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A regional-global nonhydrostatic model with a vertically Lagrangian control-volume discretization

Shian-Jiann Lin, NOAA/GFDL

NOAA/Geophysical Fluid Dynamics Laboratory [Email: Shian-Jiann.Lin@noaa.gov; Fax: 609-987-5063]

A seamless weather-climate model is being developed at NOAA/Geophysical Fluid Dynamics Laboratory (GFDL). The foundation of this unified regional-global modeling system is a non-hydrostatic extension of the "vertically Lagrangian" finite-volume dynamical core currently used at GFDL for climate applications and at NASA/Goddard Space Flight Center for weather forecasting and data assimilation applications. By formulating the un-approximated Euler equations with terrain-following Lagrangian vertical coordinate, the nonhydrostatic component of the solution (the vertically propagating soundwaves) can be separated from the 2D (x-y) hydrostatic part, resulting in a simple set of 1D (z) equations, which can then be solved semi-analytically by a newly developed Riemann Solver that is stable for large time step. The validity of this new approach is demonstrated using common 2D (x-z) non-hydrostatic testcases with and without terrains. With the conservative, high-order, and optionally monotonic finite-volume transport schemes, the resulting numerical framework is well suited for both regional and global weather and/or climate models.