Earth System Modeling (ESM) Accelerated Climate Model for Energy (ACME)

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Earth System Modeling portfolio
Global climate model development

1. 20% University-led projects (FY14-16)
(SciDAC: Scientific Discovery through Advanced Computing)
New awards: 8 multi-institutional projects on
atmosphere/cloud modeling, atmospheric chemistry,
terrestrial modeling, paleoclimate-ice-sheets, ocean
dynamics (MPAS-O, NCAR/LANL), ocean
biogeochemistry (modularize O-BGC and install in
MPAS-O, NCAR/LANL)
More awards in FY15

2. 20% SciDAC-Lab (FY11-16)

3. 60% Lab projects (now ACME)
SciDAC3, 3 Lab-led projects, 2011-2016
Co-managed, co-funded with DOE Computing
All engage with ASCR (computing) SciDAC Institutes:

1. Multiscale Methods for Accurate, Efficient, and Scale-Aware Models of the Earth System
LBNL, LANL, PNNL, ORNL, LLNL, SNL, NCAR, UW-M, CSU, UCLA
Scale-aware physics for variable mesh dycores (MPAS-O and CAM-SE):
Atmospheric convection (4 approaches); Ocean eddies

2. Predicting Ice Sheet and Climate Evolution at Extreme Scales (PISCEES)
LBNL, LANL, ORNL, SNL, NCAR, MIT, FSU, U-SC, UT-Austin
Two ice sheet dynamical cores with variable mesh; UQ for boundary, initial conditions V&V Toolkit

3. Applying Computationally Efficient Schemes for BioGeochemical Cycles (ACES4BGC)
ORNL, SNL, LLNL, PNNL, LANL, ANL, NCAR
Organic species for atmosphere, ocean and land
Tracer transport, variable mesh
ESM Multi-Laboratory projects

1. **COSIM** – ocean, sea-ice, land-ice (with RGCM)
2. **IMPACTS** – abrupt changes, e.g. permafrost, clathrates, drought
3. “Polar”: Arctic ocean, sea-ice, clouds, aerosols
4. **Ultra-high-resolution**: ocean-atmosphere focus
5. **UV-CDAT**: tools for visualization and analysis
6. **Climate Science for a Sustainable Energy Future (CSSEF)**: UQ, workflow, variable-mesh dycores
7. **Integrated Earth System Model (iESM)**: GCAM-IAM to CESM through carbon cycle (with IAR)
8. **FASTER**: using ARM data to test and improve cloud simulations
## ESM-Lab projects in 2014: Model development in 8 Laboratories and 8 projects

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## ESM-Labs:

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Multi-Laboratory development project (8 Labs, 6 non-Labs)
Proposal submitted: January 2014
Project reviewed: March 2014
High resolution (15-25 km) off-shoot of the CESM coded to run efficiently on current and future DOE computers: a climate projection capability (1970-2050) in support of DOE science and mission.

Review March 4-5, 2014
Face-to-face (reverse-site)
18 reviewers
30 Team scientists
DOE program managers

Review panel
50% from model groups; 50% University
2/3 Climate 1/3 Computational
4 non-U.S.
Major Review Findings

- Solid plan, solid team
- DOE plan to consolidate, coordinate
- “Top-down” structure, serious project commitment – crucial for this project

- Concise and more focused project description recommended.

Brief Project Plan has been developed (available soon; see DOE modeling website – next week - [http://www.climatemodeling.science.energy.gov/](http://www.climatemodeling.science.energy.gov/))

- Project management challenges
  Project engineer, management softwares…

- Energy-societal elements require further definition
  Workshop planned
Science Goals

Water cycle: How do the hydrological cycle and water resources interact with the climate system on local to global scales? *Evolution of precipitation and river flow.*


Cryosphere: How do rapid changes in cryospheric systems interact with the climate system? *Long term committed Antarctic ice sheet contribution to SLR from changes in 2010-2050.*
Accelerated Climate Model for Energy

Computation roadmap

ACME v1 (0-2 years)
- Modern SW Engineering (e.g. sw design)
- Preparing for Exascale (e.g. parallelism)
- "Big data" for Climate (e.g. validation)
- Transformative Algorithms (e.g. time integrators)
- Baseline testing and automation
- Many-core threading, libraries
- Workflow, in-situ diagnostics
- 1D implicit integrators

ACME v2 (2-4 years)
- Modern SW Engineering (e.g. sw design)
- Preparing for Exascale (e.g. parallelism)
- "Big data" for Climate (e.g. validation)
- Transformative Algorithms (e.g. time integrators)
- Modular components, coupling
- Architecture-optimized performance
- Automated analysis, data management
- 2D implicit-explicit

ACME v3+ (4-7 years)
- Modern SW Engineering (e.g. sw design)
- Preparing for Exascale (e.g. parallelism)
- "Big data" for Climate (e.g. validation)
- Transformative Algorithms (e.g. time integrators)
- Transform code for exascale
- Language-enabled performance
- Online data assimilation
- Adaptive, stochastic
Strategy: simulations-development-architectures

Relationships Among Simulation, Development and Architecture Roadmaps

- v0
- v1
- v2
- v3
- v4
- v5

Major Simulations

Model Development

Leadership Architectures

Project Year

Exascale Machines

100+ PFLOP Machines

Current Machines