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Combining Discontinuous Galerkin and Finite Differences Methods for Simulation of Seismic Wave Propagation

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Abstract

In this paper we present an original approach to combination of standard staggered grid finite-difference scheme with interior penalty discontinuous Galerkin (DG) method for simulation of seismic wave propagation in presence of sharp interfaces with complex topography. The approach takes the advantages of the two numerical techniques. Discontinuous Galerkin methods is applied in the vicinity of the free-surface or sea-bed ensuring accurate approximation of the surface by the triangular (tetrahedral) mesh. However, DG is typically more computationally intense than finite differences (FD). So, in the major part of the model the FD are applied to reduce the overall computational cost of the algorithm. As the result the designed approach combines high accuracy of the DG with computational intensity of the FD.

The idea of the approach is to combine the two approaches via transition zone where P0 discontinuous Galerkin method on a regular rectangular grid is used. This formulation is equivalent to the conventional (nonstaggered grid) scheme, approximating the elastic wave equation with a second order. So, the coupling of FD with the DG on arbitrary triangular mesh is reduced to the two independent problems. First, standard staggered grid scheme should be combined with a conventional scheme. This is done on the base of approximation of the reflection coefficients, either physical and artificial (corresponding to the spurious modes). Second, the DG on an arbitrary mesh is coupled with DG on a regular rectangular grid (conventional finite difference scheme). This is done on the base of hp-adaptivity of the DG method.

Key words: discontinuous Galerkin, finite differences, elastic wave quation.