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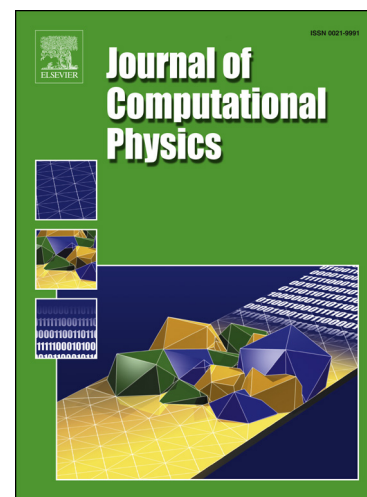
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1 A High Order Characteristic Discontinuous Galerkin Scheme
2 for Advection on Unstructured Meshes

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7 **Abstract**

8 A new *characteristic discontinuous Galerkin* (CDG) advection scheme is presented.
9 In contrast to standard discontinuous Galerkin schemes, the test functions themselves
10 follow characteristics in order to ensure conservation and the edges of each element are
11 also traced backwards along characteristics in order to create a *swept region*, which is
12 integrated in order to determine the mass flux across the edge. Both the accuracy and
13 performance of the scheme are greatly improved by the use of large Courant-Friedrichs-
14 Levy numbers for a shear flow test case and the scheme is shown to scale sublinearly with
15 the number of tracers being advected, outperforming a standard flux corrected transport
16 scheme for 10 or more tracers with a linear basis. Moreover the CDG scheme may be
17 run to arbitrarily high order spatial accuracy and on unstructured grids, and is shown
18 to give the correct order of error convergence for piecewise linear and quadratic bases on
19 regular quadrilateral and hexahedral planar grids. Using a modal Taylor series basis, the
20 scheme may be made monotone while preserving conservation with the use of a standard
21 slope limiter, although this reduces the formal accuracy of the scheme to first order.
22 The second order scheme is roughly as accurate as the incremental remap scheme with
23 nonlocal gradient reconstruction at half the horizontal resolution. The scheme is being
24 developed for implementation within the Model for Prediction Across Scales (MPAS)
25 Ocean model, an unstructured grid finite volume ocean model.

26 *Keywords:* Discontinuous Galerkin, Advection equation, High order advection,
27 Lagrangian characteristics, Unstructured grid

28 **1. Introduction**

29 Tracer advection constitutes a large portion of the compute time for modern global
30 climate models, due to the large number of chemical and hydrometeor species that must
31 be accounted for. For physical consistency, the advection of tracers must be conserva-
32 tive while being as numerically accurate and computationally efficient as possible. The

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