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Adaptive wavelet discretization of PDEs on the sphere

Thomas Dubos (1), Nicholas Kevlahan (2), and Mani Mehra (3)

(1) Lab. Meteorologie Dynamique/IPSL, Ecole Polytechnique, France (dubos@lmd.polytechnique.fr), (2) Department of Mathematics & Statistics, McMaster University, Canada (kevlahan@mcmaster.ca), (3) Department of Mathematics, IIT Delhi, India

We present a dynamically adaptive numerical method for solving partial differential equations on the sphere. This approach provides an alternative to adaptive mesh refinement (AMR) methods for static and dynamic grid refinement. The method is based on second generation spherical wavelets on a multiscale hierarchy of structured icosahedral/hexagonal grids. The Laplace–Beltrami, Jacobian and flux-divergence operators are approximated at each level of resolution using standard finite volume discretizations. Wavelet decomposition is used for grid adaptation, error control and interpolation/coarse graining between the adapted grids of successive resolutions. The accuracy and efficiency of the method is demonstrated by applying it to the advection equation, diffusion equation and the Poisson problem on the sphere.
It is straightforward to apply this method to solve the shallow water equations on the sphere. However, in order to retain the discrete conservation properties of mass- and potential vorticity-conserving schemes, some additional modifications to the multiscale operators are required. In particular, we present extensions to formally conservative discretizations on both collocated
(Z) and staggered (C) grids.

References

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