Scalar advection with adaptive moving meshes

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Geophysical flows cover an enormous range of spatial and temporal scales. For instance, flows in the Earth's atmosphere involve energy scales that span at least ten orders of magnitude. Given today's computational resources, the presence of the many different scales together with their nonlinear interactions makes numerical simulation of such flows an exceptionally challenging task. While local phenomena like density interfaces and strong shear layers require spatially high numerical resolution, other regions, where the flow is characterised by smooth varying fields, could be treated with less numerical effort.

The all-scale anelastic geophysical flow solver EULAG enables continuous dynamic grid adaptation (CDGA) by a time-dependent coordinate transformation (Prusa and Smolarkiewicz, 2003). The basic idea of CDGA is to redistribute grid points, fixed in number, in order to reduce the errors resulting from the spatial discretisation. We aim to extend the recent work of Prusa and Smolarkiewicz (2003) by coupling moving mesh partial differential equations (MMPDEs) to EULAG. The parabolic MMPDEs describe the movement of the mesh points in physical space. So-called monitor functions establish the link of the MMPDEs to the numerical solution of the physical equations. They are designed to provide a measure of the local error, numerically or physically motivated, and are also used to control the geometric properties of the generated mesh.

Here, we present a model of two-dimensional scalar advection. It couples MMPDEs for mesh adaption with the flow solver MPDATA of EULAG. Results from experiments with simple choices of the monitor function for this model are presented. Also we point to consequences for further developments.

Prusa J. M. and Smolarkiewicz P. K., An all-scale anelastic model for geophysical flows: dynamic grid deformation. J. Comp. Phys., 190 (2003) 601–622.