EMS Annual Meeting Abstracts
Vol. 16, EMS2019-847, 2019

FVM: a nonhydrostatic finite-volume dynamical core for the IFS

Christian Kühnlein, Piotr K Smolarkiewicz, and Nils P Wedi
European Centre for Medium-Range Weather Forecasts, Earth-System Modelling Section, Reading, United Kingdom (christian.kuehnlein@ecmwf.int)

We present an alternative nonhydrostatic finite-volume global atmospheric model formulation for NWP with the Integrated Forecasting System (IFS) at ECMWF, and compare it to the established operational spectral-transform formulation. The novel Finite-Volume Module of the IFS (henceforth IFS-FVM) integrates the fully compressible equations using semi-implicit time stepping and non-oscillatory forward-in-time Eulerian advection, whereas the spectral-transform IFS (named IFS-ST) solves the hydrostatic primitive equations (optionally the fully compressible equations) using a semi-implicit semi-Lagrangian scheme. The IFS-FVM complements the spectral-transform counterpart by means of the finite-volume discretisation with a local low-volume communication footprint, fully conservative and monotone advective transport, all-scale deep-atmosphere fully compressible equations and flexible horizontal meshing. Nevertheless, both the finite-volume and spectral-transform formulations can share the same quasi-uniform horizontal grid and the physical parametrizations, thereby facilitating their comparison, coexistence and combination in the IFS. We present a comprehensive comparison of IFS-FVM with IFS-ST, both in terms of forecast quality and computational performance. We discuss the coupling to the IFS physical parametrizations in the context of IFS-FVM. We also address some of its unique features, including a perturbational formulation of the governing equations and the design of the semi-implicit integration scheme with long-time-step (with respect to advection) capabilities enabling efficient NWP.

Kühnlein, C., W. Deconinck, R. Klein, S. Malardel, Z.P. Piotrowski, P.K. Smolarkiewicz, J. Szmelter, N.P. Wedi, 2018: FVM 1.0: a nonhydrostatic finite-volume dynamical core formulation for the IFS. Geosci. Model. Dev., 12, 651-676, https://doi.org/10.5194/gmd-12-651-2019, 2019

Smolarkiewicz P.K., C. Kühnlein, N.P. Wedi, Semi-implicit integrations of perturbation equations of all-scale atmospheric dynamics, J. Comput. Phys., 376, 145-159, https://doi.org/10.1016/j.jcp.2018.09.032