# The Three-Dimensional Finite-Volume Non-hydrostatic Icosahedral Model (NIM)

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A multi-scales Non-hydrostatic Icosahedral Model (NIM) has been developed at Earth System Research Laboratory (ESRL) to meet NOAA's future weather/climate prediction mission ranging from mesoscale short-range, high-impact weather forecasts to longer-term intra-seasonal climate prediction. NIM formulates the latest numerical innovation of the three-dimensional finite-volume control volume on the quasi-uniform icosahedral grid suitable for ultra-high resolution simulations. NIM is designed to utilize the state-of-art computing architecture such as Graphic Processing Units (GPU) processors to run globally at kilometer scale resolution to explicitly resolve convective storms and complex terrains. The novel features of NIM numerical design include:

1.1. A local coordinate system upon which finite-volume integrations are undertaken. The use of a local Cartesian coordinate greatly simplifies the mathematic formulation of the finite-volume operators and leads to the finite-volume integration along straight lines on the plane, rather than along curved lines on the spherical surface.
1.2. A general indirect addressing scheme developed for modeling on irregular grid. It arranges the icosahedral grid with a one-dimensional vector loop structure, table specified memory order, and an indirect addressing scheme that yields very compact code despite the complexities of this grid.
1.3. Use of three-dimensional finite-volume integration over control volumes constructed on the height coordinates. Three-dimensional finite-volume integration accurately represents the Newton Third Law over terrain and improves pressure gradient force over complex terrain.
1.4. Use of the Runge-Kutta 4th order conservative and positive-definite transport scheme
1.5. NIM dynamical solver has been implemented on CPU as well as GPU.

As one of the potential candidates for NWS next generation models, NIM dynamical core has been successfully verified with various benchmark test cases including those proposed by DCMIP. Physical parameterizations such as those used by GFS have been incorporated into NIM dynamic core and successfully tested with multi-months aqua-planet simulations as well as real data simulations. NIM has been implemented on GPUs and CPUs. Efficiency tests show GPU significantly speeds up model calculations. In the conference, NIM real weather simulations verified with satellite data will be shown.

Keywords: numerical weather prediction, finite-volume numeric, global models, Fine-Grain parallelism.