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# Structure imaging by cross-correlation of local earthquake records: Simulation on source distribution and artifacts

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Seismic interferometry synthesizes a seismic response (often called a virtual shot record) that would be recorded at one receiver as if there was a source at the other receiver location by cross-correlating the seismic traces observed at two receivers. This operation is equivalent to retrieving surface-related reflections. By applying the method to natural local earthquake records observed at a dense receiver array, we can simulate a seismic reflection survey of crustal scale without any artificial sources. Subsurface imaging can be accomplished by adopting highly advanced data processing and imaging technology of reflection seismology to the virtual shot records. In order to synthesize virtual shot records with sufficient accuracy, the assumption of seismic interferometry that sources are distributed densely and uniformly in space should be satisfied. However, the lopsided distribution of the hypocenter of natural earthquakes may result in lowering signal-to-noise ratio of the synthesized virtual shot records and generating artifacts on the seismic profiles.

In this study, numerical experiments were conducted regarding the accuracy and reliability of seismic interferometry using local earthquake records for imaging crustal structure. Following three points were investigated: 1) the influence of lopsided source distribution of natural earthquakes on the virtual shot records and the imaged profiles, 2) the source-receiver geometry that is effective for imaging the target crustal structures, and 3) the origin of artifacts and the way to suppress them. A 2-D model simulates subsurface structures beneath Tokai region in central Japan including crustal structures and subducting oceanic plate. The model is defined by 100 km x 50 km in the horizontal and the vertical direction. The survey line is subparallel to the convergence direction of the Philippine Sea plate. Using the sources distributed in shallow crust, deeper crust, oceanic slab and continental slab, 125 SH-wave seismograms were calculated in total.

As the results, the accuracy of the virtual shot records improves as the number of the sources (earthquakes) increases. The quality of the records depends on the spatial relation among the sources, the receivers and target reflector. Particular combinations of the sources and the receivers were found effective to synthesize virtual reflection records with fewer sources. Such source-target-receiver geometry is consistent with the concept of stationary phase that has been theoretically derived by previous studies. Imaging the target structures is possible as long as the geometry is retained even if the earthquake sources are not necessarily distributed uniformly, nor the range and number of the receivers are limited. The depth-migrated profile obtained using earthquakes distributed in the continental slab and oceanic slab shows good illumination to the target structures from shallow to deep area. The study shows that some particular type of artifacts are dependent on the source depth. Such depth-dependent artifacts in the migrated profiles can be suppressed by increasing the source depth variation.

Keywords: seismic wave, scattering, interferometry, crustal structure, imaging, simulation