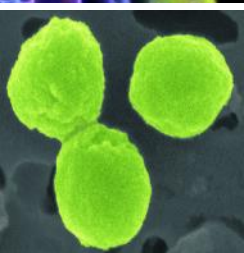
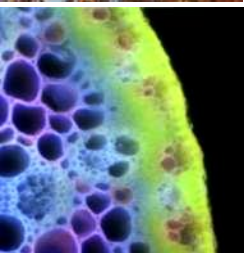


Biological & Environment Research Office (BER)

Climate modeling

Dorothy Koch

Earth System Modeling
Climate and Environmental Sciences Division
Biological and Environmental Research



July 30, 2014

SciDAC-3 Principal Investigator Meeting



U.S. DEPARTMENT OF
ENERGY

Office
of Science

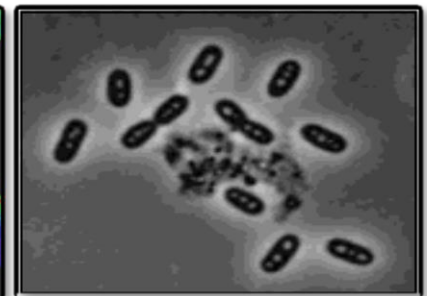
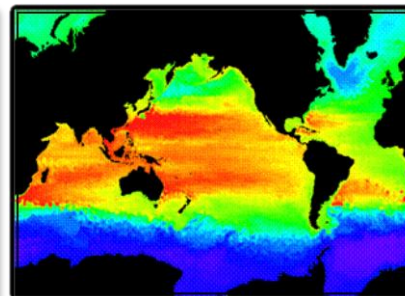
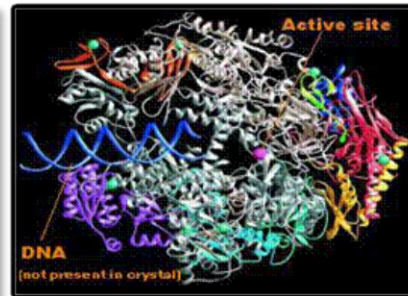
Office of Biological
and Environmental Research

Biological and Environmental Research

Understanding complex biological, climatic, and environmental systems across vast spatial and temporal scales

The Scientific Challenges:

- Understand how genomic information is translated with confidence to redesign microbes, plants or ecosystems for improved carbon storage, contaminant remediation and sustainable biofuel production
- Understand the roles of Earth's physical and biogeochemical systems (atmosphere, land, oceans, sea ice, subsurface) in determining climate so we can predict climate decades or centuries into the future, information needed to plan for future energy and resource needs.





Office of Biological & Environmental Research

Sharlene Weatherwax

Biological Systems Science

Todd Anderson

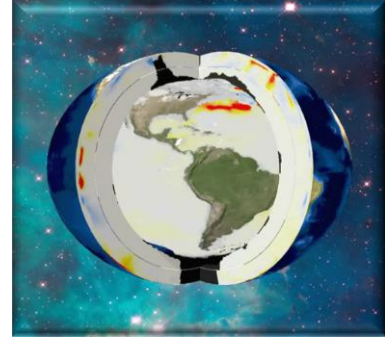
- Genomic Science
 - Bioenergy Research Centers
- Radiological Sciences
- Facilities & Infrastructure
 - Joint Genome Institute
 - Structural Biology

Climate & Environmental Sciences

Gary Geernaert

- Atmospheric System Research
- Environmental System Science
- Climate & Earth System Modeling
- Facilities & Infrastructure
 - Environmental Molec. Sciences Lab
 - ARM Climate Research Facility

BER computational activities



Biological Systems Science

- Genomic Science
 - Bioenergy Research Centers
- Radiological Sciences
- Facilities & Infrastructure
 - Joint Genome Institute
 - Structural Biology

Kbase: Systems Biology Knowledgebase
Discover biologic process from genomic data

Climate & Environmental Sciences

- Atmospheric System Research
Large Eddy, Cloud Resolving modeling
- Environmental System Science
Subsurface flow and biogeochemistry
- ❖ **Climate & Earth System Modeling**
Global climate modeling, SciDAC3 projects
- Facilities & Infrastructure
 - Environmental Molec. Sciences Lab
 - ARM Climate Research Facility

Climate and Earth System Modeling: predictive capability in support of energy and societal requirements

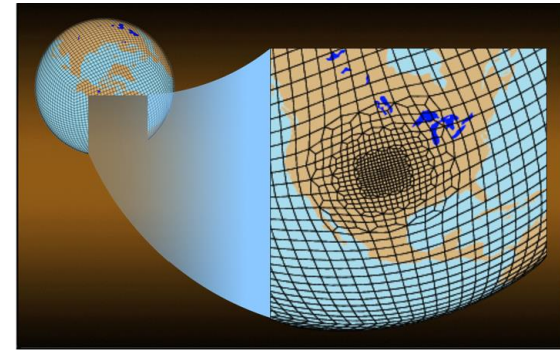
Global climate modeling

Earth System Modeling (Dorothy Koch)

- Development of a global climate model capability

Regional and Global Climate Modeling (Renu Joseph)

- Analysis of climate models
- Activities:
 - Climate model metrics, variability and change
 - Climate extremes
 - Water cycle
 - Land model benchmarking
 - Arctic systems



Integrated Assessment , Impacts, Adaptation and Vulnerability models (Bob Vallario)

- Consider broad range of energy and economic pathways, broad range of potential impacts and response options.
- Climate system is treated simply

Earth System Model development activities

1. ACME: Accelerated Climate Modeling for Energy
New coordinated model development activity
Laboratory “Science Focus Area” (SFA) (60% of portfolio, using existing projects/resources)

SciDAC projects: scoping and testing new capabilities for next-generation ACME

2. SciDAC3 Lab projects (2011-2016) (20%)

3. SciDAC (and other) University projects (2014-2016) (20%)





Accelerated Climate Model for Energy

High resolution (15-25 km) version of the Community Earth System Model coded to run efficiently on current and future DOE LCF's: a climate projection capability (1970-2050) in support of DOE science and mission.

Proposal submitted in January 2014

Review in March 2014; Face-to-face, 18 reviewers, 30 Team scientists

Project launch June 2014

Team of 8 DOE Laboratories, 6 partner institutions

Managed by project Council: Bader (Chair, LLNL), Collins (Chief scientist, LBNL), Taylor (Computational Chief, SNL), Jacob (ANL), Jones (LANL), Rasch (PNNL), Thornton (ORNL), Williams (LLNL)





Accelerated Climate Model for Energy

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.



Biogeochemistry: How do biogeochemical cycles interact with global climate change?

Evolution of natural versus managed systems fluxes of greenhouse gases.



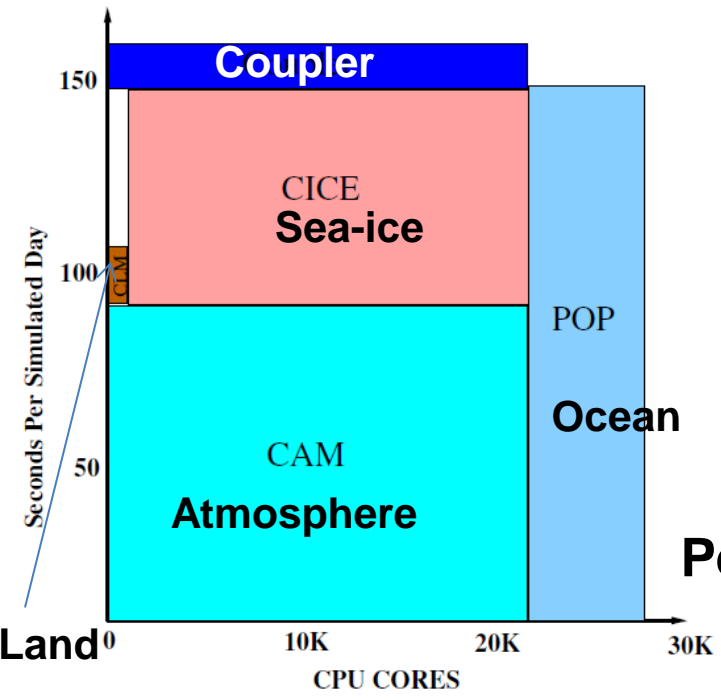
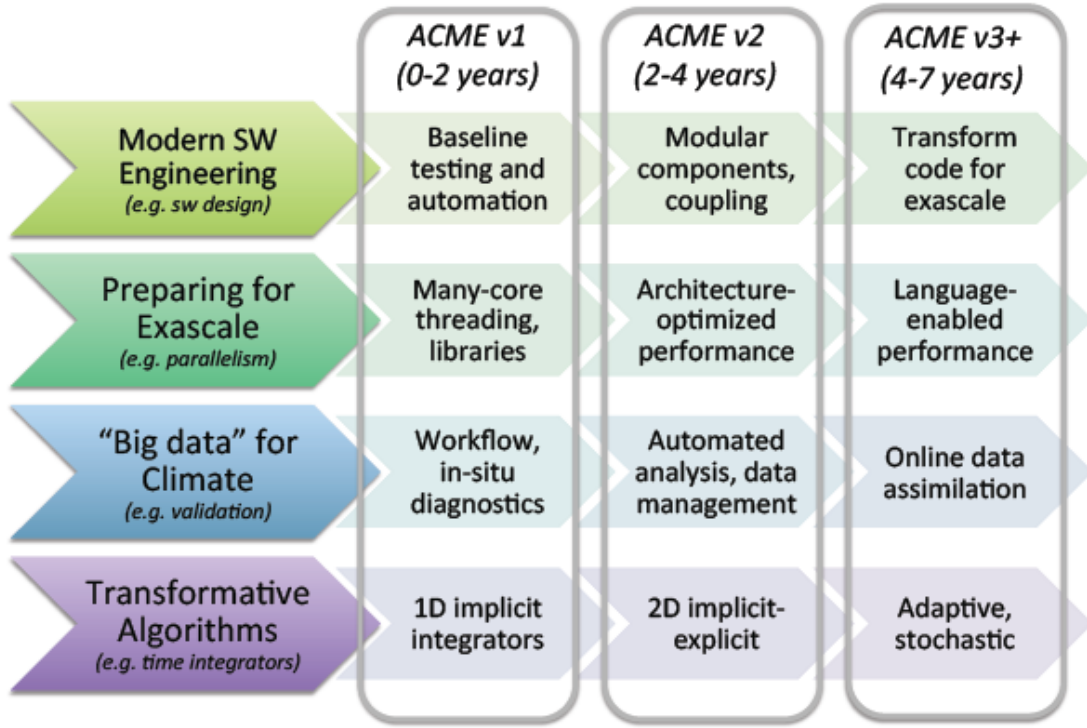
Cryosphere: How do rapid changes in cryospheric systems interact with the climate system?

Long term committed Antarctic ice sheet contribution to SLR from changes in 2010-2050.





Computation roadmap



Performance on Titan

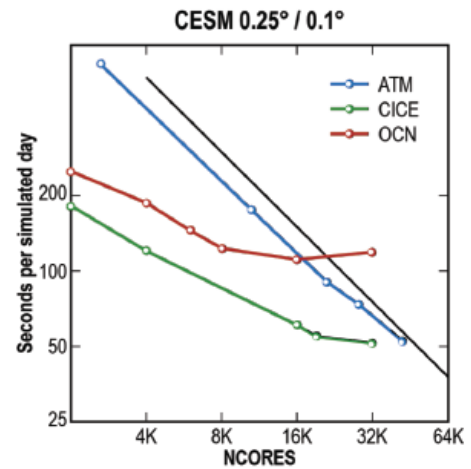


Figure 6.2-2: Strong scaling of the CAM atmosphere, POP ocean and CICE ice models in our baseline high-resolution configuration of the ACME v0 running on the ORNL Titan Cray XK6.

SciDAC3, 3 Lab-led projects, 2011-2016

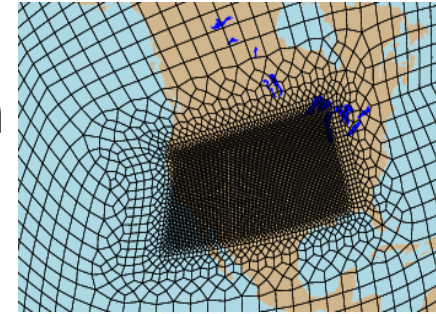
Next-generation component capabilities

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

****Next generation of convective clouds**

****MPAS-Ocean performance (SUPER case study)**

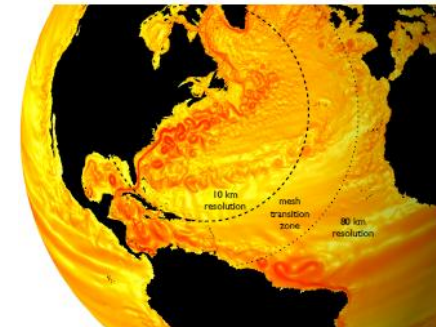


2. Predicting Ice Sheet and Climate Evolution at Extreme Scales (PISCEES)

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

****Sea-level rise projection**



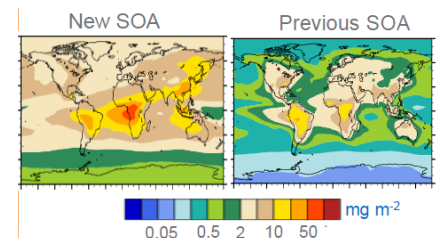
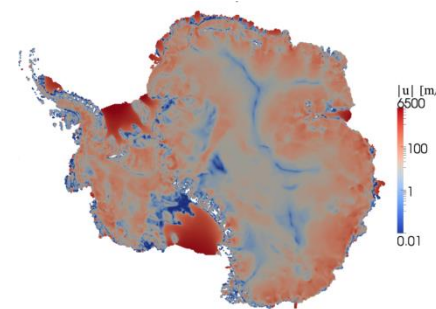
3. Applying Computationally Efficient Schemes for BioGeochemical Cycles (ACES4BGC)

ORNL, SNL, LLNL, PNNL, LANL, ANL, NCAR

Organic species for atmosphere, ocean and land

Tracer transport, variable mesh

****Carbon cycle systems**



SciDAC University (2014-2016)

8 projects recommended for funding

Next-generation capabilities

Topics

Atmospheric processes at high resolution:

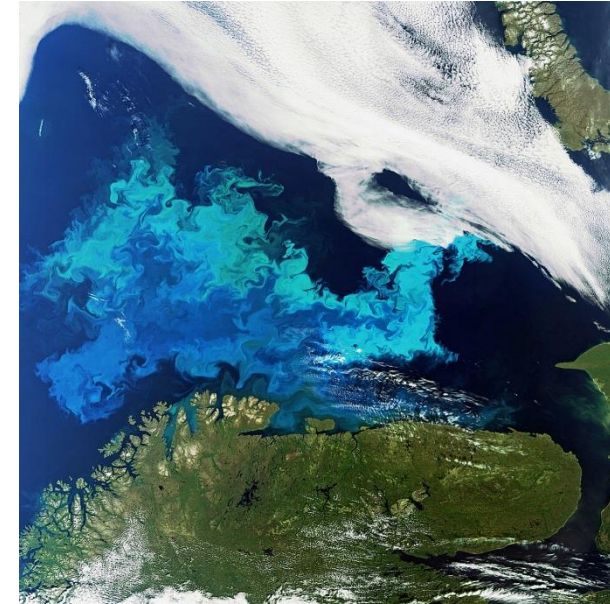
- Boundary layer turbulence
- Cloud processes
- Radiative transfer

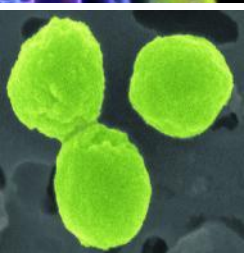
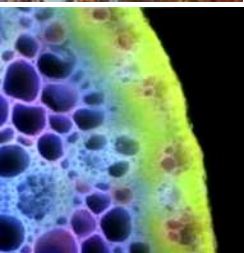
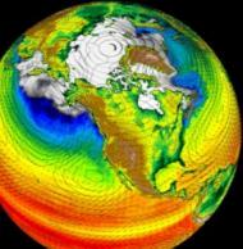
Ocean processes

- Resolving and fixing mixed-layer bias in southern ocean
- Modularizing ocean biogeochemistry
- Spin-up for ocean biogeochemistry

Land modeling

- Approach for using plant traits (instead of types)

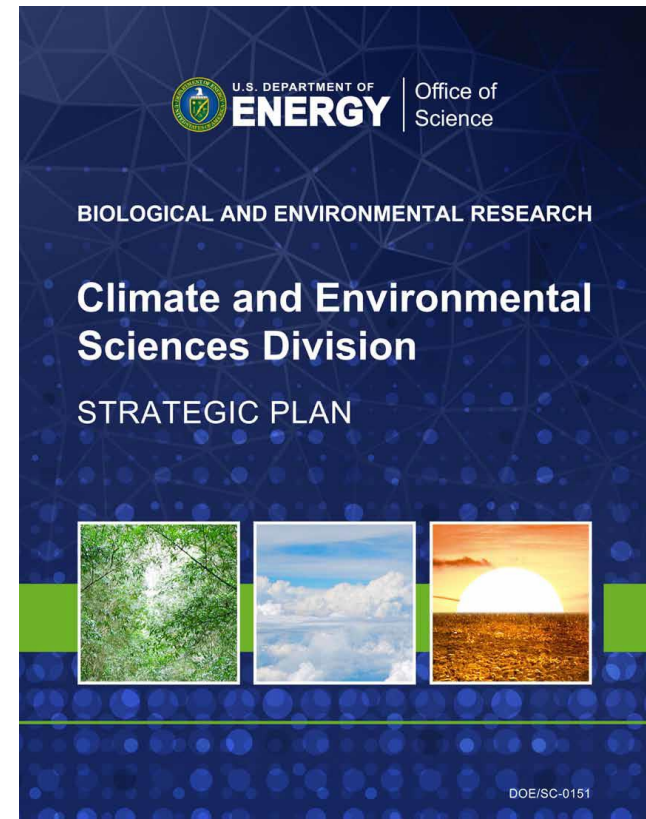




Thank you!

Dorothy Koch
Dorothy.Koch@science.doe.gov

<http://www.climatemodeling.science.energy.gov/>



<http://science.energy.gov/~media/ber/pdf/CESD-StratPlan-2012.pdf>