

Geophysical Fluid Dynamics Laboratory Review

June 30 - July 2, 2009



Modeling Services

Presented by
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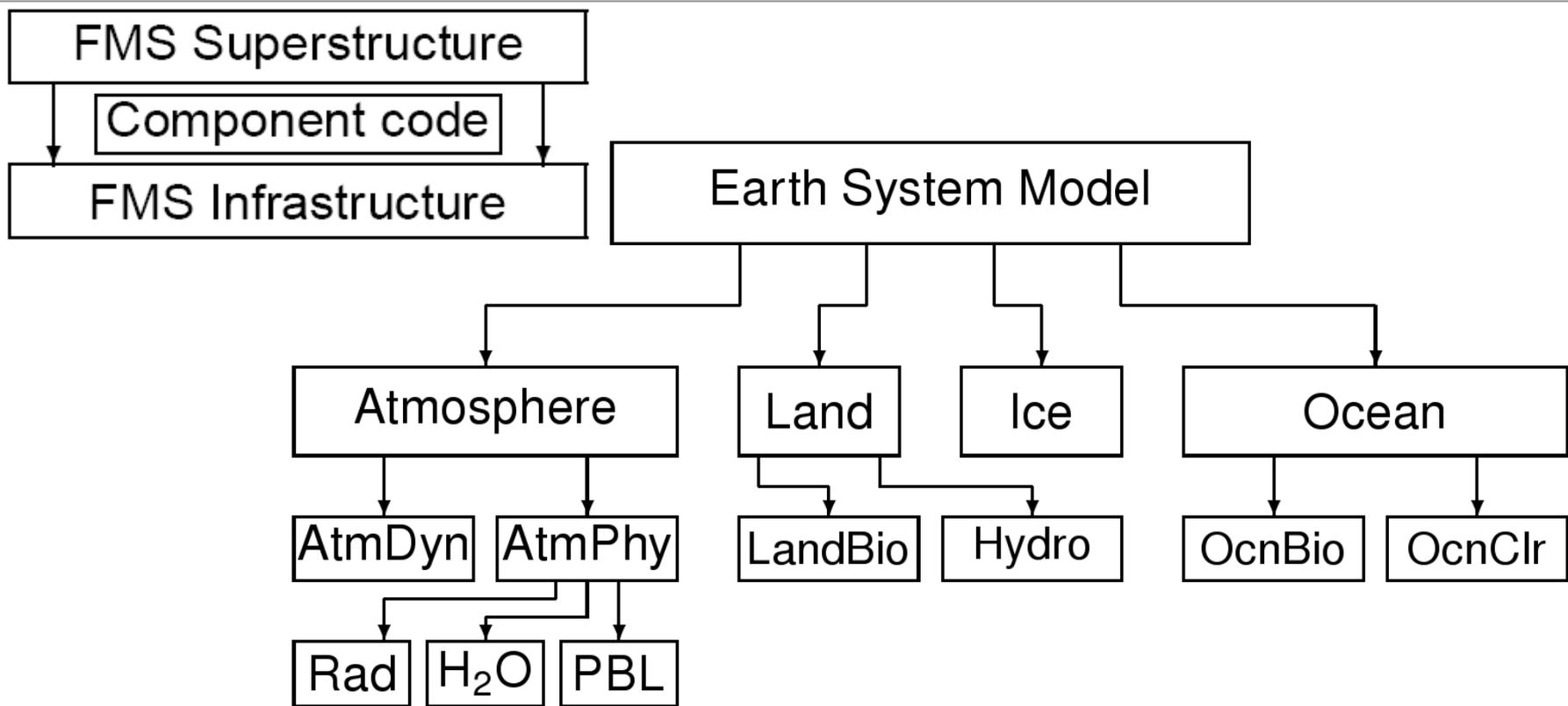


Modeling Services: Software Infrastructure for Climate Modeling

- **Flexible Modeling System (FMS):** Common software framework (FMS) for the construction of models out of components. **Superstructure** and **infrastructure**.
- **FMS Runtime Environment (FRE):** encapsulated model **workflow**: configuration, job scheduling and management, post-processing and analysis.
- **GFDL Data Portal:** publication and delivery of model output. Data **curator**.
- Community-building: coordinated experiments, metadata and interface standards, shared tools.

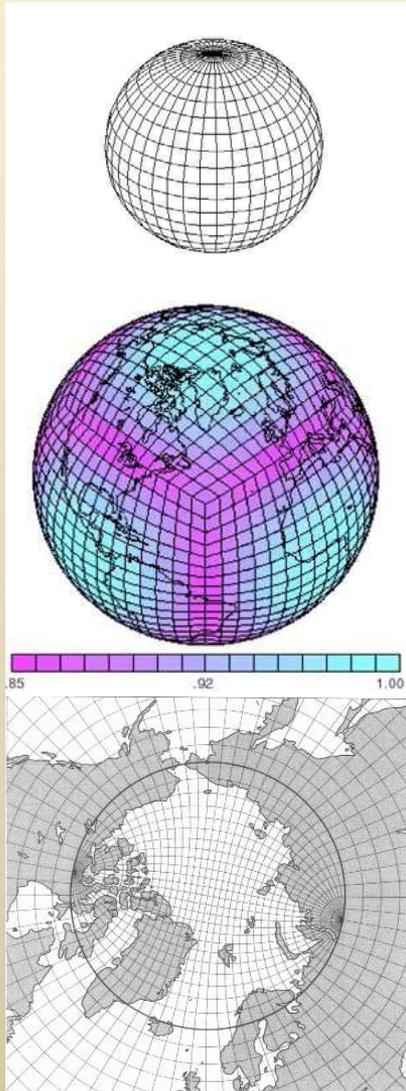
FMS: A Pioneering Modeling Framework

The construction of complex Earth system models out of **components** is now commonplace in the design of modeling software (ESMF, PRISM). Components are embedded in the framework “sandwich.”



<http://www.gfdl.noaa.gov/fms>

FMS Mosaic: Coupled Algorithms On Novel Grids



- The Finite-Volume conventional grid dycore (**FVLL**): Fourier filter at the pole limits scalability on distributed memory.
- The Finite-Volume Cubed-Sphere dycore (**FVCS**) eliminates the pole and vastly increases scalability on distributed memory.
- **MOM4** and **GOLD** models run on a tripolar grid: also has no pole problem.
- GFDL **Gridspec** provides specification of mosaics and nested grids, including conservative interpolation weights: Now adopted by Unidata as CF prototype.
- **Exchange grid** provides conservative flux exchange at planetary surface, implicit and explicit timestepping.

FRE: Expression of Complete Scientific Workflow

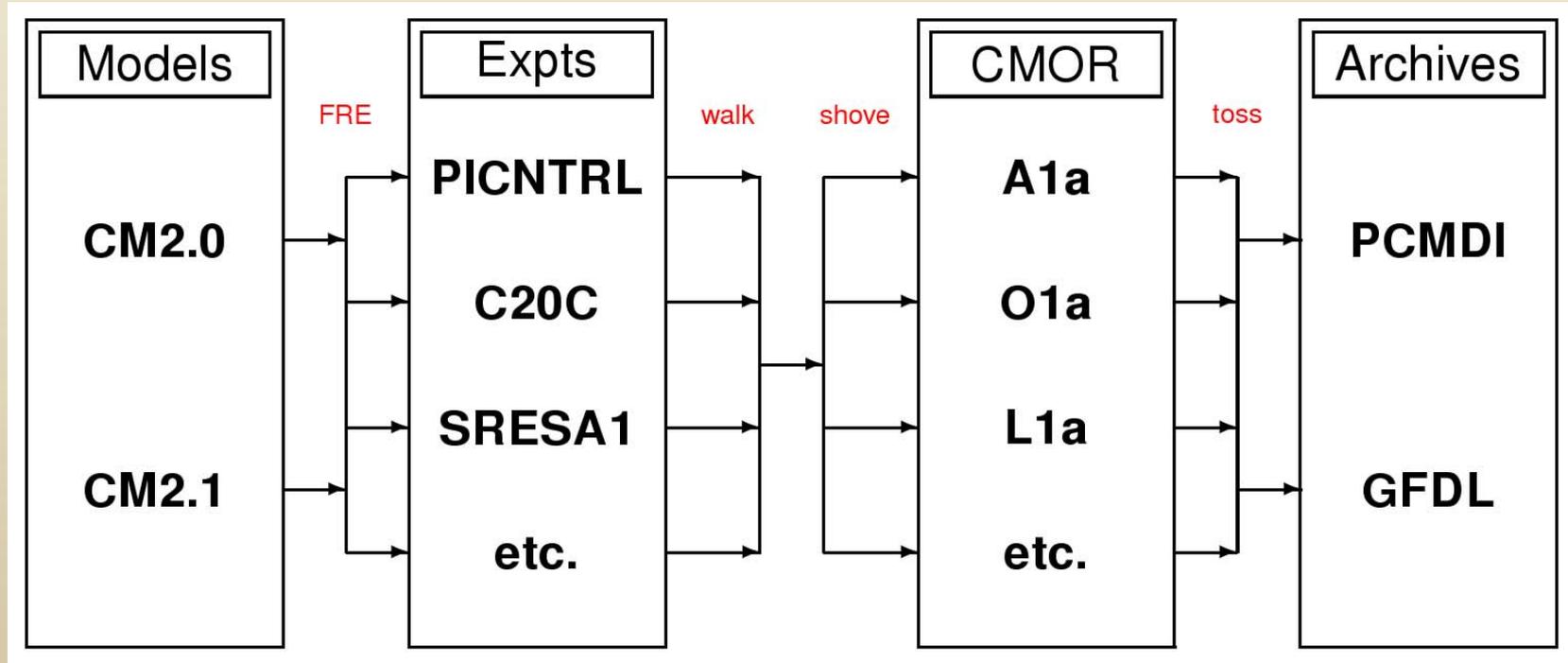
- Operational since 2003, designed to provide an environment for integrated testing and production.
- Rigorous standardized test procedure for evaluating new code and new model assemblies and configurations.
- Integrated existing post-processing structure.
- Captures complete configuration from source assembly to compilation to running, post-processing and analysis.
- Simulation database provides retrieval of model output, model analysis, and now model state and configuration information.
- XML-based FRE **workflow** is again influential in community, with “**curators**” being prototyped at various sites.

<http://www.gfdl.noaa.gov/fms/fre>



GFDL Data Portal

- Based on NOMADS, maintained in collaboration with NOAA/PMEL.
- Data pipeline for IPCC AR4 established in 2004.
- GFDL Curator links data portal with FRE, aiming to provide a single integrated pipeline for data publication in IPCC AR5.



FMS/FRE/Curator: A Sound Basis for The Future

Trends in HPC:

- **Integrated systems**, multi-core, co-processors
- Weak vs. strong **scalability**
- **I/O** for models and archives
- New **programming models**: OpenMP/OpenCL, PGAS
- **Reproducibility?**

Trends in use of ESMs:

- **Multi-model ensembles**
- **Climate impacts** and “**downstream**” users
- **Decision support data** and runs “**on-demand**”
- **Fundamental research** leading to **predictive understanding**

We are well-poised to adapt to hardware trends and enable routine mass production of model runs.

Summary: Modeling Services

- Modeling Services: liaison between science and computational infrastructure
- FMS: "sandwich" framework. Now running at up to 50kp on DOE leadership systems. Mosaic structure for novel grids
- FRE: formal specification of scientific workflow. Mass production and publication of model runs
- GFDL Data Portal: IPCC AR4 and AR5 holdings. Participation in national and international data governance
- Future developments: collaboration with DOE labs to extend scalability to the 100kp-1Mp range
- Research areas: strong scalability and reproducibility

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