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1D and 2D simulations of seismic wave propagation in fractured media

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Fractures and cracks have a significant influence on the propagation of seismic waves. Their presence causes reflections and scattering and makes the medium effectively anisotropic. We present a numerical approach to simulation of seismic waves in fractured media that does not require direct modelling of the fracture itself, but uses the concept of linear slip interfaces developed by Schoenberg (1980). This condition states that at an interface between two imperfectly bonded elastic media, stress is continuous across the interface while displacement is discontinuous. It is assumed that the jump of displacement is proportional to stress which implies a jump in particle velocity at the interface. We use this condition as a boundary condition to the elastic wave equation and solve this equation in the framework of a Nodal Discontinuous Galerkin scheme using a velocity-stress formulation. We use meshes with tetrahedral elements to discretise the medium. Each individual element face may be declared as a slip interface. Numerical fluxes have been derived by solving the 1D Riemann problem for slip interfaces with elastic and viscoelastic rheology. Viscoelasticity is realised either by a Kelvin-Voigt body or a Standard Linear Solid. These fluxes are not limited to 1D and can - with little modification - be used for simulations in higher dimensions as well. The Nodal Discontinuous Galerkin code “neXd” developed by Lambrecht (2013) is used as a basis for the numerical implementation of this concept. We present examples of simulations in 1D and 2D that illustrate the influence of fractures on the seismic wavefield. We demonstrate the accuracy of the simulation through comparison to an analytical solution in 1D.