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Simulation of near-surface seismic wave propagation in porous media

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We present a novel numerical algorithm for the simulation of poro-elastic seismic wave propagation in general and for the accurate and realistic modeling of Scholte, Stoneley, and Rayleigh waves in porous media in particular. The differential equations of motion are based on Biot's theory of poro-elasticity and solved with a pseudo-spectral approach using Fourier and Chebyshev methods to compute the spatial derivatives along the horizontal and vertical directions, respectively. We stretch the mesh in the vertical direction to decrease the minimum grid spacing and reduce the computational cost. The free-surface boundary conditions are implemented with a characteristics approach, where the characteristics variables are evaluated at zero viscosity. The same procedure is used to model seismic wave propagation at the interface between a fluid and porous medium. In this case, each medium is represented by a different mesh and the two meshes are combined through a domain-decomposition method. We simulate seismic wave propagation with open and sealed boundary conditions and compare the numerical solution to an analytical solution obtained from the 2-D Green's function. This algorithm represents a versatile and powerful basis for the poro-elastic analysis and interpretation of near-surface seismic wave propagation phenomena in general and of seismic surface-wave-type data in particular.