



A three-dimensional Conservative Cascade semi-Lagrangian transport Scheme using the Reduced Grid on the sphere (CCS-RG)

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Cell-integrated semi-Lagrangian (CISL) transport schemes is being considered in literature as a viable alternative for traditional Eulerian finite-volume and finite-difference schemes and also for emerging spectral element and discontinuous Galerkin algorithms. CISL approach ensures mass-conservation and shape-preservation during numerical solution while allowing for longer time-steps as compared to the Eulerian schemes. Recently the scalable CISL schemes was created (Erath et al. 2012, Erath and Nair 2014).

The presented CCS-RG scheme is the extension of the cascade scheme by Nair et al. 2002 to the three-dimensional space and to the reduced lat-lon grid case. Using a reduced lat-lon grid, i.e. the grid where the number of points in longitude at each latitude circle is gradually diminished while approaching the pole is one of the ways to avoid concentration of grid points near the poles on the regular lat-lon grid. The reduced grids for the CCS-RG are constructed with the algorithm by Fadeev 2013.

The important part of CCS-RG is the integration of the tracer density over the Lagrangian control volume. The cascade approach is used to split the three-dimensional integration in three subsequent one-dimensional integrations. Two different options for shape-preservation are used. First is the Barth and Jespersen 1989 (BJ) filter also used in the CSLAM CISL advection scheme by Lauritzen et al. 2010. The second option is the diagnostic filter (DF) which moves a part of the tracer mass to the neighboring Lagrangian control volume in the case of monotonicity violation is detected.

Here we present the results for the three-dimensional tracer transport test cases from Dynamical Core Model Intercomparison Project (DCMIP) test suite (Kent et al., 2013). The CCS-RG is found to have comparable accuracy as the SLICE transport scheme (Zerroukat and Allen 2012) on the regular lat-lon grid (also using cascade CISL approach). The impact of the reduced grid with 20% less points than the regular grid of the same resolution at the equator is found to be negligible. The diagnostic monotonic filter (DF) was found to be less diffusive than the BJ filter.