Long-duration long-period ground motion in Hokkaido during off-Tohoku earthquakes (2) Roles of crust and Pacific slab

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Anomalously large, long-time-lasting long-period later phases were observed widely in Hokkaido, Japan during moderate to large (M>6.5) earthquakes occurred at off-Tohoku Pacific earthquakes. Such long-period signals spread widely over Hokkaido not only at deep Ishikari basin as reported by Noguchi et al. (2017; JpGU). In this study we discuss new mechanisms to generate this later phase in addition to well recognized deep sediment effect by means of 3D FDM simulations of seismic wave propagation using 3D heterogeneous subsurface structure model.

This long-period later phase caused by off Tohoku earthquakes appeared at most F-net stations in Hokkaido except for a few stations at southwestern Hokkaido. However, these later phases did not appear from inland earthquakes, outer-rise earthquakes and earthquakes occurred near Hokkaido. Dominant period of this later phases lay within the range between 15 s to 25 s, varying among earthquakes. The later phase in transverse component expected to be Love wave showed longer period and appeared earlier than that in radial and vertical components expected to be Rayleigh wave. Both waves showed normal dispersion.

The FDM simulations of seismic wave propagation in 3D heterogeneous crust and mantle structure was conducted using OpenSWPC (Maeda et al., 2017). This simulation model consists of sea water, topography, sediments and subducting plates based on Japan Integrated Velocity Structur Model (JIVSM; Koketsu et al., 2012) and the depth of Moho and Pacific slab is based on Matsubara et al. (2017) and Kita et al. (2010), respectively.

We confirmed two distinct phenomena from the FDM simulations as follows; Firstly, long tail of Rayleigh wave (< 3 km/s) propagating north and southward at western-side of Japan trench following the main packet of surface wave were generated. Then the long wavetrains spreading over Hokkaido were generated by conversion from the Rayleigh wave northward along trench at the edge of deep sediment at off Ishikari. Secondly, Love wave appearing at the junction of Japan trench and Kuril trench extended over Hokkaido in earlier time than the converted Rayleigh wave.

We investigated the phase and group velocities for Rayleigh wave and Love waves from off Tohoku to Hokkaido; we found a lower-wavespeed zone of group and phase velocities for Rayleigh wave at period around 20 s guiding Rayleigh wave along the west side of Japan trench, where was formed by the subsurface low-velocity layer covering over the Pacific slab. Such low-wavespeed zone was not appeared for Love wave. However, strong velocity contrast between the Pacific side and Japan side of trench due to different crustal thickness was confirmed which bended the ray of Love wave toward low-velocity side. Thus, Love waves traveling along low-velocity side released seismic energy toward Hokkaido at the junction of Japan trench and Kuril trench, producing anomalously large and long-time lasting long-period ground motions.

We conclude that the long period later phase observed over Hokkaido during off Tohoku earthquakes

were caused by the deep subsurface structure including crustal thickness and subducting slab in addition to deep sediments at off Ishikari.

Keywords: Long period ground motion, Subduction zone, Wave propagation simulation

