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Three dimensional modelling of earthquake rupture cycles on frictional faults

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We are developing an efficient MPI-parallel numerical method to simulate earthquake sequences on preexisting faults embedding within a three dimensional viscoelastic half-space. We solve the velocity form of the elasto(visco)dynamic equations using a continuous Galerkin Finite Element Method on an unstructured pentahedral mesh, which thus permits local spatial refinement in the vicinity of the fault. Friction sliding is coupled to the viscoelastic solid via rate- and state-dependent friction laws using the split-node technique. Our coupled formulation employs a picard-type non-linear solver with a fully implicit, first order accurate time integrator that utilises an adaptive time step that efficiently evolves the system through multiple seismic cycles. The implementation leverages advanced parallel solvers, preconditioners and linear algebra from the Portable Extensible Toolkit for Scientific Computing (PETSc) library. The model can treat heterogeneous frictional properties and stress states on the fault and surrounding solid as well as non-planar fault geometries. Preliminary tests show that the model successfully reproduces dynamic rupture on a vertical strike-slip fault in a half-space governed by rate-state friction with the ageing law.