Contribution ID: **37** Type: **Poster presentation**

Quadrature-free Discontinuous Galerkin Formulation for Shallow-water Equations with Code Generation Features

The discontinuous Galerkin (DG) method is, by now, a well established numerical method in nearly all areas of computational and geophysical fluid dynamics. In addition to the ability to use high-order approximation spaces, its robustness for problems with shocks and discontinuities and its natural support for h- and p-adaptivity count as the main strengths. However, a persistent issue of DG discretizations is a high demand for computational resources which can only be partially offset by efficient parallel scaling. In this work, we present a new quadrature-free discontinuous Galerkin formulation for the nonlinear shallow-water equations (SWE), that replaces quadrature integrations by analytical evaluations. The method is implemented within the ExaStencils code generation framework. We describe the whole code generation pipeline starting with the mapping of the new formulation of the SWE to our Python frontend GHODDESS through to an optimized stand-alone C++ code. Using automatically generated block-structured grids, we exploit performance benefits over unstructured grids while still being flexible enough to sufficiently capture the coastal geometry.

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Session Classification: Posters

Track Classification: Annual Seminar