Performance-Portability Results for the Non-Hydrostatic Atmosphere Dycore of E3SM at Cloud-Resolving Resolutions.

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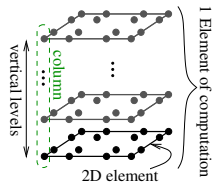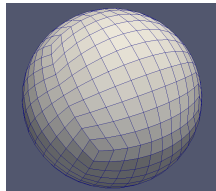
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High-Order Methods Modeling Environment

- Component of E3SM for dynamics and transport in the atmosphere.
- Horizontal (2D) and vertical (1D) differential operators are decoupled.
- Spectral Element Method (SEM) in the horizontal direction.
- Eulerian or Lagrangian schemes for vertical operators.
- Hydrostatic and non-hydrostatic models available.

A performance portable implementation of Homme.

- Use C++ and Kokkos for on-node parallelism.
- Goals: expose parallelism/vectorization, minimize memory movement.
- Minimize of architecture-specific code.

2018: Hydrostatic dycore (preqx):

- Established viability of C++/Kokkos approach.
- Paper accepted in Geoscientific Model Development[1].

2020: Non-hydrostatic dycore (theta-l):

- Main challenges: nonlinear solver, larger memory footprint.
- Paper accepted at SC20[2].

[1] *HOMMEXX 1.0: a performance-portable atmospheric dynamical core for the Energy Exascale Earth System Model*, Geo. Model Dev., 2019

[2] *A Performance-Portable Nonhydrostatic Atmospheric Dycore for the Energy Exascale Earth System Model Running at Cloud-Resolving Resolutions*, SC20 Proceedings

- Solve for state and 10 tracers (NGPPS benchmark).
- Run at 3km and 1km horizontal resolution.
- Achieves 0.97 SYPD on GPU on full Summit system.
- Excellent scaling at 3km, perfect scaling at 1km.
- CPU performance comparable (or slightly better) to original F90.
- Approximately 10x speedup when using GPUs vs P9 on Summit.
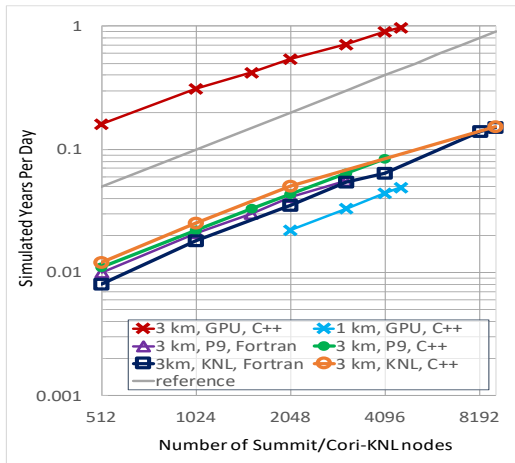- 1km resolution features approximately 1 trillion DOFs.

Figure: Achieved SYPD for different implementations and resolutions.

Conclusions

- Completed C++/Kokkos rewrite of HOMME non-hydrostatic dycore.

- New implementation faster than original on CPU.

- New implementation achieves 0.97 SYPD at 3km resolution on GPU on full Summit system.

- Performance-Portable dycore implementation crucial for Cloud-Resolving atmosphere model in E3SM.