Synthesis of High-Frequency Vector-Wave Envelopes in von Karman-type Random Media
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High-frequency seismogram envelopes of an earthquake are broadened with travel distance increasing. For P-wave, there is an excitation of the transverse-component amplitude with travel distance increasing. These phenomena are explained by scattering due to randomly velocity inhomogeneities, and mathematically described by the statistical treatment of the wave equation in random media. When random media are characterized by a Gaussian auto correlation function, an analytical solution of vector-wave envelopes has been obtained and the resultant vector-wave envelopes show broadening with travel distance; however, they are frequency independent. Here we study the envelope broadening in von Karman-type random media since they have realistic power-law spectrum at large wavenumbers. When the wavelength is smaller than the correlation distance of random media, the wave equation is approximated by the parabolic equation. Considering an ensemble of random media, we introduce the two-frequency mutual coherence function (TFMCF) of potential fields on the transverse plane orthogonal to the global ray direction. Then we statistically derive the master equation for the TFMCF as the ensemble average. Improving the finite difference simulation method and applying a new boundary condition for solving the scalar wave case, we numerically solve the master equation for the case of von Karman-type random media. By using the Fourier transform of TFMCF solution, we can derive accurate synthesis of vector-wave envelopes. Synthesized vector-wave envelopes show broadening and excitation of transverse component with travel distance increasing for the case of P-wavelet radiation from a point source in 3-D random media. The frequency dependence of the synthesized envelopes is controlled by the roll-off of the power spectrum of random inhomogeneity. We find that the peak delay time of transverse component is longer than that of longitudinal component. The envelope broadening of each component and the excitation of the transverse component become larger as the power spectrum becomes richer in short wavelength components. The time integral of the transverse-component mean square envelope with geometric correction increases according to a power of travel distance.