

A Reproduction of 1707 Hoen Tsunami with long rupture duration, referring to 2011 East Japan Pacific Ocean Earthquake

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Hoen earthquake in 1707 was the largest earthquake in the Edo period that gave the tsunami damage to a wide area along the Pacific Ocean, from the Izu Peninsula to the Southwest Japan. It was assumed that in Hoen earthquake, the source areas of Ansei Tokai and Nankai earthquakes ruptured subsequently within a very short time [e.g. Usami (2003)], or the source areas of the two earthquakes of Ansei were broken at a time [e.g. Ishibashi (2004)]. However, the recent detailed study of historical records revealed that the crustal deformation and the seismic intensity distribution tell that the western and eastern margins of the Hoen source region did not overlap with the two earthquakes in Ansei [e.g. Matsu'ura (2012)]. Hoen earthquake was the exceptionally huge earthquake, which should be called "Western Japan Pacific Ocean Earthquake" in Edo period.

In order to explain very high tsunami of Hoen in the Western Japan, Aida (1981) set the doubled slip to the source area off the cape Ashizuri. Furumura et al. (2011) even expanded the source area further west towards Kyushu. However, their models cannot match the intensity distribution in Kyushu and arrival times of tsunami to villages along the east coast of Kyushu. We suspect that the commonly used tsunami simulation method does not work for a M9-class huge tsunami like Hoen. The theoretical calculation program of crustal deformation of a rectangular fault in a semi-infinite medium [e.g. Sato and Matsu'ura (1973)], which is widely used for the tsunami simulation, inevitably produces singular margins. When the source area was huge, the singularity should affect coastal areas. When the shallow part near the trench is included in the source area, using the same elastic constants as the deeper part should result in an unrealistic deformation solution for a tsunami simulation.

To avoid these limits to applications of the theory used, we put aside obtaining crustal deformation of the sea floor from a dislocation source model, and calculate tsunami from the model of sea floor upheaval and subsidence, which evolve in time. For a test, we first examine the case of the East Japan Pacific Ocean Earthquake of 2011. In order to avoid the detailed topography along coasts, we only used data from GPS buoys and pressure gauges located offshore. We used the ocean bottom upheaval and subsidence obtained by Saito et al. (2011) as the final crustal deformation of the 2011 huge quake. From the known epicenter, the deformation spreads gradually, with the intermittent of 20 seconds, which was observed by GPS as the stop of movement. Paying the attention for the physical plausibility, the movement starts when the rupture reaches, and continues moving until the rupture reaches the edge of a source area. Since the small smooth subsidence spreads over wide area around the major large upheaval area in Saito's model, most tsunami waveform features were reproduced only from the major upheaval area and the smaller upheaval zone protruding toward Japan Trench.

Then we did for Hoen tsunami. As the source of upheaval, we use the source region proposed by Matsu'ura et al. (2011). The topography in Hoen period, we stripped down claimed lands like the islands of Kansai International airport, and Tenpozan, which are apparently made after Hoen period. We also increased the depth of Sakai port, which had been buried by depositions carried by Yamato River since 1704. Examining tsunami for two cases of hypocenter, one at the east end of the source area near Zenisu, and the other at Kumano-nada, we realized that it is impossible to distinguish a hypocenter from limited tsunami information obtained for historical earthquakes. Even with our rough model, Hoen tsunami can go up to canals in Osaka and in the Lake Ryujin in Hazako, Oita. Our experience tells that we shall leverage the recent high power of ordinary computers for a tsunami simulation and molt to go beyond the 40-year-old theoretical crustal deformation.

Keywords: Hoen Earthquake in 1707, East Japan Pacific Ocean Earthquake in 2011, rectangular source fault model, huge tsunami, historical earthquakes