Atmospheric modeling with High-Order methods for Unstructured Grids

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Bottlenecks

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- Conservation of mass, momentum, total energy
- Hydrostatic approximation
- Singularities at the poles
- Long time evolution (millions and billions of iterations) of global climate models stresses non high-resolution numerical schemes
- The fluid equations (Euler or Navier-Stokes) approximation have a profound impact on the simulation results, since they model where and how the fluids are going to move
- Parallel performance of the current generation of models is poor

Initiatives

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- The majority of leading NWP and GCM have taken the initiative to replace the dynamical cores (10 year projection)
- Non-hydrostatic compressible Euler equations
- Adaptive mesh refiment in region of interest
- Capability to accurately represent topographic configurations
- Strongly conserving numerical methods in the finite-volume methods
- Improve parallel scalability of the models

New approach

Characteristics

- Implement high-resolution, very high-order finite-volume methods suitable for any type of unstructured mesh
- Strong conservation of mass, momentum, and total energy
- Accurately representation of topography
- Suitable for long time integration of global climate models
- Great parallel efficiency
- No singular points
- Capability to resolve features in relatively coarse resolutions
- More expensive than non high-resolution methods

Experiences

Experiences

- Very high-order finite-volume methods have better efficiency than lower-order methods
- The ratio of computational time over communication time is 10 for a 5th-order WENO scheme at 1080 cores
- No master-slave framework, all the processes are involved in the computations, communications, I/O
- Intel MPI implementation with Intel compilers substantially faster than openmpi (BA, Cytera)
- Cytera HPC facility ideal for very high-order methods, due to memory available, fast interconnect and cpus with high number of IPS
- Load balancing achieved with the latest version of METIS reaches the value of 1.03
- Light I/O during simulations ,once every 4-6 hours takes less than 30 seconds in 1080 cpus

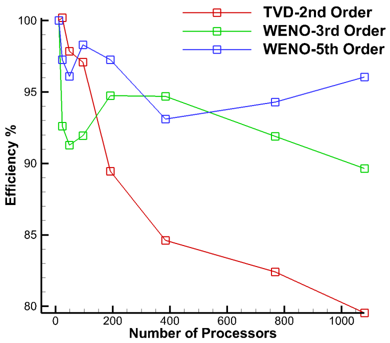

Figure: Efficiency of UCNS3D code

Future needs

1. 20-30 simulations for global modeling using the UCNS3D code ~500k-850k CPU hours
2. Small footprint of data generated from all simulation in the order of 50-70 Gigabytes
3. Ideally a different channel for node communication and I/O
4. Information regarding memory swap to hard disks, due to very high memory requirements
5. Ideally not mixing jobs at the same nodes (when users do not run on multiples of total number of cores per node)

Questions?

Thank you very much for your time !