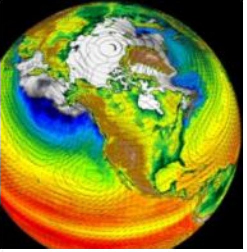
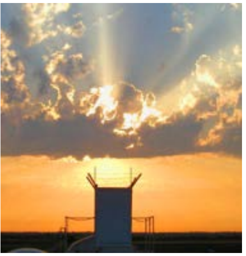
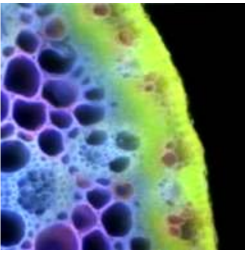
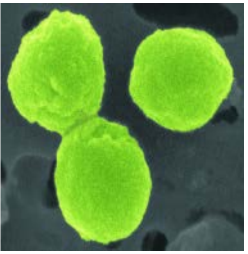



SciDAC-BER Climate Modeling

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

1. BER-climate-SciDAC context
2. SciDAC-3 projects
3. New direction for computational-climate modeling

July 24, 2013

SciDAC-3 Principal Investigator Meeting

Biological and Environmental Research

Climate and Environmental Sciences (CESD)

Biological System Sciences

Atmospheric Science

Climate and Earth System Modeling

Earth System Modeling

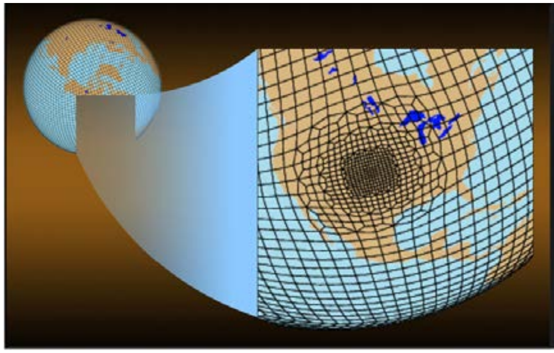
Regional & Global Climate

Integrated Assessment

Environmental System Science

CESD Mission: To advance a robust predictive understanding of Earth's climate and environmental systems and to inform the development of sustainable solutions to the Nation's energy and environmental challenges

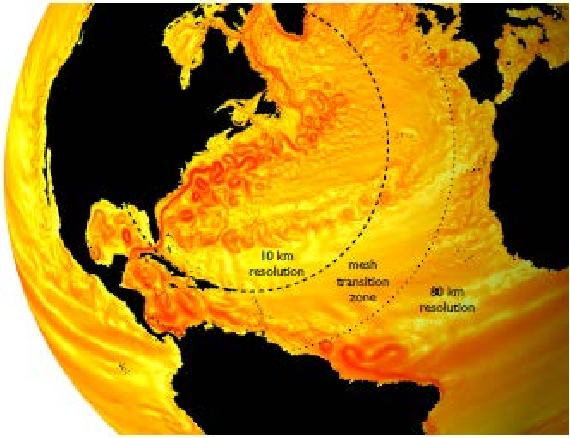
BER supports the Community Earth System Model (CESM)



CESM is supported by NSF and DOE

DOE requires the model for
- energy mission (energy-climate interactions)
- science (terrestrial and atmospheric)

DOE-BER builds *advanced codes* to run on DOE LC computers
ASCR partnership is crucial for our success!



DOE development examples

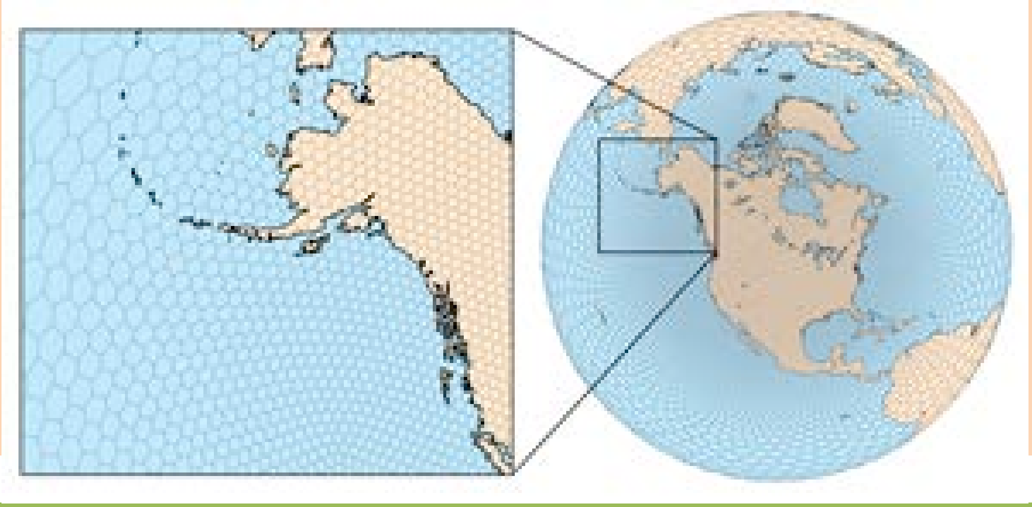
- **Ocean: POP, MPAS-O**
- **Sea-ice and land-ice: CICE, BISICLES, FELIX**
- **Atmosphere: CAM-SE**
- **Aerosols: MAM**
- **Land biogeochemistry and hydrology: CLM-Me, VIC**
- **Coupler: CPL7**
- **Workflow and visualization softwares: UV-CDAT**
- **Computational methods: UQ**

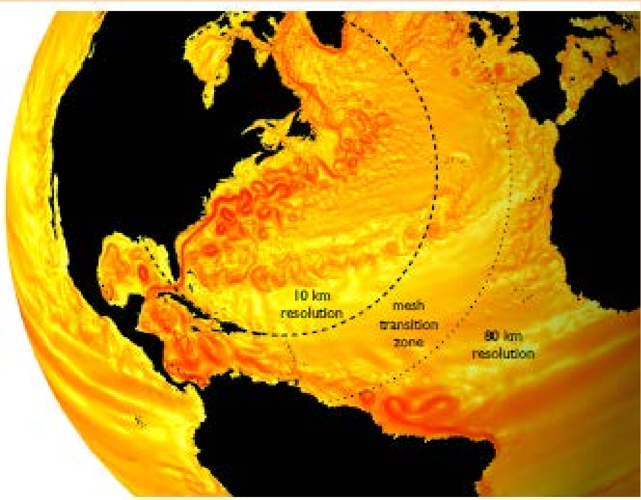
Multiscale Methods for Accurate, Efficient, and Scale-Aware Models of the Earth System

Bill Collins, PI
LBNL, LANL, PNNL, ORNL, LLNL, SNL, UCAR, UW-M, CSU, UCLA

- **Ocean and atmospheric dynamical cores with adaptive mesh now need adaptive physics: Ocean Eddies, Atmospheric Convection**

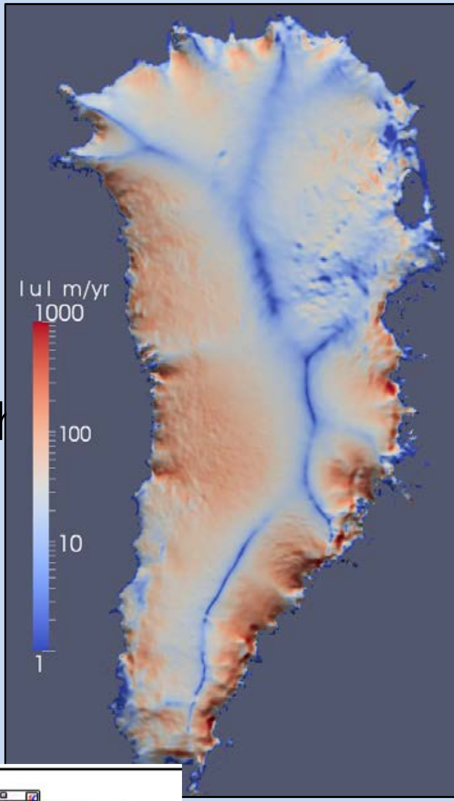
Scale-aware convection schemes, cloud microphysics and macrophysics;
Scale-aware Eddy scheme in vertical and horizontal
UQ methods for probing process sensitivities and measuring success
Multi-scale physics convergence and performance optimization





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

Phil Jones, acting PI
LBNL, LANL, ORNL, SNL, UCAR, MIT, FSU, U-SC, UT-Austin

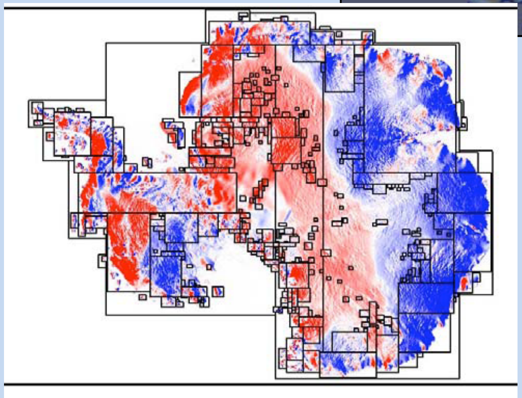


- **Climate models do not yet have dynamic ice sheets.**
- **Critical for projecting sea-level rise**

PISCEES is developing two ice sheet dynamical cores:

1) finite-volume, structured, Chombo dynamic adaptive mesh
2) finite-element, unstructured static MPAS mesh

Fine mesh where melt/motion greatest
Validation and verification toolkit
Uncertainty quantification
Adjoint methods to achieve rapid equilibrium

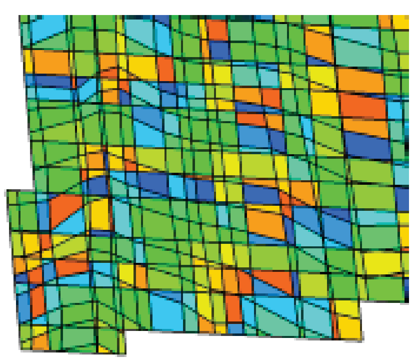


Applying Computationally Efficient Schemes for BioGeochemical Cycles (ACES4BGC)

Forrest Hoffman, PI
ORNL, SNL, LLNL, PNNL, LANL, ANL, UCAR

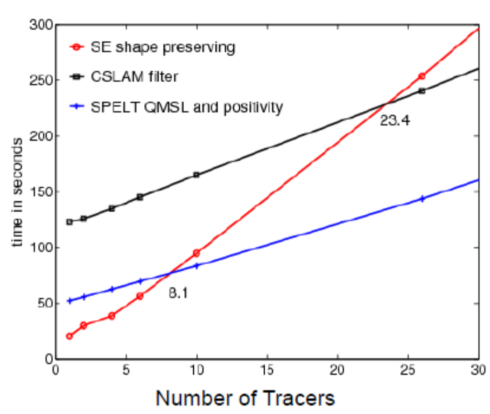
- **Critical for capturing biogenic aerosol feedbacks to climate**
- **Critical for capturing ocean and land biospheric responses and feedbacks**

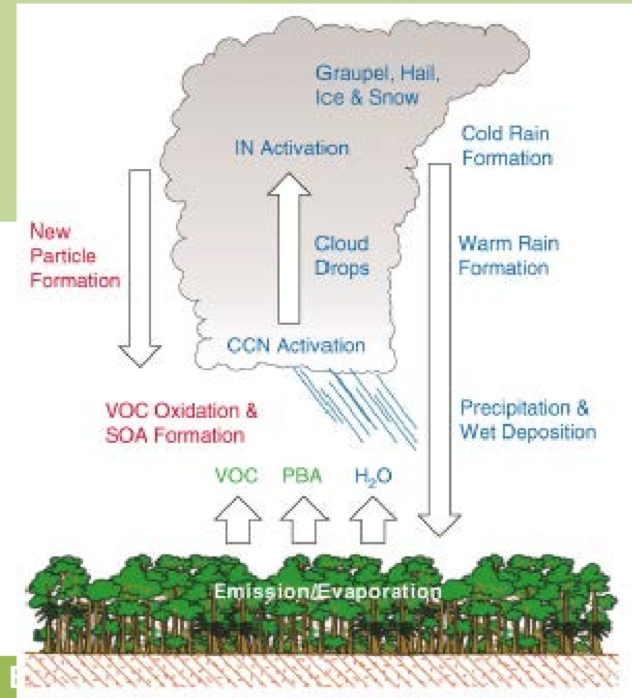
1) New tracer advection scheme for unstructured grids
2) Performance for large number of tracers
3) Improve organic emissions, chemistry
4) Uncertainty characterization



$$M_{int} = M_{dep} \cap M_{arr}$$

Transport methods





New directions: DOE's Earth System Model

DOE-BER is planning to develop a DOE-ESM branch of the Community Earth System Model (CESM) beginning in FY2014.

DOE will fold existing (non-SciDAC) Laboratory funds in the Earth System Modeling program into a single large multi-laboratory Project.

The Project will:

a) **Enable DOE to develop an ultra-high resolution model version that supports DOE mission and climate science**
b) **Provide a project-space to optimize the full coupled DOE-ESM performance on DOE computers**
c) **Enhance multi-Laboratory coordination**
d) **Ultimately contribute a better climate model back to the Community (faster, high-resolution, upgraded software and workflow capabilities)**

SciDAC is focused on components.

DOE-ESM will address full coupled climate system.

Project Draft Science Drivers

With focus on years 1970-2050:

1. **How do the hydrological cycle, and water resources, interact with the climate system on local to global scales?**

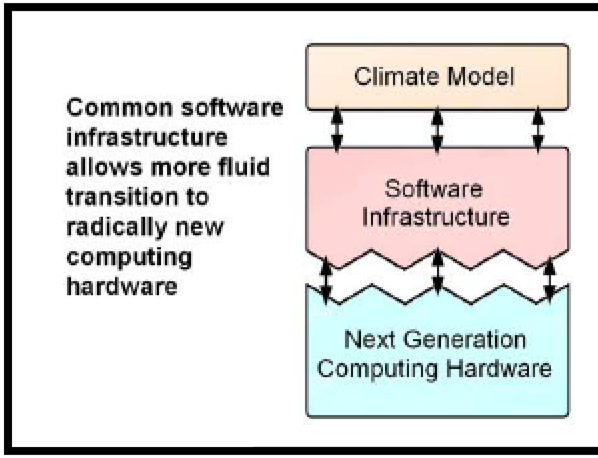
2. **How do biogeochemical cycles interact with global climate change?**

3. **How do rapid changes in cryospheric systems interact with the climate system?**

4. **How do short-term variations in natural and anthropogenic forcers interact with natural variability and contribute to regional and global environmental change?**

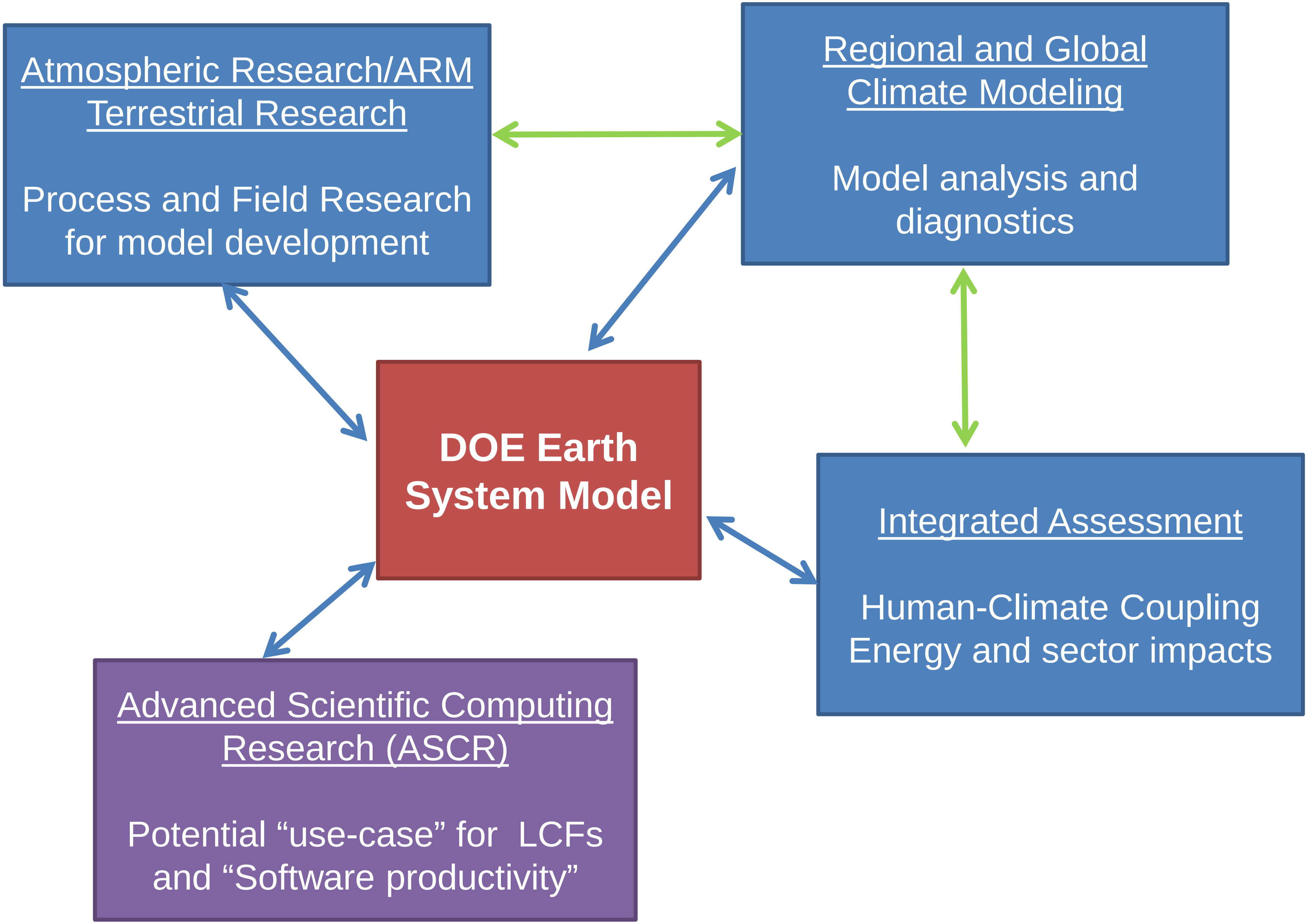
Computational Framework and Objectives
(Leveraging DOE-ASCR capabilities)

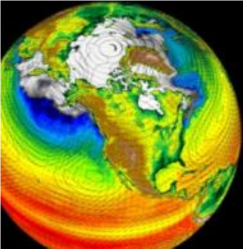
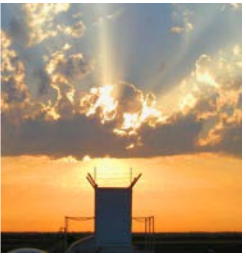
1. **Upgrade the climate code to efficiently utilize current and future DOE Leadership Class Computers, toward developing climate code architecture for the broader climate community that will adapt flexibly to future "extreme-scale" computing.**

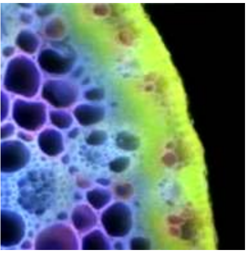
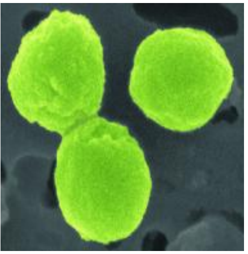


2. **Advance software engineering coding and practice to facilitate automation, calibration, provenance, code performance and code evolution.**

Links within DOE



Thank you!

Dorothy Koch
Dorothy.Koch@science.doe.gov

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