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Tandem: A discontinuous Galerkin method for sequences of earthquakes and aseismic slip on multiple faults using unstructured curvilinear grids

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Seismic cycle modeling has advanced to the point where 3D models could be connected to geodetic and seismic observations to test hypotheses about controls on the depth and along-strike extent of ruptures, and interactions between seismic and aseismic slip events in geometrically complex fault systems. Such an undertaking does however require a greater degree of geometrical flexibility, material behaviors, code performance, and community participation than has so far been the standard.

In this light we present tandem, an open-source C++ code for 3D earthquake sequence modeling (Uphoff et al., 2022a). Tandem solves the elasticity problem with a discontinuous Galerkin finite element method on unstructured tetrahedral meshes. It can handle multiple, nonplanar faults and spatially variable elastic properties (Figure 1). The method can be extended to nonlinear off-fault material response (e.g., power-law viscoelasticity). The code is parallelized with MPI and uses the PETSc-TAO library (Balay et al., 2022) for time-integrators and preconditioned Krylov methods to solve the static elasticity problem. Faults are governed by rate- state friction and adaptive time-stepping permits modeling of dynamic rupture, the postseismic period, and interseismic loading, all across multiple earthquake cycles. The code is developed with best practices for open-source community software and includes documentation and tutorials to facilitate use by the community (github.com/TEAR-ERC/tandem).

Uphoff, C., D. A. May, and A.-A. Gabriel (2022a), A discontinuous Galerkin method for sequences of earthquakes and aseismic slip on multiple faults using unstructured curvilinear grids, Geophysical Journal International.
Balay, S., et al. (2022), PETSc/TAO users manual, Tech. rep., Argonne National Lab., Argonne, IL, USA (petsc.org/).