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Modeling of Seismic Wave Propagation Through Strongly Heterogeneous Material

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We address the problem of modeling seismic wave propagation through heterogeneous material. Especially, for material variations with a spatial wavelength of the order of the mesh width, numerical methods have to be tested and their results have to be validated carefully in order to produce reliable synthetic seismograms. The high-order accurate Discontinuous Galerkin (DG) Finite-Element method combined with a time integration scheme based on the solution of Arbitrary accuracy DErivatives Riemann problems (ADER) is extended to the case of variable material approximation inside a finite element. To this end, polynomial functions of different degrees are used similar to the approximation of the wave components, i.e. stresses and particle velocities. However, the material approximation order can be chosen independently of the order of the wave propagation approximation. This way, computational cost can be kept low in cases where the material variations are smooth. The corresponding extension of the ADER-DG scheme is presented in detail. Additional terms in the form of volume integrals and the computational cost of the calculation of flux and stiffness terms per element increases. However, due to the more accurate representation of the material the scheme can use much coarser meshes even for strongly heterogeneous material with short spatial wavelengths. Our results are compared to those obtained with other numerical schemes, such as Finite Differences and Spectral Elements to investigate the performance and limitations of the different approaches for a series of numerical test cases. We particularly focus on cases typically encountered in the crust or sedimentary environments to demonstrate the feasibility of our new approach for important and realistic problems in computational seismology.