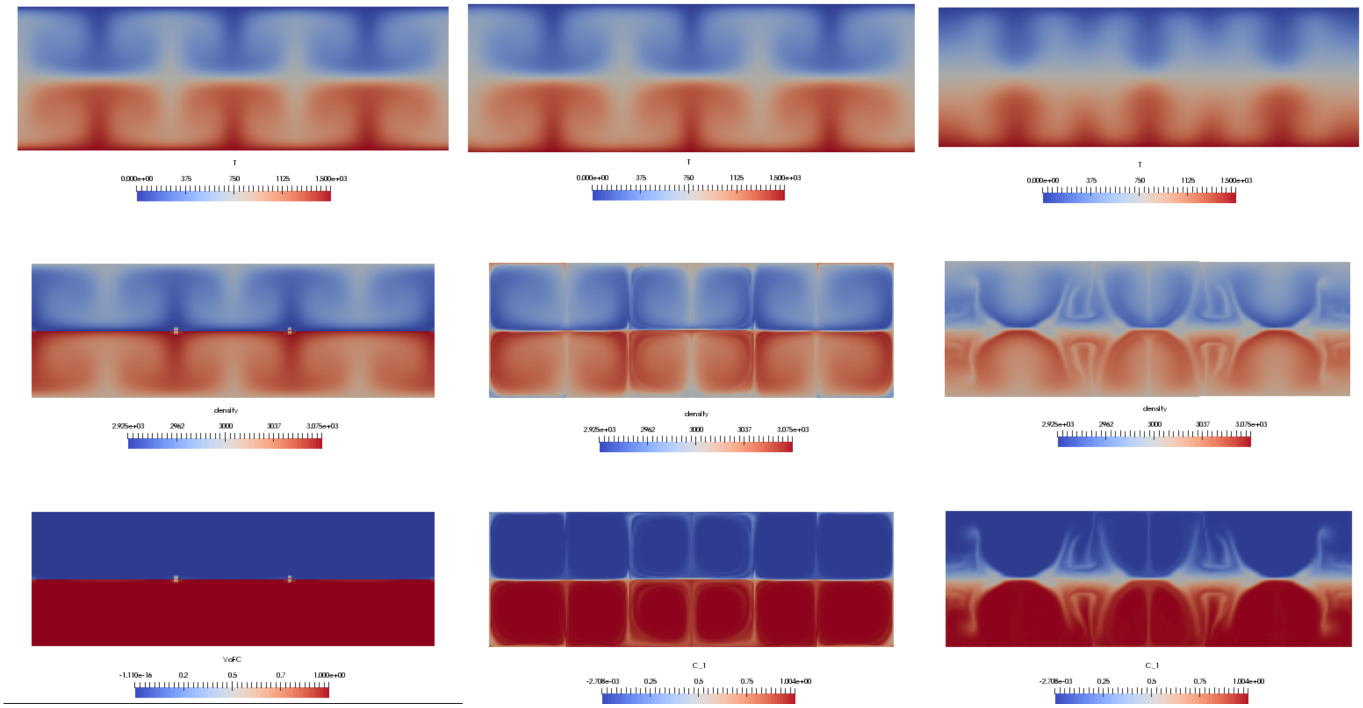
AGU FALL MEETING
San Francisco | 12–16 December 2016

DI23A-2589: New Numerical Approaches To thermal Convection In A Compositionally Stratified Fluid

Tuesday, 13 December 2016
13:40 - 18:00
Moscone South - Poster Hall

Seismic imaging of the mantle has revealed large and small scale heterogeneities in the lower mantle; specifically structures known as large low shear velocity provinces (LLSVP) below Africa and the South Pacific. Most interpretations propose that the heterogeneities are compositional in nature, differing from the overlying mantle, an interpretation that would be consistent with chemical geodynamic models. The LLSVP's are thought to be very old, meaning they have persisted thoughout much of Earth's history. Numerical modeling of persistent compositional interfaces present challenges to even state-of-the-art numerical methodology. It is extremely difficult to maintain sharp composition boundaries which migrate and distort with time dependent fingering without compositional diffusion and / or artificial diffusion. The compositional boundary must persist indefinitely. In this work we present computations of an initial compositionally stratified fluid that is subject to a thermal gradient $\Delta T = T_1 - T_0$ across the height D of a rectangular domain over a range of buoyancy numbers B and Rayleigh numbers Ra. In these computations we compare three numerical approaches to modeling the movement of two distinct, thermally driven, compositional fields; namely, a high-order Finte Element Method (FEM) that employs artifical viscosity to preserve the maximum and minimum values of the compositional field, a Discontinous Galerkin (DG) method with a Bound Preserving (BP) limiter, and a Volume-of-Fluid (VOF) interface tracking algorithm. Our computations demonstrate that the FEM approach has far too much numerical diffusion to yield meaningful results, the DGBP method yields much better resuts but with small amounts of each compositional field being (numerically) entrained within the other compositional field, while the VOF method maintains a sharp interface between the two compositions throughout the computation. In the figure we show a comparison of between the three methods for a computation made with B = 1.111 and Ra = 10,000 after the flow has reached 'steady state'. (R) the images computed with the standard FEM method (with artifical viscosity), (C) the images computed with the DGBP method (with no artifical viscosity or diffusion due to discretization errors) and (L) the images computed with the VOF algorithm.



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