Source mechanism analysis of the tsunami near Torishima on October 9, 2023

*Masumi YAMADA[1], Masaru Nakano[2]

1. DPRI, Kyoto University, 2. JAMSTEC

On October 9, 2023, between 4:00 a.m. and 7:00 a.m. local time, a cluster of earthquakes occurred near Torishima Island, and a tsunami advisory was issued for the surrounding areas. A 60-centimeter tsunami was observed at 7:17 a.m. on Hachijojima, and other tsunamis were generated over a wide area on the Pacific Ocean side. Originally the size of the earthquake was unknown due to the unclear P-wave arrivals and contamination by the T-phases, hydro-acoustic waves traveling in the seawater. The main source of this tsunami was an uplift near the Sofugan volcano, suggesting the involvement of caldera activity in the tsunami generation (Sandanbata et al., 2024; Kubota et al., 2024). This tsunami source was estimated by the inversion analysis of tsunami waveforms.

In this study, we performed the seismic waveform inversion using the broadband seismograms recorded by the F-net operated by the National Research Institute for Earth Science and Disaster Resilience (NIED). The F-net seismograms show the 14 T-phase signals in the short-period component (2-8Hz), and corresponding surface waves in the long-period component (0.01-0.05 Hz). To determine the source mechanism, we performed seismic waveform inversion in the frequency domain (Nakano et al., 2008).

The spectra of the broadband data show a large amplitude at 0.02-0.05Hz with a peak at 0.04 Hz. The amplitude is high at 0.06-0.12 Hz and 0.2-0.5 Hz due to the microseisms. Therefore, for the waveform inversion, we used a 0.02-0.05 Hz window.

The inversion technique estimates the source time function (STF) acting on a fixed location by minimizing the difference between observed and synthetic waveforms. The synthetic waveforms are a convolution of the pre-computed Green's function and the STF. We fixed the mechanisms and location (29.7N, 140.0E, 0km depth). We assumed three source mechanisms, single-force, double-couple, and isotropic mechanisms.

The figure shows the STFs of the vertical component of the 13 inverted events assuming a single-force mechanism. The main period is about 25 seconds, and the shape is a harmonic function. The event duration is 1-2 min and depends on the event. The horizontal STFs are substantially smaller than the vertical component. We also tested double-couple and isotropic mechanisms. The residual of isotropic mechanism is larger than the single-force mechanism, but smaller than the double-couple mechanism. A force source symmetric about the Z axis, such as a single-force or isotropic mechanism, explains the waveform better than a double-couple mechanism.

Our analysis shows that this sequence of events has a similar mechanism with different amplitude and duration. The amplitude increased up to event 12 and decreased for events 13 and 14, which is consistent with the T-phase amplitude and tsunami STF (Sandanbata et al., 2024). The vertical STF is dominant for all events, so the source of the tsunami is either the uplift or subsidence of the seafloor caldera.

STF (single-force 0.02-0.05Hz)