Time reversal in heterogeneous solid half-spaces

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The heterogeneities of elastic properties in the Earth's interior exist over all scales. Seismic waves propagating through heterogeneous media are scattered thus the waveforms are distorted. Consequently, our ability to image the source is compromised. Time reversal technique can utilize the reciprocity of linear elastodynamics and can be applied effectively in heterogeneous media. In this work, the refocusing properties of time reversal wave fields in heterogeneous solid half-spaces are investigated numerically. Here the 3D numerical simulations are performed with a spectral-element method by using open-source software package SPECFEM3D. The simulation results indicate that in the regime where the heterogeneous scale is of the order of the dominant seismic wavelength, the refocusing fields become statistical stable that they are independent of the particular realizations of random fields. Furthermore, the super-resolution phenomenon is also observed as the width of focal spot can transcend the diffraction limit, i.e., the effective array aperture is increased due to the multi-pathing and multi-scattering effects caused by heterogeneities.