Supporting Information for

"Elastogravity waves and dynamic ground motions in the Korean Peninsula generated by the 11 March 2011 M_W9.0 Tohoku-Oki megathrust earthquake"

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Introduction

This supporting information provides additional materials with discussion and figures.

Additional information

The 11 March 2011 M_W9.0 Tohoku-Oki megathrust earthquake produced strong seismic waves that propagate through the Earth. Strong low-frequency energy is persistently observed at regional and teleseismic distances (Fig. S1). The low frequency energy is observed in all three components. The peak ground displacements are ∼1 cm around the antipodal regions.

The full-frequency-range ground motions are calculated using a time-domain deconvolution and integration method based on unclipped broadband velocity records. In order to verify the method and resultant records, we compare the displacement records with those from conventional signal processing (Fig. S2). Considering the frequency limitation of conventional signal processing method, we produce displacement records in frequencies of 0.004-8.0 Hz from raw velocity record sections using a frequency-domain deconvolution method. Also, we prepare the displacement records in the same frequency band retrieved from the full-frequency-range displacements. We find that the displacement records match well each other at both stations (SES, KWJ). The observation supports the validity of the method for recovery of full-frequency-range ground motions.

We separate the seismic energy in the full-frequency-range ground motions by frequency. The ground motion records for the Tohoku-Oki earthquake are bandpass filtered between 0.004 and 8.0 Hz, presenting dominant low-frequency energy (Fig. S3). On the other hand, the 12 September 2016 M_L5.8 (M_W5.4) Gyeongju earthquake present seismic energy dominant at frequencies >0.03 Hz (Fig. S4).

We analyze unclipped seismic records from accelerometers for the Tohoku-Oki earthquake

and Gyeongju earthquake. We measure the, peak ground displacement (PGD), peak ground velocity (PGV), and peak ground acceleration (PGA) (Figs. S5, S6, S7).

The PGDs of the Tohoku-Oki earthquake at far-regional distances are ∼20-500 times larger than those of the Gyeongju earthquake at all distances (Fig. S5). The PGVs for the Tohoku-Oki earthquake are comparable to those for the Gyeongju earthquake in tens of kilometers (Fig. S6). The PGAs of the Gyeongju earthquake are larger than 50 cm/s^2 in distances $\leq$ 100 km, while those for the Tohoku-Oki earthquake are less than 1 cm/s^2 in all regions (Fig. S7).

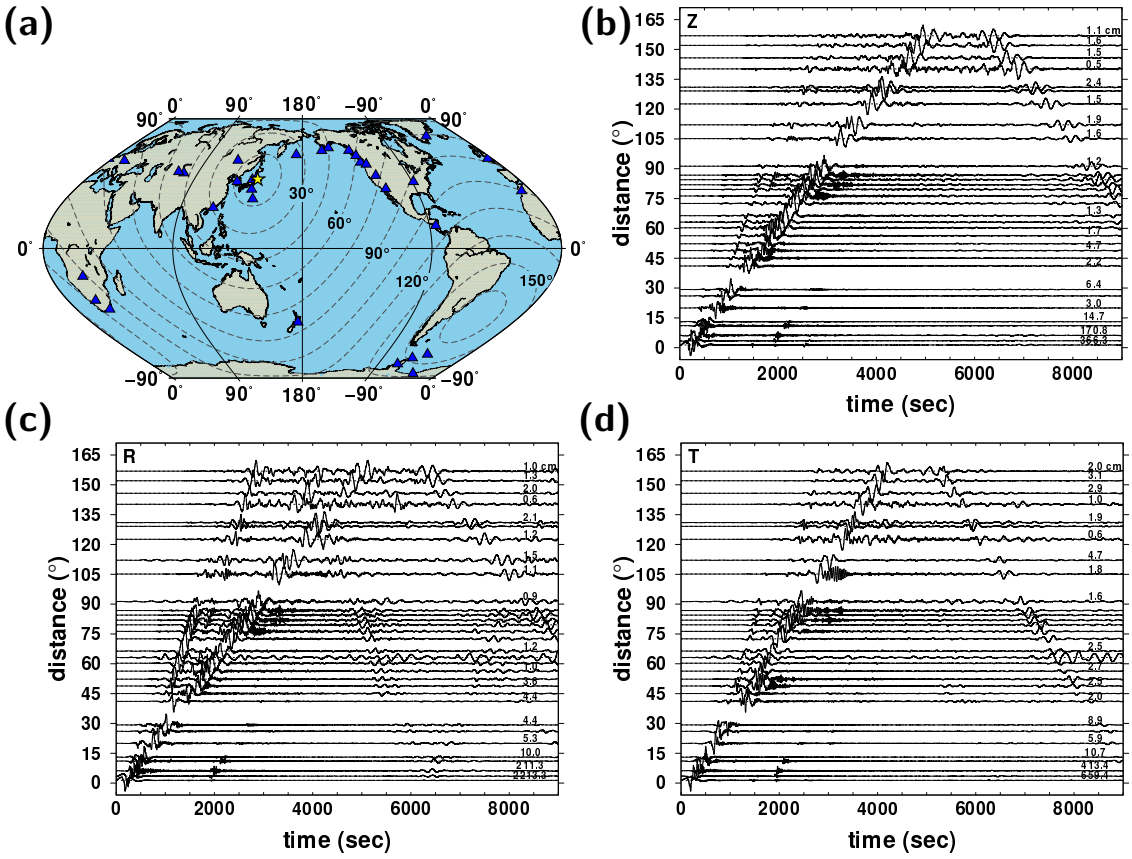

Figure S1. Displacement seismic waveforms for the 2011 M_W 9.0 Tohoku-Oki megathrust earthquake: (a) map of the event and stations, and seismic records on the (b) vertical, (c) radial and (d) tangential components. The seismic records are bandpass filtered in the frequency range of 0.004-8.0 Hz. Strong low-frequency seismic records are observed over the globe.

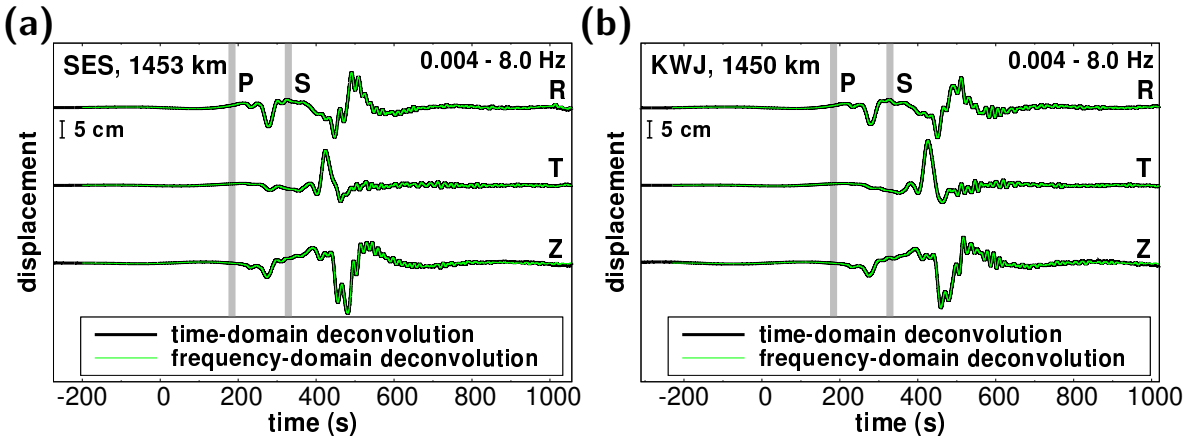

Figure S2. Comparison of three-component ground motion records in frequencies of 0.004-8.0 Hz at stations (a) SES, and (b) KWJ. One record section is retrieved from the ground motions in the full frequency range that are calculated based on a time-domain deconvolution method. The other record section is obtained from the raw record section based on a conventional signal processing based on a frequency-domain deconvolution method. The waveform records match well each other. The arrival times of P and S waves are marked.

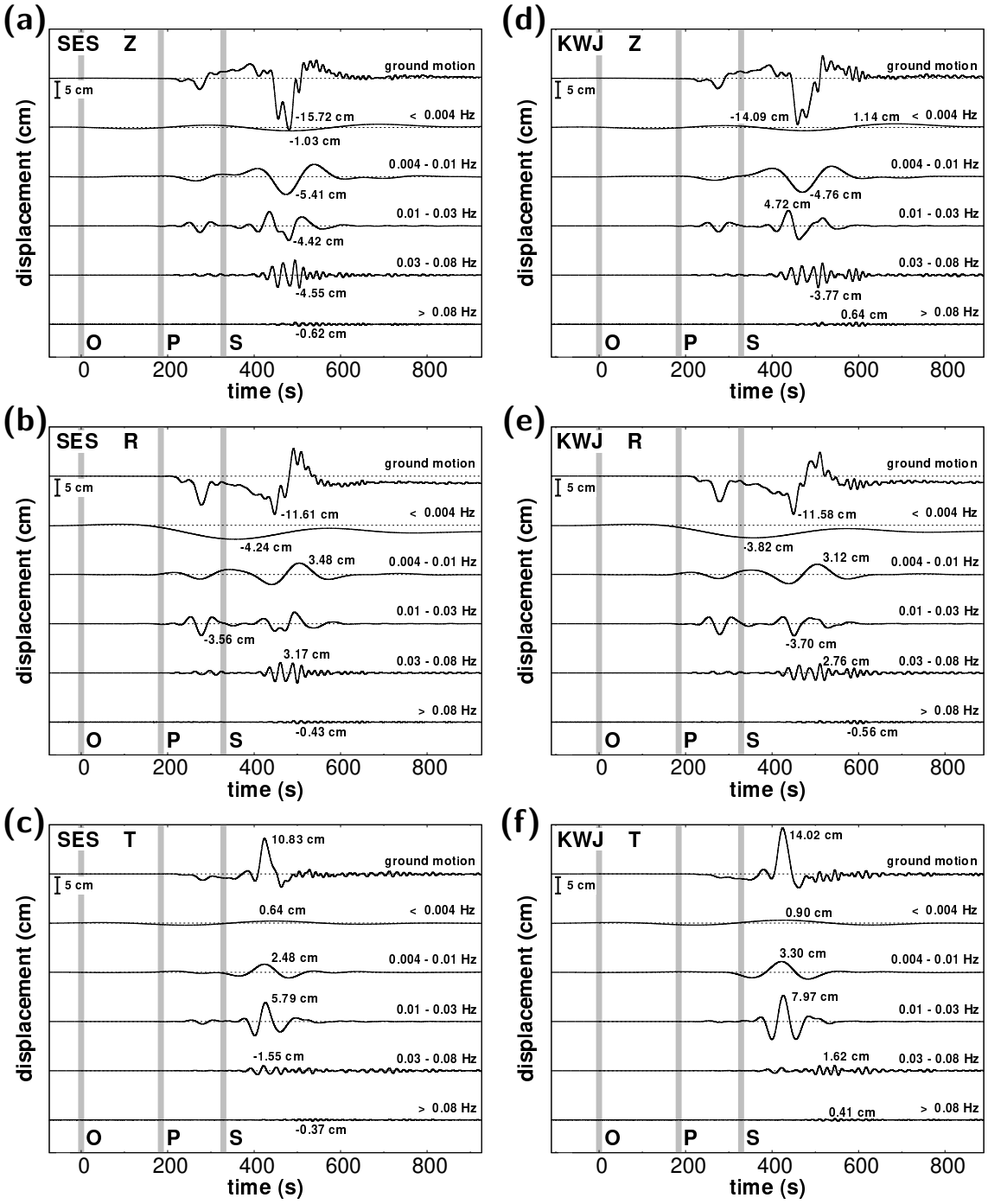

Figure S3. Three-component waveform record sections for the 11 March 2011 M_W9.0 Tohoku-Oki megathrust earthquake: (a) vertical, (b) radial and (c) tangential components at station SES, and (d) vertical, (e) radial and (f) tangential components at station KWJ. The peak amplitudes are annotated. Most energy is observed at frequencies of less than 0.08 Hz. The energy of the seismic waveforms at frequencies of 0.03-0.08 Hz is contained mostly within the surface waves. The arrival times of P and S waves are indicated.

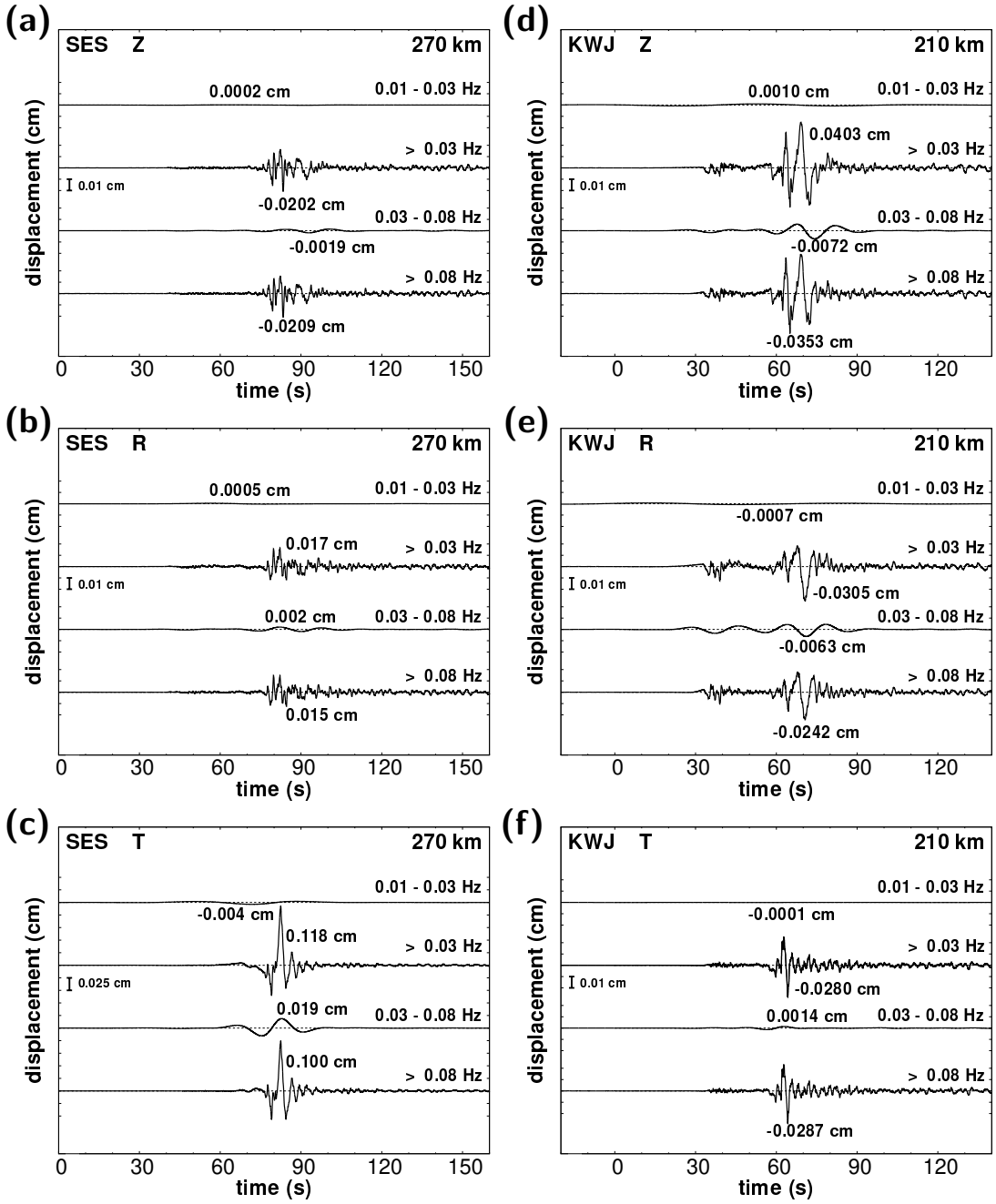

Figure S4. Three-component seismic waveforms for the 12 September 2016 M_L5.8 (M_W5.4) Gyeongju earthquake Gyeongju earthquake: (a) vertical, (b) radial and (c) tangential components at station SES, and (d) vertical, (e) radial and (f) tangential components at station KWJ. Most seismic energy is at frequencies greater than 0.08 Hz. The epicentral distances and peak amplitudes are annotated.

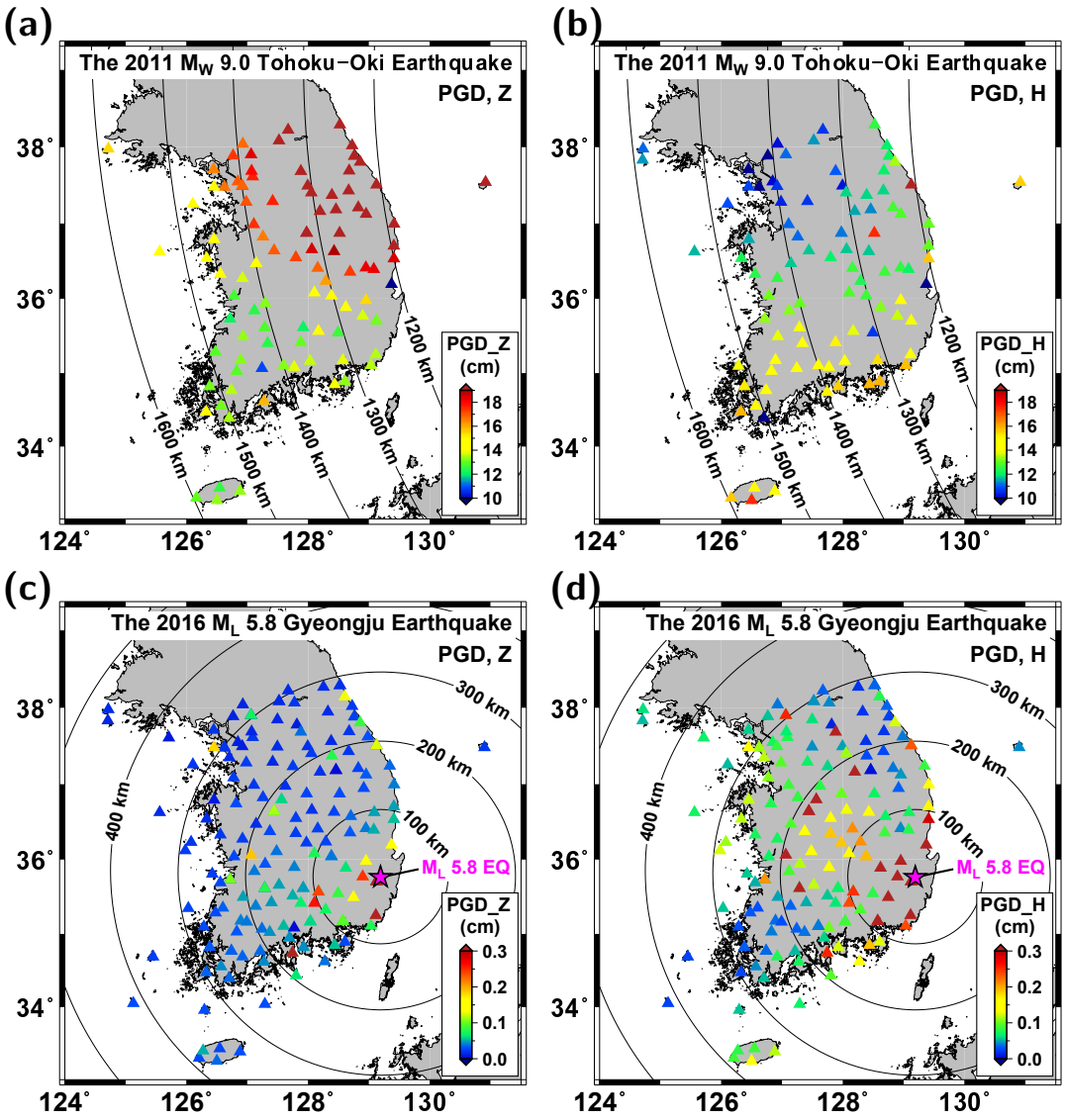

Figure S5. Peak ground displacements (PGDs) for the Tohoku-Oki earthquake in the (a) vertical and (b) horizontal directions, and for the Gyeongju earthquake in the (c) vertical and (d) horizontal directions. The PGDs for the Gyeongju earthquake at local distances are much weaker than those for the Tohoku-Oki earthquake at far-regional distances.

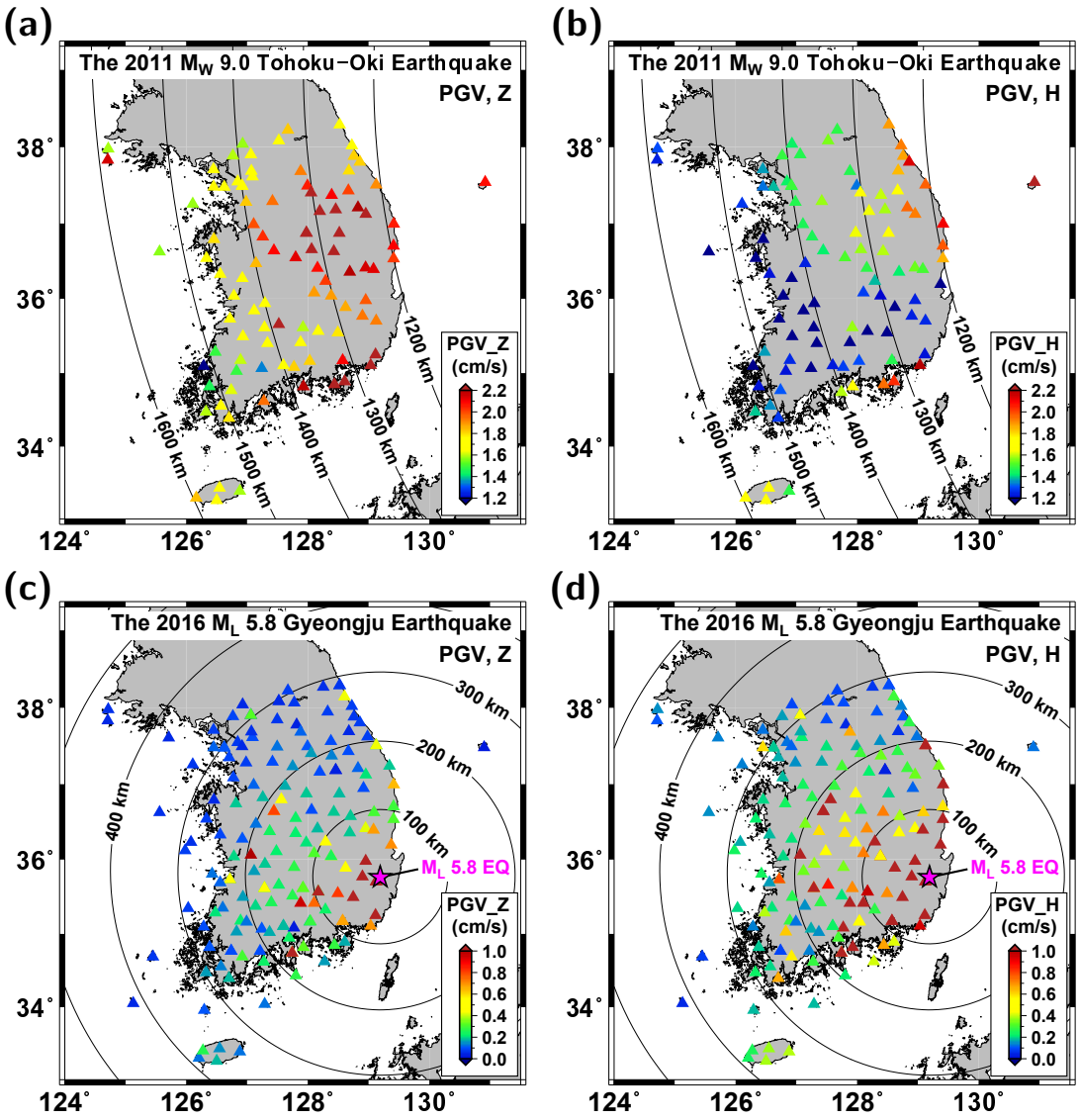

Figure S6. Peak ground velocities (PGVs) for the Tohoku-Oki earthquake in the (a) vertical and (b) horizontal directions, and for the Gyeongju earthquake in the (c) vertical and (d) horizontal directions. The PGVs for the Gyeongju earthquake at local distances are comparable to those for the Tohoku-Oki earthquake at far-regional distances.

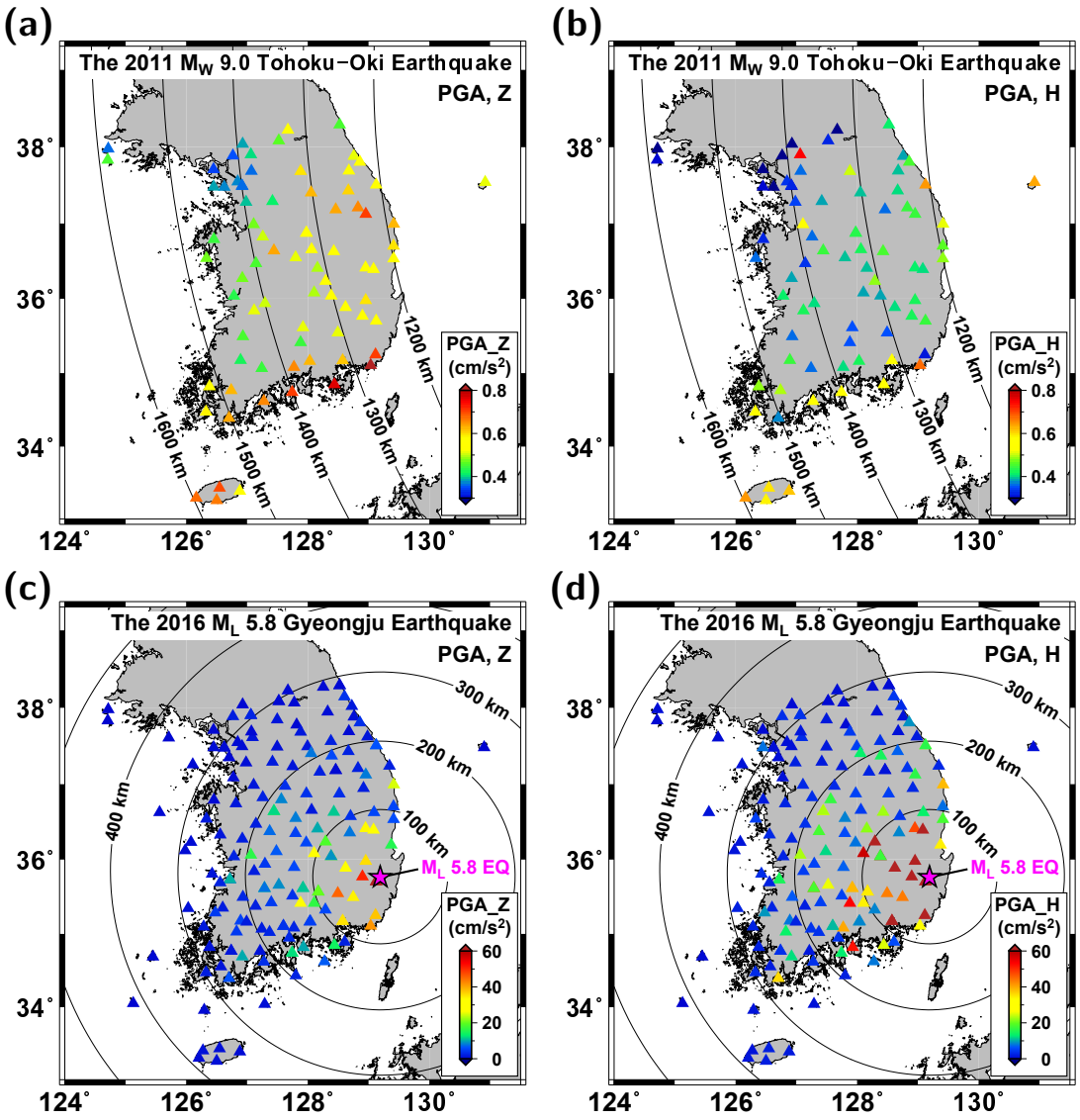

Figure S7. Peak ground accelerations (PGAs) for the Tohoku-Oki earthquake in the (a) vertical and (b) horizontal directions, and for the Gyeongju earthquake in the (c) vertical and (d) horizontal directions. The PGAs for the Gyeongju earthquake at local distances are much stronger than those for the Tohoku-Oki earthquake at far-regional distances.