Discontinuous Galerkin Methods for the Shallow Water Equations Using Mixed Meshes

(poster presentation)

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Discontinuous Galerkin (DG) methods for the shallow water equations using mixed meshes that consist of triangular and quadrilateral elements in two-dimensions and triangular prisms and hexahedra in three-dimensions are developed, implemented, and tested. The main motivation behind this work is to gain more insight on whether the use of quadrilateral/hexahedral elements improves the efficiency of DG methods in a setting in which two (adjacent) triangular/triangular prism elements are merged to form a single quadrilateral/hexahedral element. The elements that are used in this study are constructed from a set of orthogonal, modal basis functions formed from products of Legendre and Jacobi polynomials. Given the fact that DG methods do not require continuity of the approximate solution between elements, quadrilateral and hexahedral element basis functions may be developed that exclude the usual cross-terms that are present in standard C^0 elements, e.g., a linear quadrilateral element may be used instead of a bilinear quadrilateral element. The performance of the developed DG methods on triangular/triangular prism meshes, quadrilateral/hexahedral meshes, and mixed element meshes of arbitrary polynomial order p is evaluated in terms of accuracy and computational time on a set of analytic test cases for the linear shallow water equations. The numerical results provide evidence that there may be a substantial benefit in using quadrilateral/hexahedral elements, especially for cases where p is low to moderate (up to $p = 5$ to 6).