CAM dynamical cores

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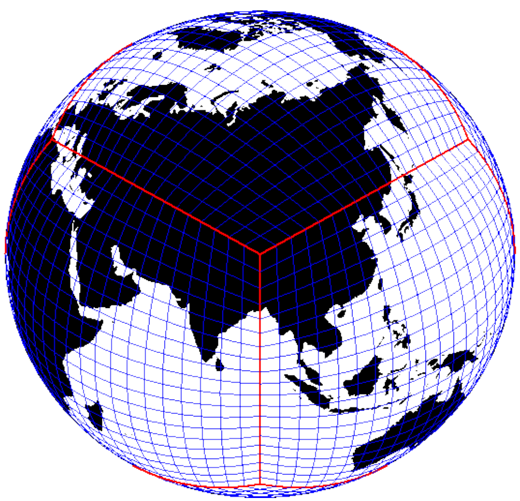

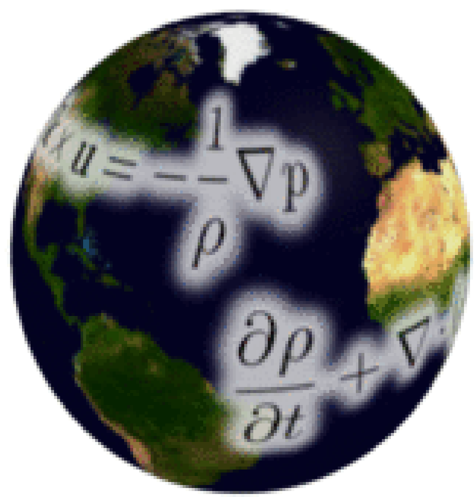

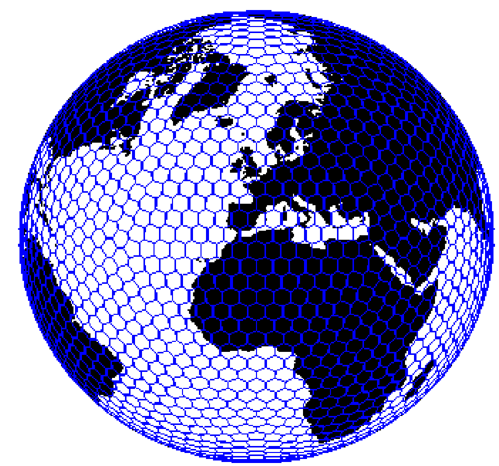

CESM Working Group Meeting
March 1, 2017
Boulder, Colorado, USA

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.

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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 dyna

- **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 dyna

- "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

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

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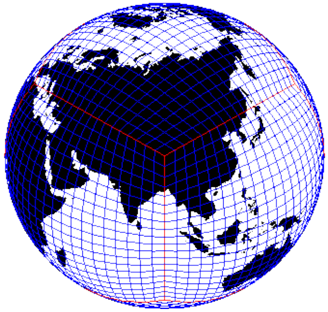

- **CISL’s HOMME (High-Order Methods Modeling Environment); Now SE is managed by CGD i.e. a standalone version of HOMME will not be used in CESM2!**

- **Actively being developed by CGD and CISL:**
  <u>Numerical methods</u>: separate physics grids, CSLAM transport, … (See Lauritzen talk “CESM2 release of CAM-SE” and “Variable-resolution updates: CAM-SE” talk by Zarzycki)
  <u>Performance and new architectures</u>: Used widely by CISL for computer science applications and performance research

- **Current “wo … ions**

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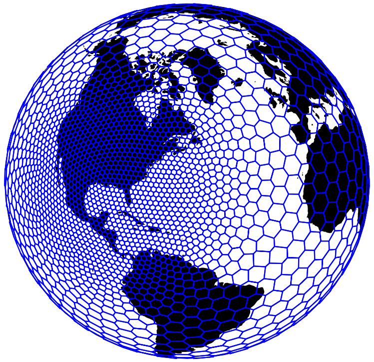

- **Developed by MMM with WRF physics for high resolution global weather forecasting**
- **Being implemented and tested in CAM**
- **Plans:**

  - 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				✓	✓	

<u>Acronyms:</u>
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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 reg