# Trial and error estimation of the initial sea surface deformation of the tsunami caused by the 2009 Suruga Bay earthquake

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Tsunamis are caused by not only submarine earthquakes but also by submarine landslides. Because tsunami caused by earthquakes that simultaneously generate seismic waves can be expected due to precursory shaking. However, a submarine landslide would not generate strong seismic waves, so we would underestimate a coastal risk of submarine landslide tsunami. During the 2009 Suruga Bay earthquake, a tide gauge (Yaizu) recorded tsunami much larger than we expected from the magnitude of the earthquake. Bathymetric traces of submarine landslides were observed by post-event surveys (Matsumoto et al., 2012). A tsunami modeling based on the topographic change between before and after the event could not simulate the observed tsunami waveforms (Baba et al., 2012). In this study, the source of the tsunami was estimated by a trial and error method neglecting the topographic changes. For estimations of the initial sea surface deformation, we used a method proposed by Watts et al. (2005) and combination of multi Gaussian distributions. In tsunami propagations, the nonlinear long wave equations were solved by a finite difference method. Also, the volume and location of the submarine landslide body were estimated using a two-layer flow model.

In the model of Watts et al., the six parameters of landslide length, width, collapse depth, slope gradient, moving distance and thickness of sediment deposit, were changed in ranges between 130 to 1750 m, 115 to 660 m, 15 to 250 m, 2 to 10 ˚, 500 to 8000 m, 3 to 45 m, respectively, while parameters of landslide position, strike, depth, specific gravity, added mass coefficient, and shape were fixed. In the use of Gaussian distributions, three parameters of standard deviation, amplitude, and position were changed ranges between -15 to 6m, 8 to 19.2m, (x,y)=([BT1] 205 to 379, 81 to 183), respectively, where (x, y) is index number of 90m mesh grid of the calculated region. It is about 3 to 18km off Yaizu. For the two-layer flow model, the location of initial dirt mass was fixed at a position of about 5km off Yaizu. The dirt mass was given in a circular shape with radius, height, and seabed friction changing ranges between 2000 to 4000 m, 10 to 30 m, and 0 to 0.5 $sm^{-1/3}$, respectively. Tsunami calculations were repeated varying these models and parameters to find the best model that fits with the observed tsunami waveforms.

However, all examinations could not simulate the observations. In the Yaizu tide gauge record, the amplitude of the first drawn wave was observed by -0.62 m at about 720 seconds since the occurrence of the earthquake. The maximum wave of about 0.33 m appeared at about 1080 seconds. The best Watts model provided an amplitude of -0.63 m at 302 seconds for the first drawn wave, the amplitude of 0.55 m at 438 seconds for the maximum wave. In the best Gaussian model, these were -0.61 m at 427 seconds and 0.91 m at 709 seconds, respectively. In the two-layer flow model, these were -0.67 m at 350 seconds and 0.45 m at 504 seconds, respectively. To summarize, the amplitude of the maximum wave in the simulations was about 1.5 to 3 times larger than the observation even when the amplitude of the first drawn wave was close to the observation. The tsunamis in all simulations arrived at the Yaizu station earlier by 300-420 seconds.

 

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