ABSTRACT
Fractures play an important role in most carbonate and unconventional reservoirs. They can be major resources for hydrocarbon fluid storage and migration pathways. Identifying fractures and their associated properties in fractured anisotropic reservoirs can have significant impact on reservoir management and hydrocarbon recovery. Traditional seismic methods for fracture identification and characterization, such as shear birefringence and amplitude variations with offset and azimuth, are based on equivalent medium theory with the assumption that fracture dimensions and spacing are small relative to the seismic wavelength. We present an alternate study based on seismic modeling and scattered seismic energy. Forward modeling with the discontinuous Galerkin (DG) finite element algorithm provides the seismic responses from individual fractures and fractured layers. We simulate 1D compressional plane wave reflection and transmission coefficients for a single fracture represented by a linear slip condition and compare them to the analytical solution. The expected phase shift and amplitude effects were obtained from the DG simulation test. Meanwhile, the analytical solutions were derived from a compressional plane wave in a linear slip boundary condition. This confirmed the discontinuous Galerkin method using the linear slip condition to represent a fracture provides good agreement with the analytical solution. Furthermore, to study the effects of multiple fractures represented by the linear slip condition, we simulated 3D elastic wave propagation through a one-layer model and a three-layer model. The scattering energy among fractures was observed, but the scattering pattern varied with different planes and azimuths in 3D.
Z component for three planes (X-Z, Y-Z, X-Y plane) extracted from the 3D wavefield of a one-layer fractured medium. The P and S-wave scattering energy is obvious in the wavefield.