Sub-basin effects during the 2003 Tokachi-oki earthquake

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The 2003 Tokachi-oki earthquake generated significant long-period ground motion and extended duration of a few hundred seconds in the Yufutsu basin, where oil tanks were damaged at Tomakomai by sloshing due to the long-period ground motion. We have performed the 3D finite-difference (FD) simulation to explore generation and propagation mechanisms of the long-period ground motion using a source model from the waveform inversion and a geological- and geophysical-based 3D velocity model. General characteristics of long-period ground motion due to a combination of the large earthquake and the deep sedimentary basin were reproduced by large-scale computation in a period range of 3.3 to 25 s. Towards quantitative understanding of the long-period ground motion, we here focus on basin and sub-basin response to long-period ground motion in the Yufutsu basin. The Yufutsu basin is composed of whole basin shape and inside sub-basin, where the basin becomes thicker from west to east with a deepest point of 7 km, in contrast the sub-basin becomes thicker from east to west with a deepest point of 1 km or more. The long-period ground motions were amplified in the both eastern and western parts of the basin, and those durations were much extended in the western part. Visualization of the 3D FD simulations displays that the surface waves from the source direction are amplified in the both eastern and western part of the basin at the first 100 s. In the next 100 s, the surface waves are still trapped inside the sub-basin composed of shallow layers, and these layers amplified ground motions and extended the duration in the western part of the basin. A series of our computations with/without each velocity layer in the basin examined that the basin response is recognized as 1.5 to 2 times of amplification, and the sub-basin response as extension of ground motion durations and around 1.5 times of amplification. The importance of the interaction between the basin and sub-basin response was qualitatively pointed out by the 2D numerical simulations. Our 3D FD simulations quantitatively clarified that the combination of the both basin and sub-basin response is essential for understanding of disastrous long-period ground motions in the Yufutsu basin during the 2003 Tokachi-oki earthquake.