AGU FALL MEETING
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T31E-07: Local Discontinuous Galerkin (LDG) Method for Advection of Active Compositional Fields with Discontinuous Boundaries: Demonstration and Comparison with Other Methods in the Mantle Convection Code ASPECT

Flow in the Earth's mantle is driven by thermo-chemical convection in which the properties and geochemical signatures of rocks vary depending on their origin and composition. For example, tectonic plates are composed of compositionally-distinct layers of crust, residual lithosphere and fertile mantle, while in the lower-most mantle there are large compositionally distinct "piles" with thinner lenses of different material. Therefore, tracking of active or passive fields with distinct compositional, geochemical or rheologic properties is important for incorporating physical realism into mantle convection simulations, and for investigating the long term mixing properties of the mantle. The difficulty in numerically advecting fields arises because they are non-diffusive and have sharp boundaries, and therefore require different methods than usually used for temperature. Previous methods for tracking fields include the marker-chain, tracer particle, and field-correction (e.g., the Lenardic Filter) methods: each of these has different advantages or disadvantages, trading off computational speed with accuracy in tracking feature boundaries. Here we present a method for modeling active fields in mantle dynamics simulations using a new solver implemented in the deal.II package that underlies the ASPECT software. The new solver for the advection-diffusion equation uses a Local Discontinuous Galerkin (LDG) algorithm, which combines features of both finite element and finite volume methods, and is particularly suitable for problems with a dominant first-order term and discontinuities. Furthermore, we have applied a post-processing technique to insure that the solution satisfies a global maximum/minimum. One potential drawback for the LDG method is that the total number of degrees of freedom is larger than the finite element method. To demonstrate the capabilities of this new method we present results for two benchmarks used previously: a falling cube with distinct buoyancy and viscosity, and a Rayleigh-Taylor instability of a compositionally buoyant layer. To evaluate the trade-offs in computational speed and solution accuracy we present results for these same benchmarks using the two field tracking methods available in ASPECT: active tracer particles and the entropy viscosity method.

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