SciDAC-BER Earth and Environmental System Modeling (EESM)

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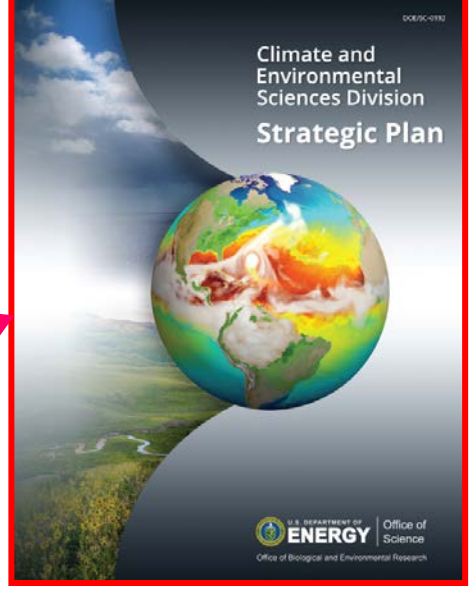
1. BER Earth system modeling context, E3SM
2. SciDAC-4 projects
3. Themes of broader SciDAC interest

Biological and Environmental Research



Biological System Sciences

Climate and Environmental Sciences (CESD)

Atmospheric Science

Earth and Environmental System Modeling

Development

Analysis

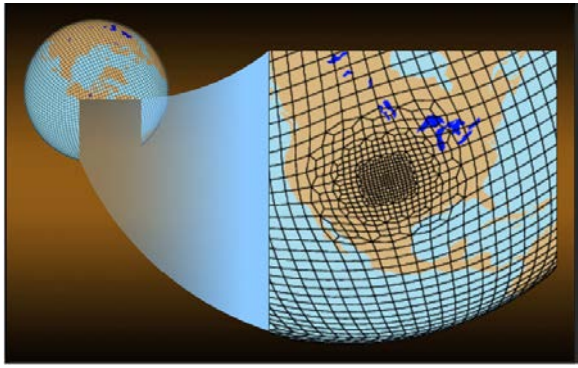
Multisector dynamics

Environmental System Science

CESD Mission: The Division's mission is dedicated to providing the fundamental science needed to inform the development and deployment of advanced solutions to the nation's energy challenges.

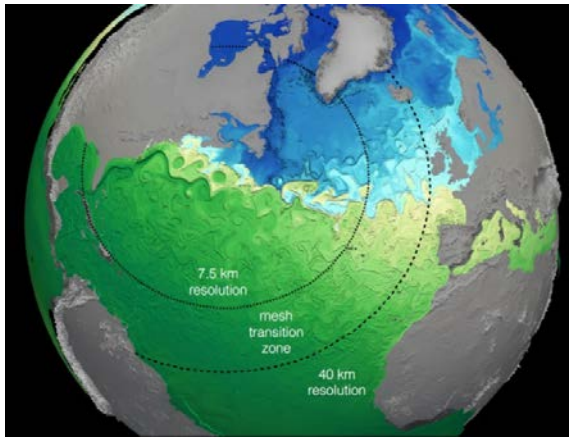
BER SciDAC

Earth System Model (ESM) development



The international community of Earth System Models (ESM's) face a crisis in terms of using newest architectures:

- Traditional performance approaches, distributing grids over nodes, is not sufficient
- ESM's require communication across nodes
- ESM's are complex, extensive and often old (e.g. fortran)
- ESM's have typically evolved from simple to complex without sufficient care to how processes are coupled
- ESM's have not always prioritized performance

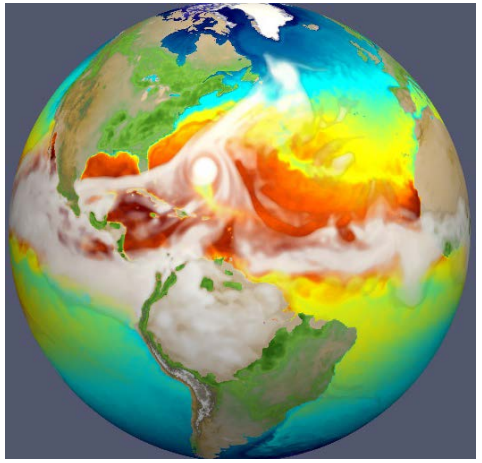


SciDAC is vital for addressing such challenges

Energy Exascale Earth System Model and project

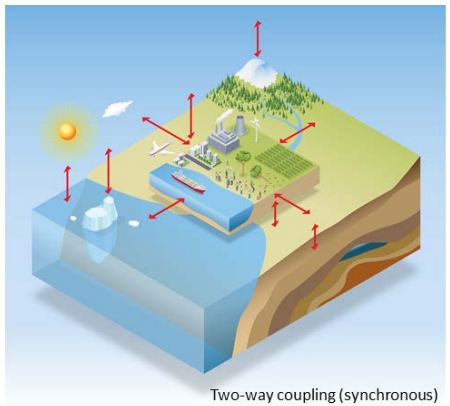
BER's E3SM unique features (compared to other ESMs):

- Effective use of DOE supercomputers and advanced software practice; Needs to use all LCF and NERSC machines.
- Focus is on high-resolution configuration (25km) and the coupled system
- DOE science and mission are central to the development priorities
- Variable-resolution-mesh capabilities included in all components (up to 10km atmosphere, 6km ocean, 500m ice-sheet)



Science Goals

- "Water cycle": What factors govern precipitation and water cycle (land-atmosphere-ocean) now and in the future? How will freshwater supplies change?
- "Cryosphere-ocean": What is likelihood of Antarctic-ice-sheet destabilization, regional sea-level changes and storm-surge?
- "Biogeochemistry": What are the effects of nutrients and land-use on soil carbon reservoirs?



Energy Exascale Earth System Model

Programmatics:

- Version 1 (v1) was released in April, 2018: includes code, output data, analysis tools
- The Project code is now Open-Development: https://github.com/E3SM-Project/E3SM
- New project website: https://E3SM.org
- Phase 2 project proposal was reviewed May 14-16, 2018

Simulation progress (v1):

- The low resolution (100km) simulations are progressing.
- High-resolution (25 km) production simulations imminent

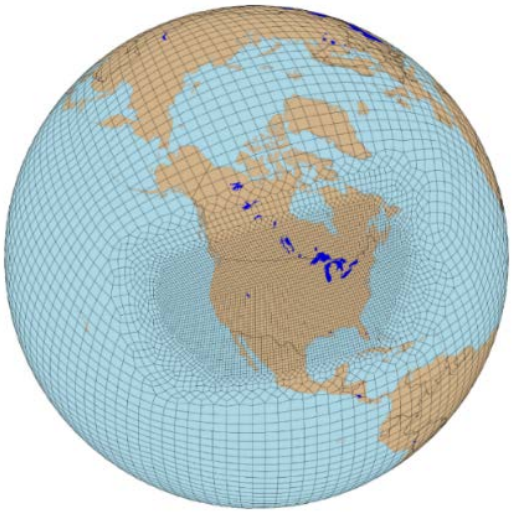
Phase 2 plans (versions v2-v3-v4)

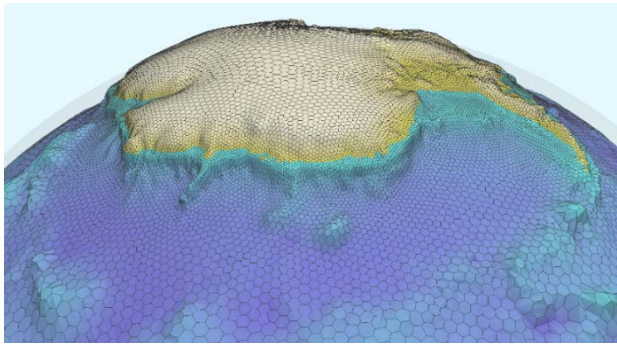
- V2 - Regional refinement over North America, focus on energy-relevant science (e.g. water management, land-use, crops)
- V3-v4 aims for high-resolution (3km) reconfigured atmosphere and strong scaling on DOE computers
- Antarctic ice-ocean simulations use variable mesh ocean and ice-sheets

Community engagement

- Several new projects, including SciDAC projects, will use E3SM. On-line training provided early this fall.

****SciDAC projects will contribute mainly to v4-v5**





SciDAC-4

BER-SciDAC4 has 2 types of projects:

Part1: First call was for 5-year Lab-led projects to address specific E3SM challenges:

1. Tracing uncertainty in sea-level to ice-sheet and coupled system processes
2. Improving the treatment of coupling, both in terms of improved fidelity as well as performance
3. Developing an approach for initializing the high-resolution coupled E3SM system quickly, needed because a) there is not compute-time for extensive control run and b) because the E3SM needs to have predictive skill

Part 2: Second was an open call for innovative, possibly high-risk, new designs for the E3SM (v3 or later). These must improve E3SM computational performance and fidelity. These are smaller, could be led by Labs or Universities, and are 2.5 year pilot projects, with the potential for renewal funding pending demonstrated success.

SciDAC-4 Projects

Part 1: 5-year Lab-led projects to address pressing problems for E3SM:

- ✓ **Tracing uncertainty in sea-level to ice-sheet and coupled system processes (ProSPect)**
- ✓ **Improving the treatment of coupling, from fidelity and from performance perspectives (CANGA)**

No award made for: Developing an approach for initializing the high-resolution coupled E3SM system …

We will hold an informal side meeting this afternoon to discuss how ASCR UQ and algorithmic designs for data assimilation, system equilibration might help on this challenging problem

Part 2: 6 exploratory-Pilot project awards (2017-2019):

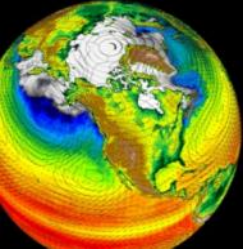
- ✓ Non-Hydrostatic Atmosphere Dynamics with Multi-Moment Characteristic Discontinuous Galerkin Methods
- ✓ Assessing and Improving the Numerical Solution of Atmospheric Physics in E3SM
- ✓ Adaptive Vertical Grid Enhancement for E3SM atmosphere
- ✓ DEMSI: Discrete Element Model for Sea Ice
- ✓ OSCM: Optimization of Sensor networks for Climate Models
- ✓ Development of Terrestrial Dynamical Cores for E3SM

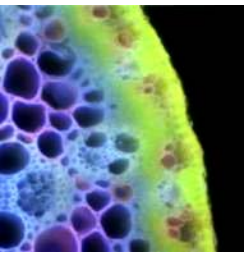
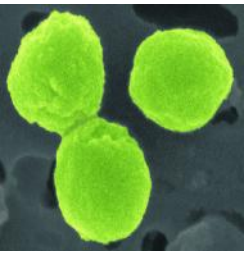
Themes and challenges for BER

1. Time-stepping – e.g. how to increase time-step size while also obtaining good solutions, increasing resolution (sometimes with regional refinement)
2. Programming modeling directions: e.g. Kokkos and Legion
3. Process coupling and solution convergence
4. Working with unstructured or dynamic meshes
5. Working with dynamic boundaries between components
6. Propagation of uncertainty through processes or components
7. Approaches for facilitating collaboration between domain and computational scientists

We will update this list in the BER session!
Other offices might consider making a list like this for future topic-oriented discussions or collaborations

BER SciDAC4 institute coordinator: Kate Evans



Thank you!

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Modeling
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E3SM
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