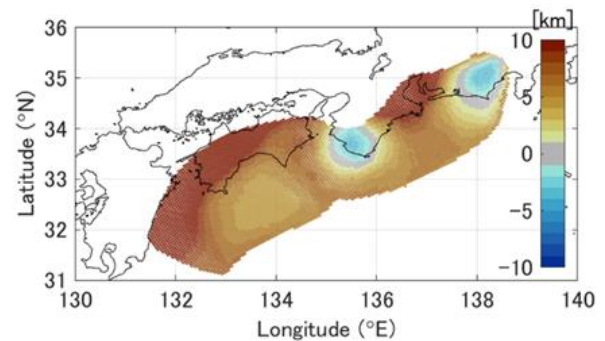
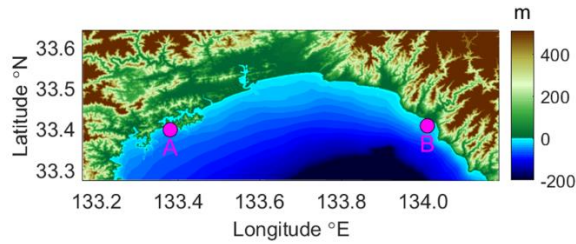
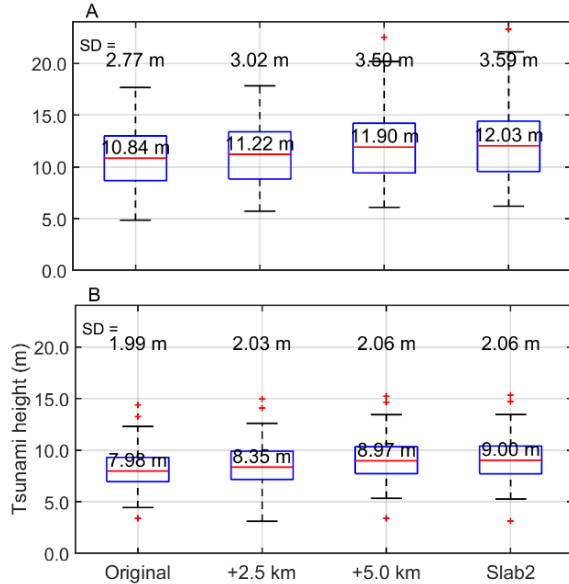


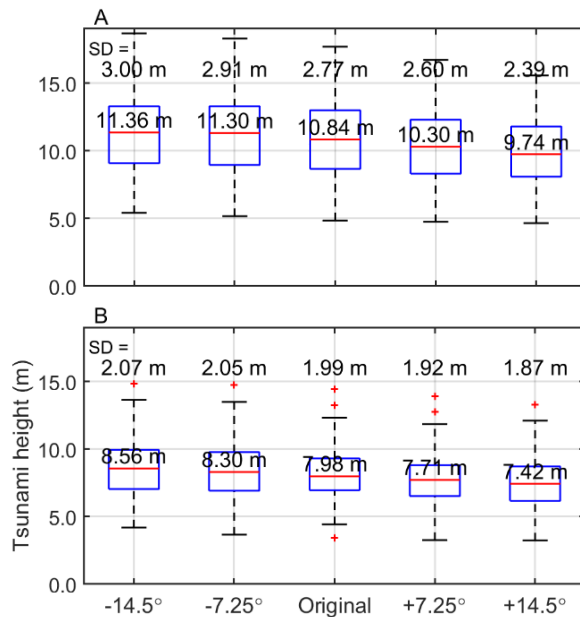
Figure 1: Difference between Slab2 model and Cabinet Office model for fault depth (positive values indicate that the Slab2 model is deeper)



(a) Location of tsunami height evaluation points



(b) Distribution of tsunami heights for each 100 cases at four different fault depths (The middle number indicates the median and the upper number indicates the standard deviation)



(c) Distribution of tsunami heights for each 100 cases at five different rakes

Figure 2: Tsunami height evaluation at two points (A, B) in Kochi Prefecture

CONCLUSIONS

We performed 100 cases of tsunami calculations for different fault depths and rakes, and evaluated their effects on tsunami heights. Figure 3 shows the difference in median tsunami heights between the Cabinet Office model and the model with varying fault parameters for 68 points in 20 m water depth along the western Japan coast. Comparing (i) and (iii), the tsunami height in (iii) is about 1 m larger at the location facing the open ocean, while the tsunami height in (iii) is about 0.4 m larger at the inner bay or inland sea. Comparing (iii) and (iv), the tsunami heights coincide at many points, but at some points in Wakayama and Aichi, the tsunami height of (iv) is smaller than that of (iii). This is because the fault in (iv) is shallower in the vicinity of this point. Finally, comparing (i) and (viii), the tsunami height in (viii) is about 0.4 m larger at the location facing the open ocean, while the tsunami height in (viii) is about 0.15 m larger at the inner bay or inland sea. Therefore, the tsunami height increases as the slip angle approaches 90 degrees. The effect of the change in fault parameters on the tsunami height is large in the open ocean and small in the inner bay or inland sea.

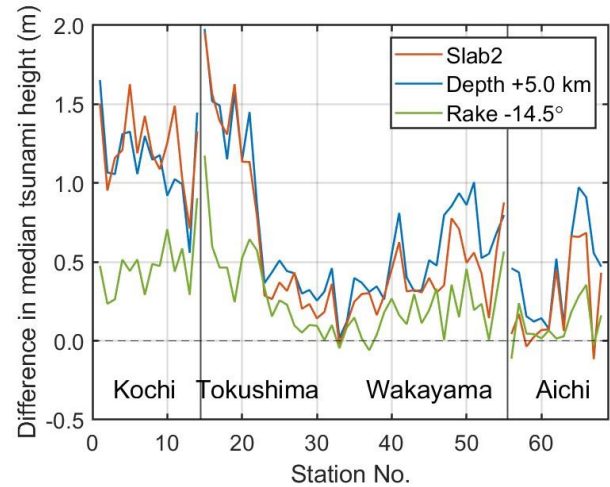


Figure 3: Difference in median tsunami height between the model with different fault parameters and the Cabinet Office model

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