EGU22-11370
https://doi.org/10.5194/egusphere-egu22-11370
EGU General Assembly 2022

Long Time Steps for Advection: MPDATA with implicit time stepping

Hilary Weller[1], James Woodfield[1], Christian Kuehnlein[2], and Piotr Smolarkiewicz[3]
[1]University of Reading
[2]ECMWF (European Centre for Medium Range Weather Forecasts)
[3]NCAR/UCAR

Semi-Lagrangian advection schemes are accurate, efficient and retain accuracy and stability even for large Courant numbers, but are not conservative. Flux-form semi-Lagrangian schemes are conservative and used to achieve large Courant numbers. However, this is complicated and would be prohibitively expensive on grids that
are not topologically rectangular.

Strong winds or updrafts can lead to localised violations of Courant number restrictions which can cause a model with explicit Eulerian advection to crash. Schemes are needed that remain stable in the presence of large Courant numbers and general grids, while the accuracy in the presence of localised large Courant numbers may not be so crucial.

Implicit time stepping for advection is not popular in atmospheric science because of the cost of the global matrix solution and the phase errors for large Courant numbers. However, implicit advection is simple to implement (once appropriate matrix solvers are available) and is conservative on any grid structure and can exploit improvements in solver efficiency and parallelisation. This talk will describe an implicit version of the MPDATA advection scheme and show results of linear advection test cases. To optimise accuracy and efficiency, implicit time stepping is only used locally where needed. This makes the matrix inversion problem local rather than global. With implicit time stepping MPDATA retains positivity, smooth solutions and accuracy in space and time.