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Comparing finite element function spaces for hydrostatic problems in Thetis

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Thetis is a three-dimensional coastal ocean model. It solves the hydrostatic equations coupled with the Generic Length Scale (GLS) turbulence closure model. Thetis is implemented on the Firedrake finite element modeling framework, where governing equations are declared with a Domain Specific Language (DSL). At runtime, a just-in-time compiler generates efficient C code for the model's kernels. By default, Thetis uses a linear Discontinuous Galerkin (DG) discretization, which has been evaluated with idealized benchmarks (Kärnä et al, 2018), and also used in realistic applications such as the Columbia River plume (Kärnä, 2019). The results indicate that numerical mixing is low, i.e. similar to existing structured-grid global ocean models, and lower compared to typical unstructured grid coastal models. The DSL framework, however, allows rapid testing of different spatial discretization choices. In this presentation, we evaluate a mimetic finite element pair, RT2-P1DG, which uses Raviart-Thomas (RT) elements for the velocity. Contrary to the default P1DG-P1DG pair, the RT2-P1DG pair is energy–and enstrophy–conserving. It is, however, more expensive as the velocity space is formally quadratic. We show that the RT discretization does indeed better preserve eddies and also reduces internal pressure gradient errors with terrain-following grids.

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No

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