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Adaptive discontinuous Galerkin method for tsunami modeling and prediction on a global scale

The need to accurately and efficiently predict the impact of earthquake-driven tsunamis requires the development of large scale simulation tools to solve the shallow water equations on a global scale. Such tools can serve as an integral part of tsunami warning system.

In this talk, we present a novel high-order discontinuous Galerkin discretization for the spherical shallow water equations, able to handle wetting/drying and non-conforming, curved meshes in a well-balanced manner. This requires a well-balanced discretization, that cannot rely on exact quadrature, due to the curved mesh. Using the strong form of the discontinuous Galerkin discretization, we achieve a splitting of the well-balanced condition into individual problems for the flux and volume terms and discuss its advantages. More importantly, this approach enables the development of a new method for handling wet/dry transitions which, in contrast to alternative wetting/drying techniques, it is well-balanced and able to handle wetting/drying robustly at any polynomial order, without the introduction of additional physical model assumptions, e.g., viscosity, artificial porosity or cancellation of gravity. The flexibility of the formulation also allows for the use of a fully non-conforming discretization, opening the path to efficient adaptive formulations.

We illustrate the properties of the scheme through a series of simple one-dimensional tests and analyze the properties of our scheme. To validate the method for the simulation of large-scale tsunami events on the rotating sphere, we perform numerical simulations of several historical large scale events and compare our results to real-world data. By considering both static and dynamic earthquake models, we demonstrate that the method is able to predict arrival times and wave amplitudes accurately, even over long distances.

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