AGU FALL MEETING
San Francisco | 12–16 December 2016

T22D-03: Discontinuous Galerkin (DG) Method for solving time dependent convection-diffusion type temperature equation : Demonstration and Comparison with Other Methods in the Mantle Convection Code ASPECT

Tuesday, 13 December 2016
10:50 - 11:05
Moscone South - 304

For a convection-dominated system, like convection in the Earth's mantle, accurate modeling of the temperature field in terms of the interaction between convective and diffusive processes is one of the most common numerical challenges. In the geodynamics community using Finite Element Method (FEM) with artificial entropy viscosity is a popular approach to resolve this difficulty, but introduce numerical diffusion. The extra artificial viscosity added into the temperature system will not only oversmooth the temperature field where the convective process dominates, but also change the physical properties by increasing the local material conductivity, which will eventually change the local conservation of energy. Accurate modeling of temperature is especially important in the mantle, where material properties are strongly dependent on temperature. In subduction zones, for example, the rheology of the cold sinking slab depends nonlinearly on the temperature, and physical processes such as slab detachment, rollback, and melting all are sensitively dependent on temperature and rheology. Therefore methods that overly smooth the temperature may inaccurately represent the physical processes governing subduction, lithospheric instabilities, plume generation and other aspects of mantle convection.

Here we present a method for modeling the temperature field in mantle dynamics simulations using a new solver implemented in the ASPECT software. The new solver for the temperature equation uses a Discontinuous Galerkin (DG) approach, which combines features of both finite element and finite volume methods, and is particularly suitable for problems satisfying the conservation law, and the solution has a large variation locally. Furthermore, we have applied a post-processing technique to insure that the solution satisfies a local discrete maximum principle in order to eliminate the overshoots and undershoots in the temperature locally. To demonstrate the capabilities of this new method we present benchmark results (e.g., falling sphere), and a simple subduction models with kinematic surface boundary condition. To evaluate the trade-offs in computational speed and solution accuracy we present results for the same benchmarks using the Finite Element entropy viscosity method available in ASPECT.

Authors

Ying He *
University of California Davis

Magali I Billen
UC Davis

Elbridge Gerry Puckett
University of California Davis

Louise H Kellogg
UC Davis

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