U.S. DEPARTMENT OF ENERGY

Office of Science

Biological and Environmental Research

David Thomassen, Ph.D.

Chief Scientist

Biological and Environmental Research

ENERGY

Leading Basic Research for a Sustainable Future

ENVIRONMENT

Understanding Climate Change and Improving the Environment

INNOVATION

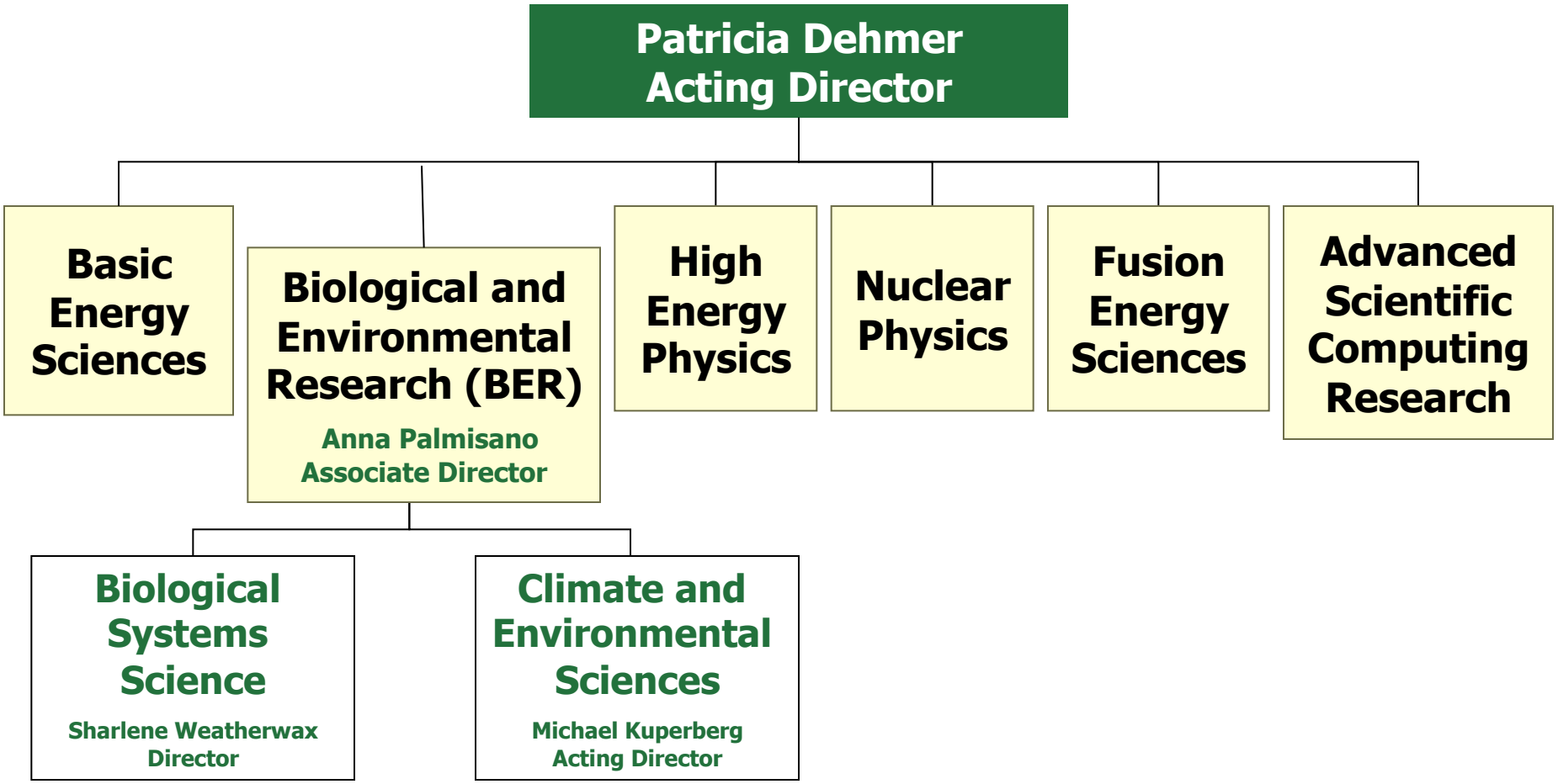
Building Research Infrastructure and Partnerships that Foster Innovation

DISCOVERY

Unraveling Nature's Deepest Mysteries

SCIENCE.DOE.GOV

DOE Office of Science



BER Mission

To understand complex biological, climatic, and environmental systems across spatial and temporal scales by:

- Exploring the frontiers of genome-enabled biology
- Discovering the physical, chemical, and biological drivers of climate change
- Seeking the biological, geochemical, and hydrologcial determinants of environmental sustainability and stewardship

BER Mission Drivers

Provide the foundational science for:

- Developing biofuels as major, secure, and sustainable national energy resources
- Understanding potential effects of greenhouse gas emissions on Earth's climate and biosphere and the implications of these emissions for our energy future
- Predicting the fate and transport of contaminants in the subsurface environment at DOE sites
- Developing new tools to explore the interface of biological and physical sciences

The BER Approach

- Understanding *complex* biological and environmental systems across many spatial and temporal scales, including:

  from the sub-micron to the global

  from individual molecules to ecosystems

  from nanoseconds to millennia

- Integrating science by tightly coupling theory, observations, experiments, models, and simulations
- Supporting interdisciplinary research to address critical National needs
- Engaging national laboratories, universities, and the private sector to generate the best possible science

Biological and Environmental Research

(Appropriations in millions $)	FY 2008 Appropriation	FY 2009 Appropriation
Research		
Biological Systems	167	173
Bioenergy Research Centers	75	75
Climate Change Research	132	98
Environmental Remediation Science	47	49
Total, Research	**387**	**429**
Facilities		
Scientific User Facility Operations		
Environmental Molecular Sciences Laboratory (PNNL)	43	49
Production Genomics Facility (JGI)	60	65
Atmospheric Radiation Measurement (ARM)	35	40
Total, Facilities	**138**	**154**
Other		
(e.g., Small Business Innovation Research)	19	17
Total, BER	**544**	**600**

BER HPC Needs & Opportunities

Example 1 – Biology, a long discussed and rapidly growing opportunity and need

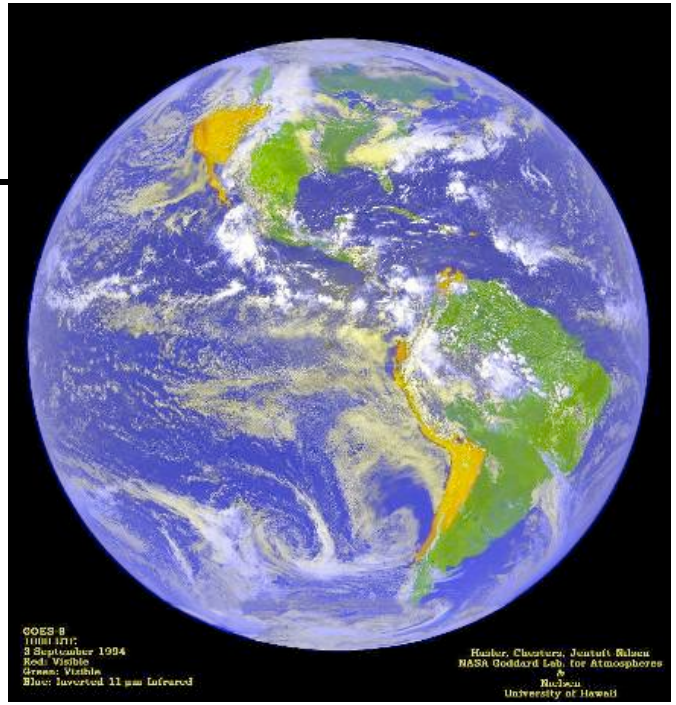
Genomics:GTL

A Vision of Systems Biology Research

- Within 10 years, we will start with a plant, microbe, or microbial community of interest and in a matter of a few days for microbes or years for plants:
  - Fully and accurately annotate genome or community DNA
  - Identify the functions and products of the majority of genes
  - Generate a working regulatory network model
  - Identify the biochemical capabilities of the organisms
  - Design re-engineering or control strategies *in silico*
  - Redesign or refocus an organism for mission-critical needs
- Today, almost all of these activities take months to decades!

Ecogenomics

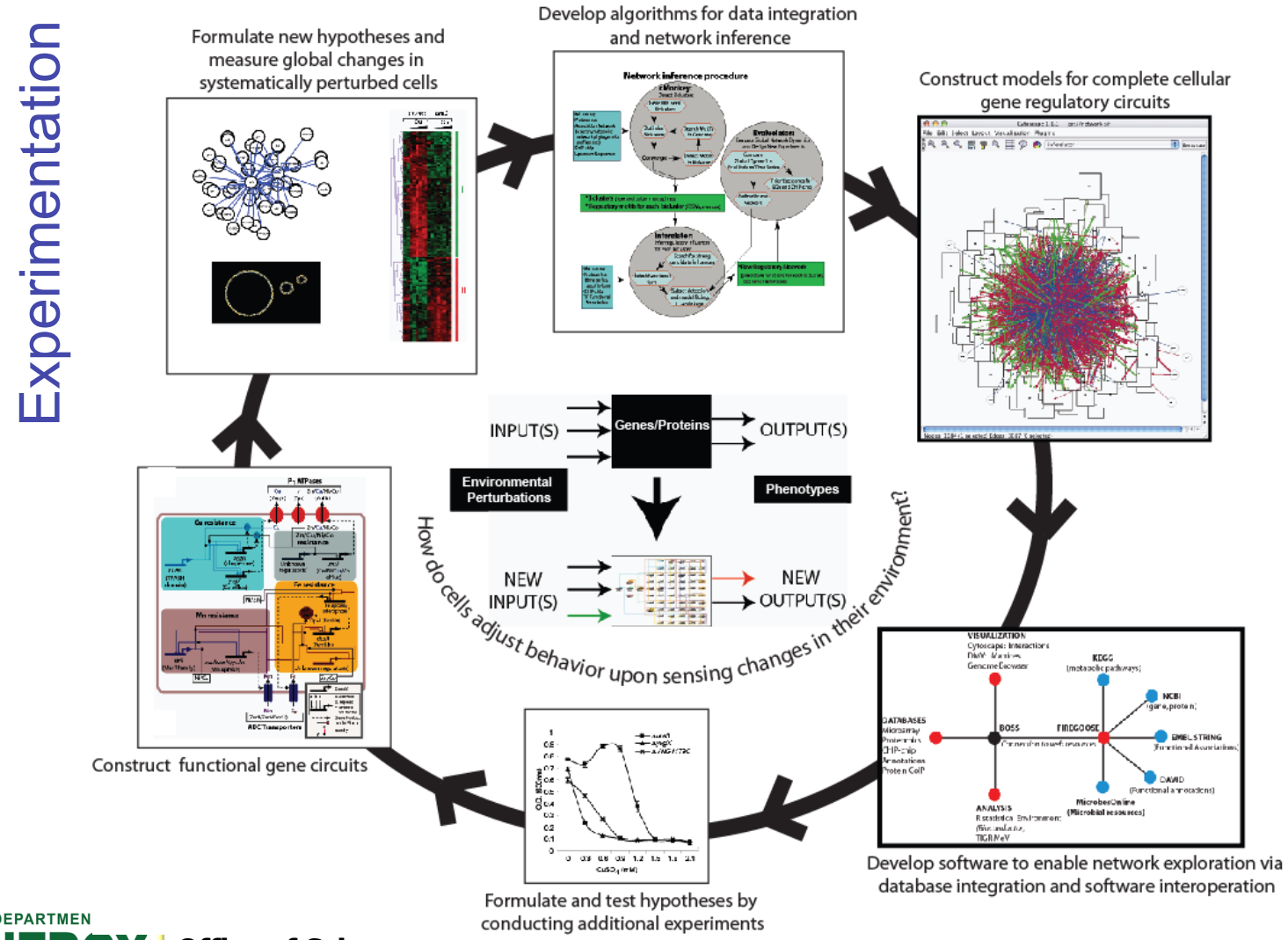
A New Scientific Frontier



Global biogeochemical processes are mediated by microbes, but relatively few have been cultured

- *Ecogenomics* – Applying the tools of genomics, proteomics, and systems biology to ecological questions
- Metagenome-scale sequences may reveal:
  - Structure and function of microbial communities
  - Microbe-host and microbe-microbe interactions
  - Metabolic capabilities that drive global-scale processes

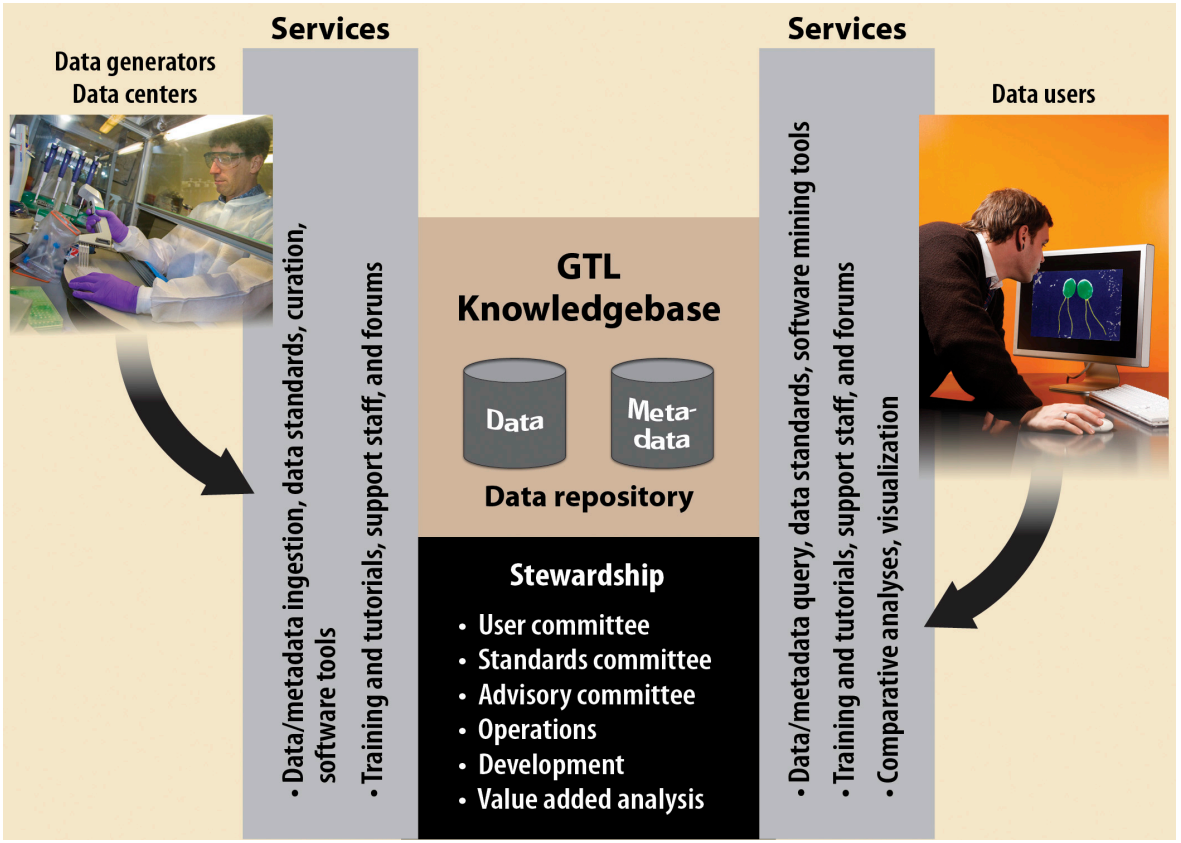
Systems Biology Needs an Iterative Approach



Knowledgebase: A New Era in Biology

Knowledgebase will:

- Be an integrated repository for critical GTL data & information
- Balance architecture types, performance, scalability and latency requirements
- Link together ontology, data standards and data curation
- Adapt existing tools for data analysis and extend new tools for data visualization
- Integrate & connect with other data repositories & communities
- Provide performance measurements and metrics



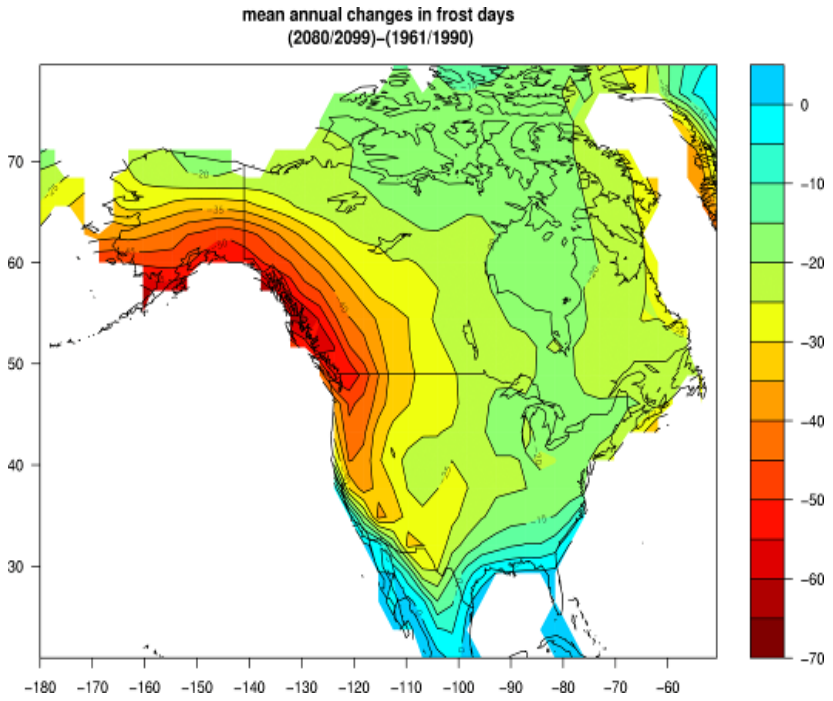
BER HPC Needs & Opportunities

Example 2 – Climate, a long standing success story and continuing need

BER Climate Change Research

The Energy-Climate Connection

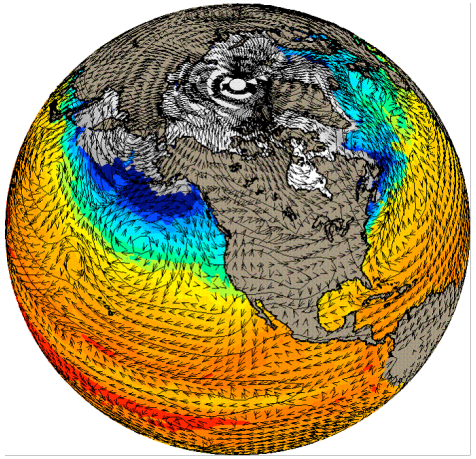
"Advance climate change research to provide knowledge of effects of greenhouse gas emissions on Earth's climate and biosphere—supporting effective energy and environmental decision making."

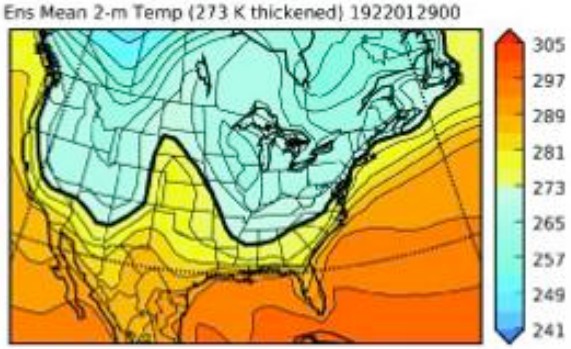


Modeling the Impacts of Climate Change. Future changes in frost days predicted from a climate model

Climate Change Prediction Program

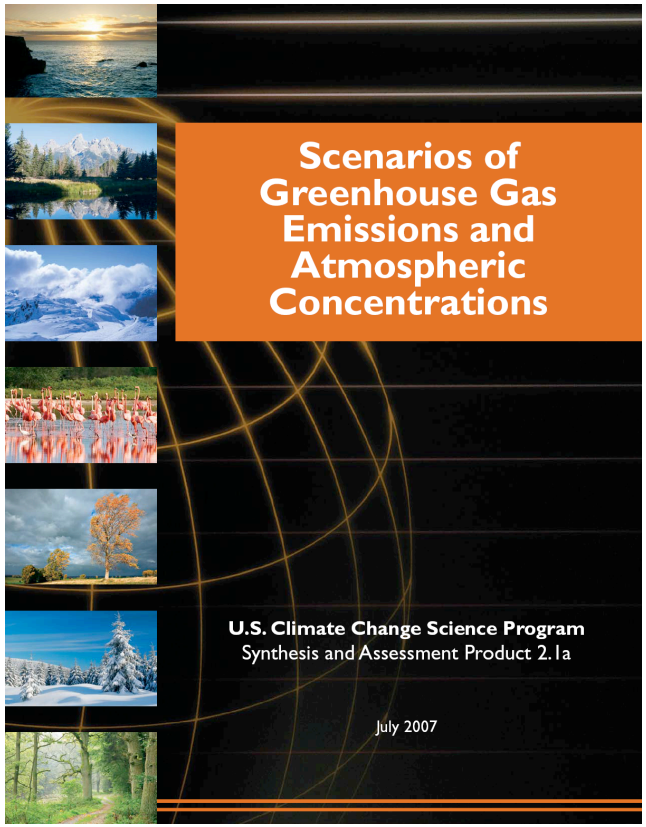
- Develop models based on definitive theoretical foundations
- Develop better representations of key climate processes
- Develop diagnostic methods and tools to evaluate models
- Test and apply coupled climate and Earth system models that stay at leading edge of scientific knowledge
- Increase fidelity and throughput of climate change projections
- Examine issues related to climate change detection and attribution



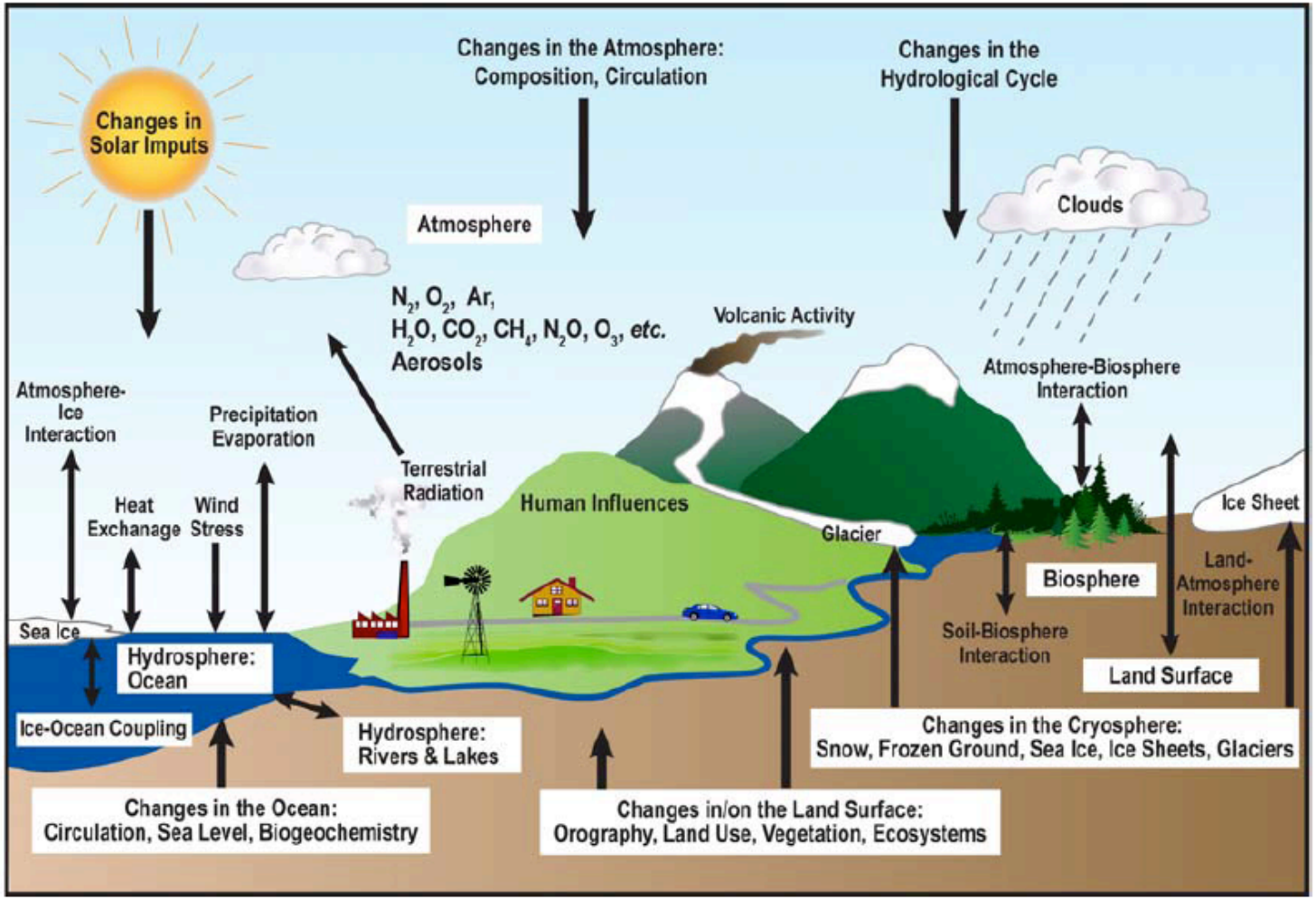


Integrated Assessment Research Program

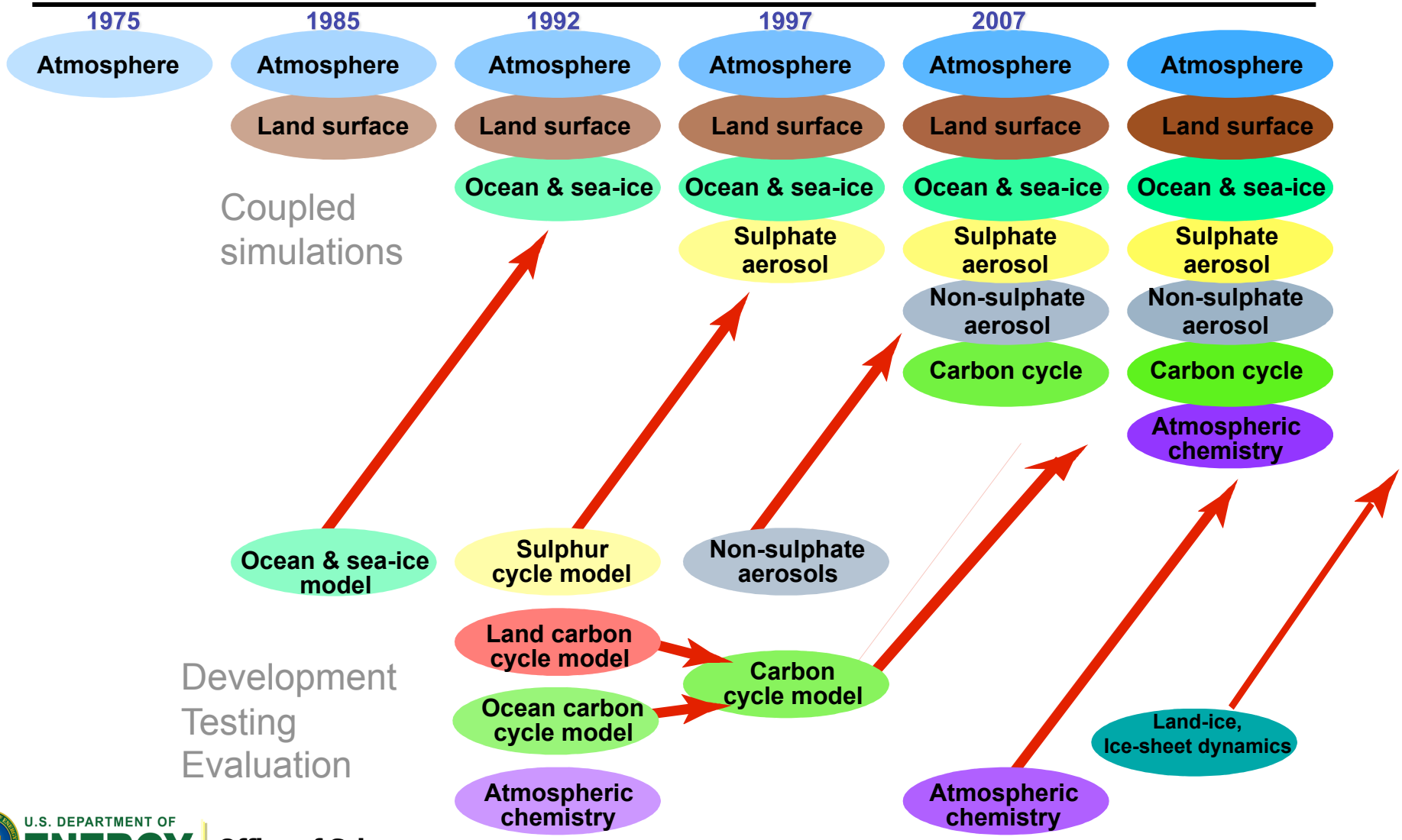
- Understand and model the complex interactions of human and natural systems
- Explore developmental pathways, emissions, the role of energy innovations, and mitigation strategies
- Provide insights into climate change impacts, adaptations, and the effects of combined, multiple stressors
- Develop global, national, and regional perspectives within economic and other policy-relevant frameworks



Climate Processes and Components: Modeling Grand Challenge



Scientific Challenge: Earth System Modeling



BER HPC Needs & Opportunities

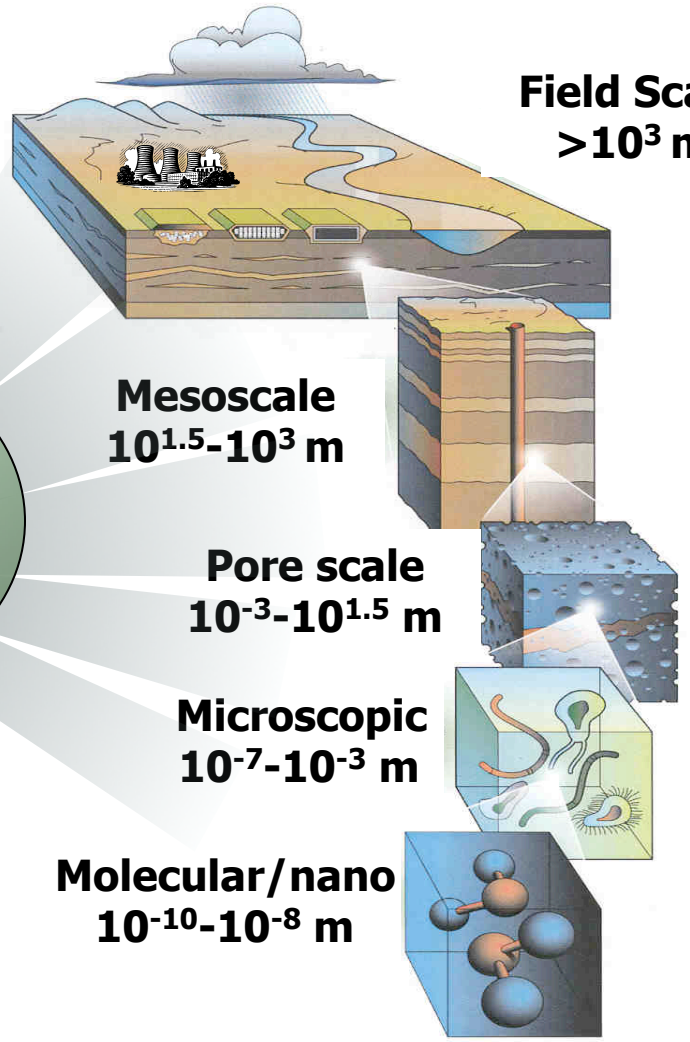
Example 3 – Subsurface science, a new opportunity and challenge

Subsurface Research Across Scales

Integrative, multidisciplinary approaches to understanding multi-scale processes controlling contaminant mobility in the environment

- Characterization and monitoring
- Microbiology, geochemistry, hydrology
- Modeling and high-performance computing
- Molecular science, EMSL, light sources

Field Research

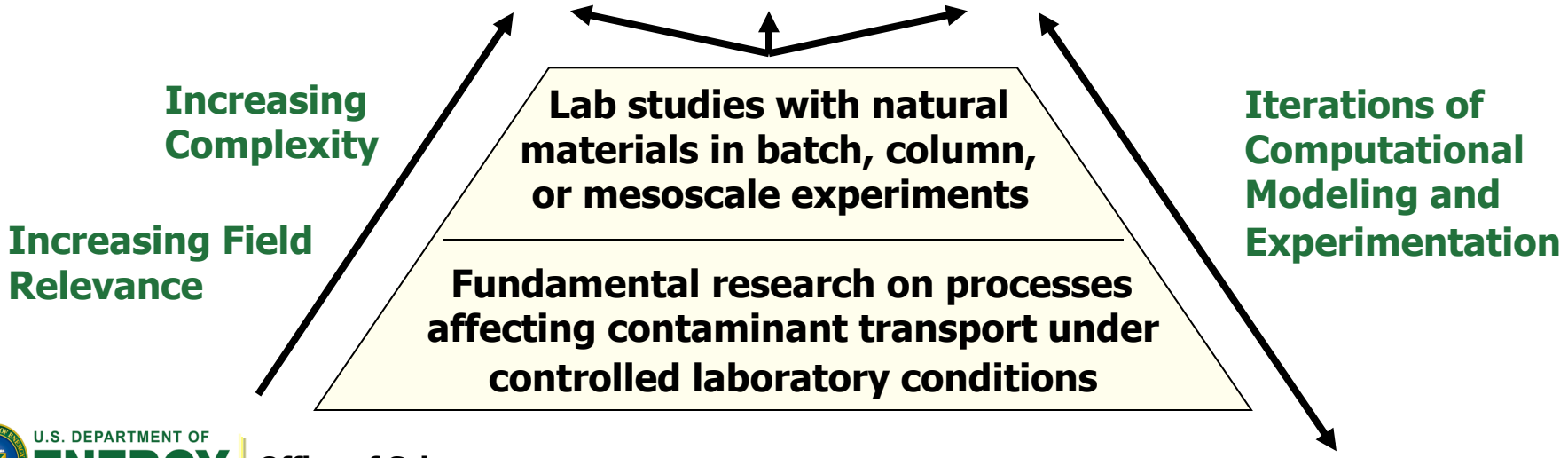


Linking Laboratory Research with Field-Scale Studies

Oak Ridge Y-12

Hanford 300 Area

Rifle UMTRA site



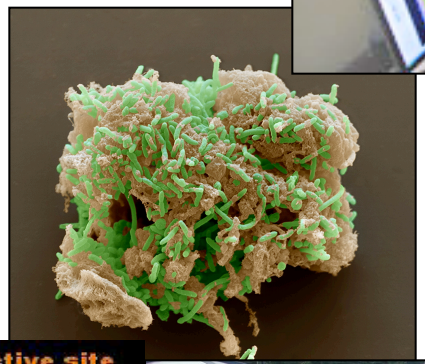
Scientific Discovery through Advanced Computing (SciDAC)

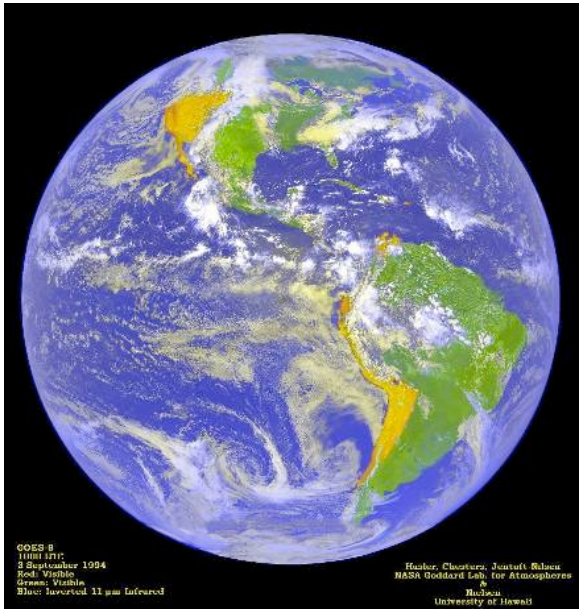
SciDAC – Conducts collaborative projects with the Office of Advanced Scientific Computing Research to leverage the Nation's intellectual investment in computational science for scientific discovery. SciDAC contributes to:

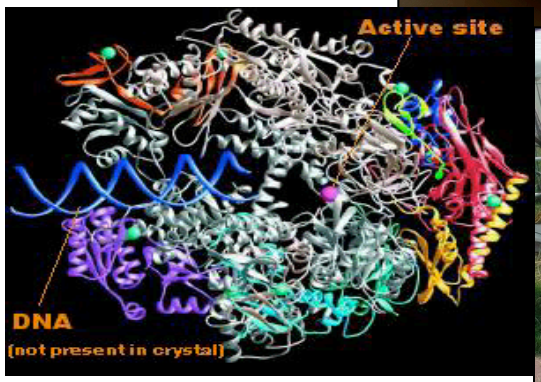
- **Climate Change Research** – Modeling how Earth's climate will respond to physical, chemical, and biological changes produced by global alterations of the atmosphere, ocean, and land
- **Genomics:GTL** – Developing new methods for modeling complex biological systems, including molecular complexes; metabolic and signaling pathways; individual cells; and, ultimately, interacting organisms and ecosystems
- **Environmental Remediation Sciences** – Developing more advanced models to better understand the movement of subsurface contamination

Biological and Environmental Research

Complex systems science to meet DOE mission needs in bioenergy, climate, and the environment







U.S. DEPARTMENT OF ENERGY | Office of Science