Geophysical Research Abstracts
Vol. 19, EGU2017-5112, 2017
EGU General Assembly 2017
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A finite-volume module for all-scale Earth-system modelling at ECMWF

Christian Kühnlein, Sylvie Malardel, and Piotr Smolarkiewicz

European Centre for Medium-Range Weather Forecasts, Earth-System Modelling Section, Reading, United Kingdom (christian.kuehnlein@ecmwf.int)

We highlight recent advancements in the development of the finite-volume module (FVM) (Smolarkiewicz et al., 2016) for the IFS at ECMWF. FVM represents an alternative dynamical core that complements the operational spectral dynamical core of the IFS with new capabilities. Most notably, these include a compact-stencil finite-volume discretisation, flexible meshes, conservative non-oscillatory transport and all-scale governing equations.
As a default, FVM solves the compressible Euler equations in a geospherical framework (Szmelter and Smolarkiewicz, 2010). The formulation incorporates a generalised terrain-following vertical coordinate. A hybrid computational mesh, fully unstructured in the horizontal and structured in the vertical, enables efficient global atmospheric modelling. Moreover, a centred two-time-level semi-implicit integration scheme is employed with 3D implicit treatment of acoustic, buoyant, and rotational modes. The associated 3D elliptic Helmholtz problem is solved using a preconditioned Generalised Conjugate Residual approach. The solution procedure employs the non-oscillatory finite-volume MPDATA advection scheme that is bespoke for the compressible dynamics on the hybrid mesh (Kühnlein and Smolarkiewicz, 2017). The recent progress of FVM is illustrated with results of benchmark simulations of intermediate complexity, and comparison to the operational spectral dynamical core of the IFS.

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