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Determination of Earth structure using waveform inversion and Spectral-Element Method

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Recent progress in large scale computing by using Spectral-Element Method and the Earth Simulator has demonstrated possibilities to perform full-waveform inversion of three dimensional (3D) seismic velocity structure inside the Earth. Specifically Liu and Tromp (2006) have shown that it becomes feasible to compute finite frequency kernel for seismic velocity structure based on adjoint method. We apply their method to obtain 3D velocity structure beneath East Asia. We take one chunk from global mesh of Spectral-Element Method and compute synthetic seismograms with accuracy of about 10 second. We use GAP-P2 mantle tomography model (Obayashi et al., 2009) as an initial 3D model and try to use as many broadband seismic stations available in this region as possible to perform inversion. We then use the time windows for body waves and surface waves to compute adjoint sources and calculate adjoint kernels for seismic velocity structure. We use the earthquakes, which occurred in East Asia since 2001, with magnitude greater than 5.5 and selected 161 events for this inversion. One iteration of the waveform inversion using 256 cores of massively parallel supercomputer, such as K-computer, requires 0.1 million CPU hours. We have performed several iteration and obtained improved 3D velocity structure beneath East Asia. The result demonstrates that waveform misfits between observed and theoretical seismograms improves with the iteration proceeds and it now becomes feasible to perform waveform inversion within practical computational time. We will use much shorter period in our synthetic waveform computation and will try to obtain seismic velocity structure for basin scale model in our future study.

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Keywords: Earth structure, Seismic tomography, Synthetic seismogram, Spectral Element Method