ABSTRACT
Much research in numerical seismology is focused on the development of methods to approximate acoustic and elastic wave propagation in the Earth. More recently, Finite Element Methods (FEM) have become increasingly popular to model seismic wave propagation. These methods offer better control on the accuracy and more geometrical flexibility than finite difference methods that have been traditionally used for the generation of synthetic seismograms. In this work, we first formulate and implement an enriched Galerkin finite element method (EG) for elastic wave propagation. EG is formulated by enriching the Galerkin finite element method (CG) with piecewise constant or linear functions. The additional piecewise constant or linear functions can be considered as additional penalty stabilization terms. The EG method is both locally and globally conservative, while keeping lower degrees of freedom when compared to the Discontinuous Galerkin finite element method (DGM). We consider the continuous, discontinuous and enriched Galerkin approximations for the elastic wave propagation problem and present numerical optimal a-priori error estimates. We include some numerical examples in two dimensions to verify the theoretical results. In addition, we also numerically simulate elastic wave propagation in fractured media using the linear slip model (LSM) and EG. Further, we validate this numerical solution with the DG solution and show that convergence estimates similar to the above can be observed. Therefore, we see that EG has some advantages over DGM while keeping the computational costs comparable to SEM.
a) Vertical snapshots at t=0.3s for a homogeneous medium for DGM, SEM, EG (left to right) using a ricker source b) Horizontal snapshots at t=0.3s for a homogeneous medium for DGM, SEM, EG (left to right) using a ricker source c) Computed error estimates versus the mesh size, h, for different polynomial approximation degrees k = 2, 3, and 4. A good match between the snapshots from all the three methods can be seen. The error curves tell us that the solution converges to the true solution as the mesh size decreases and the polynomial degree increases.