Flux-Form Upstream Eulerian Schemes as a reconstruction operator for a conservative non-oscillatory semi-Lagrangian scheme.

Sylvie Malardel - ECMWF

A method of field reconstruction at departure points (sometimes called ``non-interpolating'' scheme, Ritchie, 1986) using Eulerian upstream advection schemes (Smolarkiewicz and Grell, 1992, Smolarkiewicz and Pudykiewicz, 1992, Smolarkiewicz and Rash, 1991) has recently been coded for the semi-Lagrangian scheme of the ECMWF model. 2D and 3D tracer advection tests showed that Eulerian reconstruction using the non-oscillatory 2nd order MPDATA scheme produces the same systematic errors in highly deformational or divergent flows as the current conventional cubic interpolation.

The original ``non-interpolating'' reconstruction method has been modified in order to keep the local conservative property of the Eulerian flux-form scheme taking inspiration from Hill and Szmelter, 2010. The residual velocities connecting each departure point to one of its nearest grid points are considered as a non-constant velocity field which reflects the deformational and divergent properties of the real wind field. When, in the original method, the Eulerian scheme transports the departure point to its nearest grid point, in the modified method, it also deforms the fluid in order to fill the nearest grid box with the mass of fluid which will be in the arrival grid box at arrival time.

The method has been tested for 2D academic cases with prescribed winds on a Cartesian grid and with a shallow water model on the sphere. It is conservative if the connectivity of the grid formed by the ``nearest'' grid points is the same as the connectivity of the model grid (i.e. the neighbours of a ``nearest'' grid point are the ``nearest'' grid points of the neighbours of each arrival point). In the case of constant wind, the semi-Lagrangian method with Eulerian reconstruction is not limited by the CFL criterion unlike in a ``pure'' Eulerian flux-form advection scheme. However, for more complex flows and long time steps, the connectivity of the ``nearest grid point'' grid may not be conserved. Then, the conservative properties of the Eulerian scheme are lost and results show large errors. Further studies will investigate the properties of the new method in comparison with a ``pure'' Eulerian scheme and more conventional SL schemes.