CAM dynamical cores

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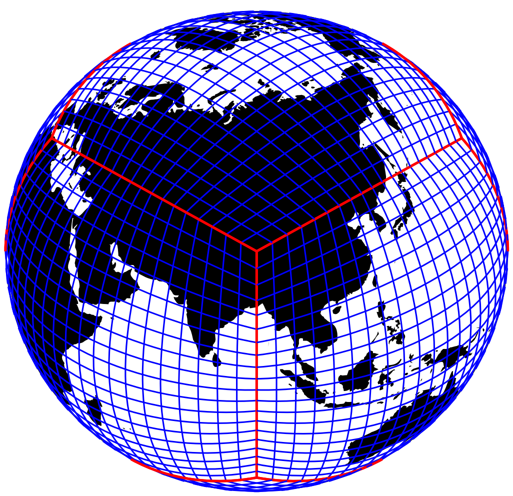
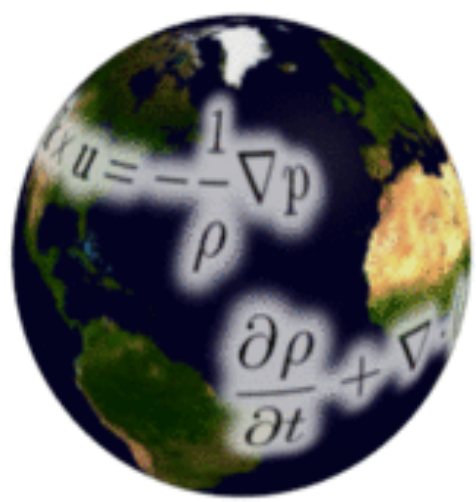


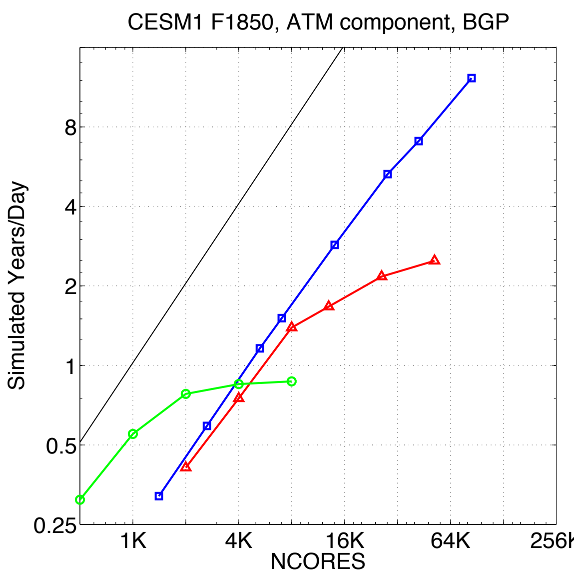


CESM Working Group Meeting
March 1, 2017
Boulder, Colorado, USA

Historically CAM has accommodated several dynamical cores (dycores)

- **Provides a unique modeling environment where the same physics can easily be run with different dycores:**
  -> evaluate physics sensitivity to dycore
  -> easily compare dycores in idealized settings

- **CAM can accommodate throughput requirements on small compute platforms to massive parallel supercomputers by having dycores suitable for the respective platforms.**



Performance in through-put for different dynamical cores in NCAR's global atmospheric climate model:

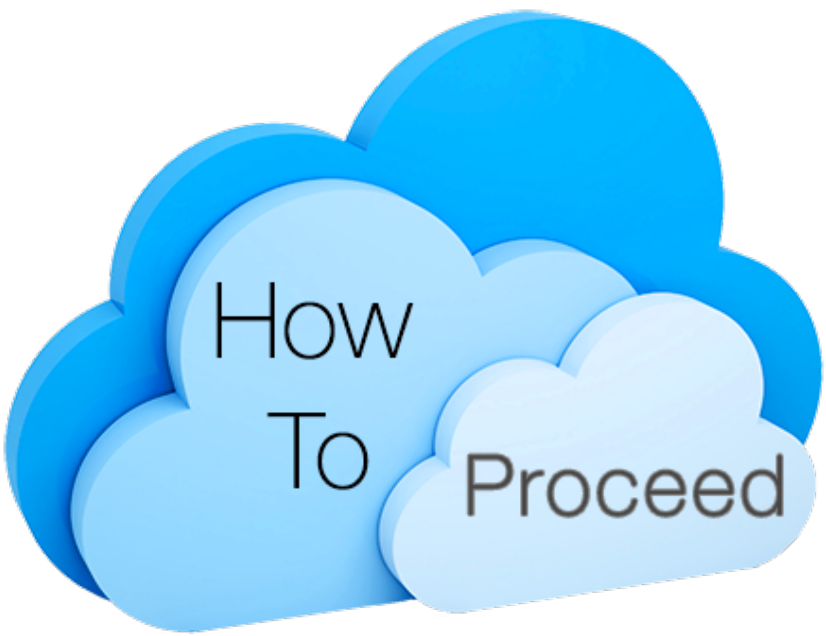
horizontal resolution: approximately 25km × 25km grid boxes

- EUL = spectral transform (lat-lon grid)
- FV = finite-volume (reg. lat-lon grid)
- SE = spectral element (cubed-sphere grid)

Computer = Intrepid (IBM Blue Gene/P Solution) at Argonne National Laboratory

Historically CAM has accommodated several dynamical cores (dycores)

- Our dycores capability requirements have evolved and some of the dycores do not meet our needs anymore (e.g., mesh-refinement capability)
- We do not have the resources to support an increasing number of dycores (scientific support and software engineering support)



CAM dynamical core inventory

Current dycores:

EUL (Eulerian spectral-transform)
SLD (semi-Lagrangian spectral-transform)
FV (finite-volume)
SE (spectral-elements)

Dycores being integrated into CAM:

MPAS (Model for Prediction Across Scales)
FV3 ("cubed-sphere version" of FV from NOAA)

CAM dyn

Current dycor

EUL (Euleri
SLD (semi-Lag
FV (finite-volume)
SE (spectral-elements)

- Not used anymore for climate (used to be a "workhorse" dynamical core)
- Used by the university community for paleo climate applications and simpler models configurations
- Documented and with some functional support (fully supported for simpler model applications)

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CAM dyn

- "workhorse" dynamical core in CESM for 1 degree (horizontal resolution) applications
- Used in CAM, WACCM, WACCM-X
- Documented and supported
- Very well tested and widely used (very mature dycore)
- Plans: No further development

Current dycor

EUL (Eu

~~SLD (Semi-Lag~~

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Current dycor

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~~SLD (semi-Lag~~
FV (finite-volume)
SE (spectral-el

- NOAA funded effort to implement FV3 (“cubed-sphere non-hydrostatic version” of FV) in CESM
  -> implementation starting soon

Dycores being

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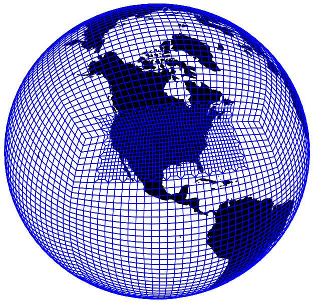
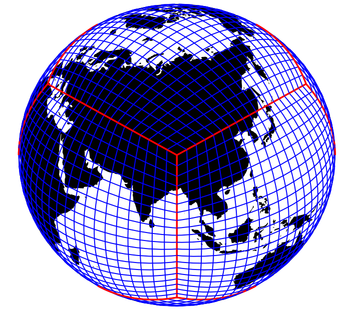


SE (Spectral-Elements)



- CISL's HOMME (High-Order Methods Modeling Environment); Now SE is managed by CGD i.e. a standalone version of HOMME will not be used in CESM2!

- Actively being developed by CGD and CISL:
  Numerical methods: separate physics grids, CSLAM transport, … (See Lauritzen talk "CESM2 release of CAM-SE" and "Variable-resolution updates: CAM-SE" talk by Zarzycki)
  Performance and new architectures: Used widely by CISL for computer science applications and performance research
- Current "workhorse" for ¼ degree applications
- Ongoing: Development of non-hydrostatic deep-atmosphere version (led by Ram Nair; collaboration with CGD)

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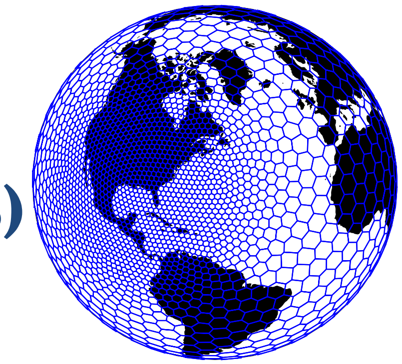

- Developed by MMM with WRF physics for high resolution global weather forecasting
- Being implemented and tested in CAM
- Plans:

  - Given adequate resources the integration into CAM should be completed soon

  - Evaluation as a dynamical core for climate with CAM6 physics

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Summary of "capabilities" (does not reflect accuracy, throughput, etc.)

	EUL	SLD	FV	SE	MPAS	FV3
Scalable				✔	✔	✔
Mesh-refinement capability				✔	✔	✔
Non-hydrostatic				Ongoing	✔	✔
Deep atmosphere				Ongoing	Doable	?
Active development inside NCAR				✔	✔	

Acronyms:
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CESM plans

Please note: CESM will be in a unique position having three state-of-the-art dynamical cores (in the same infrastructure) spanning diverse spherical grids and numerical methods

The CESM group is planning to perform a comparison of the different dycores for "workhorse" CESM applications

The dynamical core requirements list includes (not an exhaustive list):

- Sufficient throughput (cost not just scalability is important!) on current and future architectures
- Conservation (mass, a closed energy budget in the system as a whole, axial angular momentum, …)
- Dynamical core developer support
- Support for simplified setups (see Lauritzen's talk "An Overview of the Simplified CESM2 Model Configurations")
- Climate needs to be competitive with CESM2 release simulations
- Mesh-refinement capability for regional climate applications and parameterization development