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A p-adaptive ADER-DG Scheme for Seismic Waves in highly complex 3-D Models

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The simulation of seismic wave propagation in a complex 3-D model is still a great challenge. Due to geometrical constraints, i.e. model features of complicated shape or small spatial extend, a small mesh spacing often has to be chosen to account for these features. Meshes consisting of tetrahedral elements are suitable for the discretization of such models as the tetrahedral faces can be aligned with the complex shapes of internal or external boundaries like subsurface material interfaces or free surface topography. Moreover, the transition from extremely fine to extremely coarse meshes is possible and allows for highly flexible discretizations with local mesh refinement where necessary or reasonable. However, the time step of explicit schemes like the highly accurate ADER-Discontinuous Galerkin (ADER-DG) method depends on the mesh spacing, i.e. the insphere radius of a tetrahedron, on the seismic wave speed inside the tetrahedral element, as well as on the utilized order of the polynomial approximation. Therefore, we present an adaptive ADER-DG approach, where the order p of the approximation polynomial can vary from one element to the other. To optimize for the required CPU-time, it seems to be logical to use high order approximation in large elements and lower order in small elements, where the spatial sampling of the problem is high anyway. This way, a larger time step is allowed and, moreover, the total number of degrees of freedom of the problem can be reduced drastically. However, the choice of the approximation order p for each tetrahedral element is still subject to ongoing research. Instead of coupling the order directly with the element size, it can also depend on particular zones of interests, where the high order approximation is required. We present comparisons between standard and p-adaptive ADER-DG schemes with respect to speedup versus loss of accuracy. Finally, applications to complex 3-D models are shown to comfirm the performance of the new schemes.