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A new multi-tracer transport scheme for the dynamical core of NCAR's Community Atmosphere Model

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The integration of a conservative semi-Lagrangian multi-tracer transport scheme (CSLAM) in NCAR's High-Order Method Modeling Environment (HOMME) is considered here. HOMME is a highly scalable atmospheric modeling framework, and its current horizontal discretization relies on spectral element (SE) and/or discontinuous Galerkin (DG) methods on the cubed-sphere. It is one dynamical core of NCAR's Community Atmosphere Model (CAM).

The main advantage of CSLAM is that the upstream cell (trajectories) information and computation of weights of integrals can be reused for each additional tracer. This makes CSLAM particularly interesting for global atmospheric modeling with growing number of tracers, e.g. more than 100 tracers for the chemistry version of CAM.

An algorithm specifically designed for multiple processors and on the cubed-sphere grid for CSLAM in HOMME is a challenging task. HOMME is running on an element ansatz on the six cube faces. Inside these elements we create an Eulerian finite volume grid of equiangular gnomonic type, which represents the arrival grid in the scheme. But CSLAM relies on backward trajectories, which entails a departure grid. That means departure and arrival grid don't necessary have to be on the same element and certainly not on the same cube face. Also the reconstruction for higher order modeling needs a patch of tracer values which extend the element. Here we consider a third order reconstruction method. Therefore, we introduce a halo for the tracer values in the cell centers of a cube-element. The size of this halo depends on the Courant number (CFL condition) and the reconstruction type. Note that for a third order scheme and CFL number < 1 we need at least a halo size four (four values in the halo in one direction). But the communication can be limited to one per time step. This data structure allows us to consider an element with its halo as one task where we have to be extra carful for elements which share a cube edge due to projection and orientation reasons. We stress that the reconstruction coefficients for elements which share an element edge are calculated twice - of course on separate processors. This can be done to machine precision. Therefore, the scheme locally conserves mass to machine precision as well.

We aim to provide a highly scalable algorithm and compare and discuss CSLAM with the existing spectral element transport scheme in CAM-HOMME.

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