

3-D Finite Difference Simulation for the 2003 Tokachi-oki Earthquake

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Associated with the 2003 the Tokachi-oki earthquake (2003/09/26,04:50, 41.7797N, 144.0785E, 42km; JMA, Mw 8.0), which is an interplate earthquake of Kuril Trench, the long-period ground motion with long duration was observed. At Tomakomai located more than 200 km from epicenter, large oil tanks were damaged by sloshing and a heavy fire broke out. It was pointed out that the cause of these damages was the long-period ground motion due to the combination of the large earthquake and the deep sedimentary plain. We performed a simulation of the wave propagation of this earthquake with 3D finite-difference method (FDM) to examine this phenomenon.

We constructed the crustal model for FD simulation based on the crustal structure estimated by travel time analysis (Iwasaki et al., 1991). We also adopted the Pacific plate model that was compiled by the Headquarters for Earthquake Research Promotion (2003). On the top of the model, taking into consideration the result of the refraction surveys, reflection surveys, downhole measurements and the geological information, we established sedimentary layers consisting of five layers. There are several plains that have deep sediments such as Tokachi plain, Ishikari plain and Konsen plain. Yufutsu plain where Tomakomai is located has an especially thick sediment whose maximum thickness is near 10 km.

Honda et al. (2004) estimated the rupture process of this earthquake by the multi-time window linear waveform inversion method (Hartzell and Heaton, 1983). The observed acceleration records from 15 stations of K-NET and KiK-net whose epicentral distance is less than 200 km are integrated into velocity and bandpass filtered between 0.02 - 0.2 Hz and used for the inversion analysis. We discretized their rupture model and used it for FD simulation.

The minimum volume of the FD model is 400 km square by 100 km deep in order to include the large fault model (140km*160km) and Yufutsu, Tokachi, Ishikari and Konsen plains. If we use the grids with uniform spacing, 250m, in the entire 3D simulation model space, the total number of the grid is more than a billion that requires impractically heavy computation. In this study, we used discontinuous grids that consist of small grids (spacing of 250 m) in the region shallower than 10 km where there are low-velocity sedimentary layers, and coarse grids (spacing of 750 m) in the deeper region. In this way, we were able to reduce both the time and memory required for the computation to approximately 1/7 of what was needed in a calculation using small, uniform grids in the entire region.

Our simulation showed that the incident waves are amplified by the soft sediment and successfully reproduced the long-duration wave in the Yufutsu plain. Waves are trapped in the soft sediment and continue for several hundred seconds by propagating back and forth in the plain. Similar phenomena are also witnessed at other deep plains, Tokachi, Ishikari and Konsen plains. This implies that if large-scale structures had existed on those plains, they would have been severely damaged.