Source model of 1854 Ansei-Tokai earthquake using tsunami waveform to understand a future Nankai earthquake

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The great earthquake has repeatedly occurred at the Nankai Trough subduction zone and has caused severe disasters in southwest Japan. Existing studies indicated that the 1944 Tonankai earthquake re-ruptured the large slip area of the 1854 Ansei-Tokai earthquake except the plate interface along the Sagami trough (Tokai area). However, recent studies also showed the large variability of the rupture models for repeated great earthquakes in this region. Although the source process of the 1944 Tonankai earthquake has been studied vigorously using the seismological data and tsunami records, that of the 1854 Ansei-Tokai earthquake has been insufficiently discussed because of the lack of quantitative instrumental data. A tsunami generated by the 1854 earthquake, on the other hand, arrived at San Francisco, USA, and was observed at the tide gauge station of San Francisco. This study, therefore, examined the source process of the 1854 Ansei-Tokai earthquake using the observed tsunami waveform.

We fixed the fault length of 115km, fault width of 70km, and the slip amount of 4m along the Sagami trough and also the fault length of 150km, fault width of 61.4km, and the slip amount of 4m at deeper part of the plate interface in Nankai trough as same as a previous study, suggested by Ishibashi (1981), so the surveyed coseismic crustal deformation data should be explained. A slip amount of the shallower part of the plate interface near the trough was set to be an unknown parameter. Next, a tsunami propagation due to the above fault models was simulated based on a linear dispersive model. Then, we applied a wave dispersion curves estimated by Watada et al. (2014) to consider seawater compressibility, the elasticity of the Earth, and geopotential perturbations for a far-field tsunami simulation. To estimate the slip amount of the shallower fault, the observed tsunami waveform at San Francisco was compared with the computed ones. Because the earthquake occurred in 1854, the origin time of the earthquake was not accurately observed. Bache (1856) indicated that the Russian Frigate *Diana*, which was buffeted by tsunami at Simoda, felt shake at a quarter past nine. To determine the origin time of the 1854 earthquake and the slip amount of the shallow fault, we shifted computed waveform at 1-minute intervals and calculated RMSE between computed and observed tsunami waveforms.

The result (Figure1) showed that the slip amount at the plate interface near the trough was 5m, larger than the slip amount of 4 m at the deeper part of the fault model, and the earthquake were assumed to occurred at 9:29am which is consistent with the origin time suggested by Bache (1856). This indicated that the large slip area of the 1854 earthquake was different from that of the 1944 earthquake estimated by the previous studies. Especially, the shallow part of the plate interface ruptured by the 1854 earthquake was not re-ruptured by the 1944 earthquake. The stress may have been accumulated at that part of the plate interface since 1854.

References

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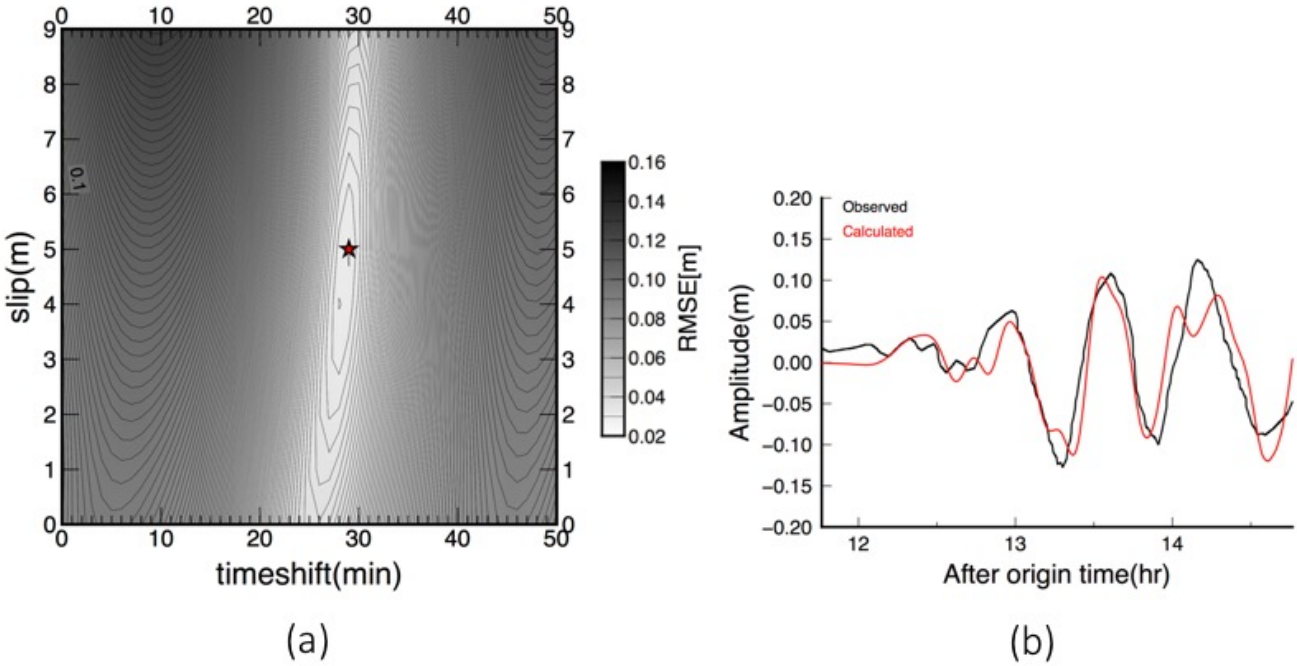

Figure1. (a) Distribution of RMSE at interval of slip amount 1m and timeshift 1min. The lowest RMSE residual is about 0.03m when we assumed the slip amount is 5m and the timeshift is +29min (red star). (b) Comparison of the computed waveform with the observed waveform at San Francisco.