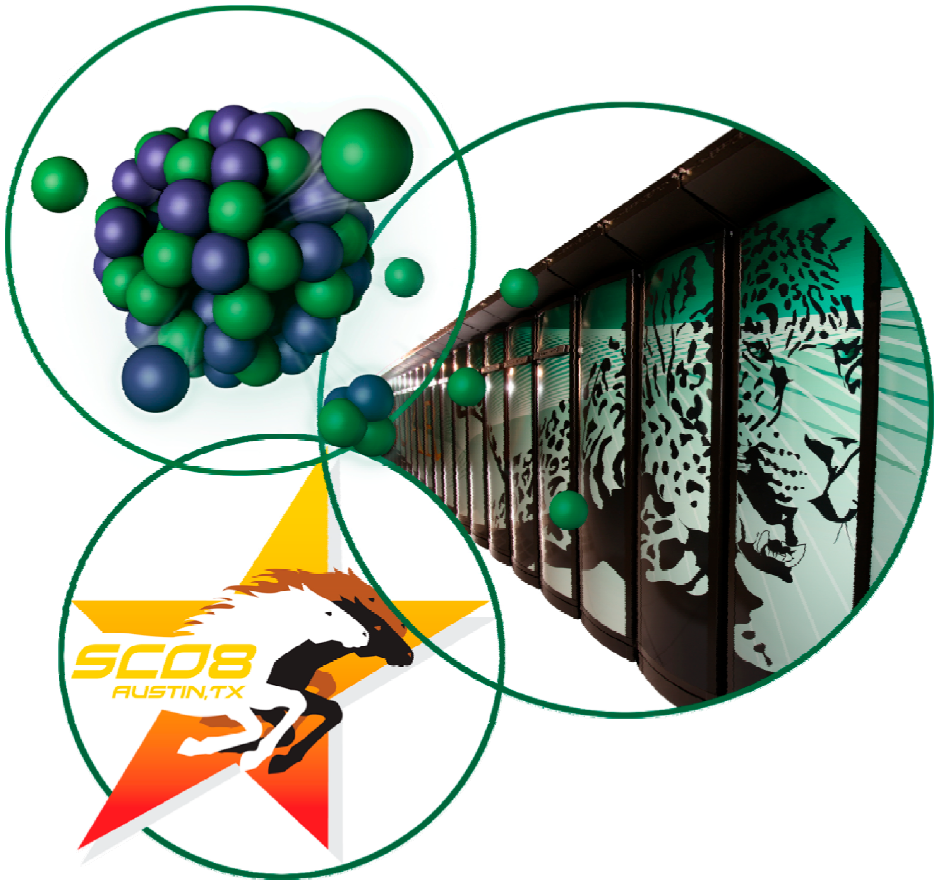
LCF Climate Science Computational End Station



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Objectives of the Climate Science Computational End Station

- **Predict future climate**
  - **Based on scenarios of anthropogenic emissions**
  - **Resulting from options in energy policies**
- **Deliver simulations that improve climate models**
  - **Scientific basis**
  - **Accuracy**
  - **Fidelity**
- **Inform national science policy**
- **Thus contribute to DOE science mission**

Approach of the Climate Science Computational End Station

- **Develop, maintain, and support the Community Climate System Model (CCSM)**
- **Execute high-priority simulations at LCF**
- **Provide outreach to research community**
  - **Simulation products**
  - **Analysis of model results**
  - **CCSM workshop**
- **Champion and execute research program to deliver CCSM4 in 3 years**
  - **In time for next assessment by the Intergovernmental Panel on Climate Change (IPCC)**

CCSM4 development objectives

- **Document, understand, and correct biases and systematic errors**
  - **Improved simulation of important quantities like regional precipitation patterns**
  - **Higher resolution in dynamics**
  - **Higher fidelity in physical parameterizations**
- **Characterize dominant nonlinear dynamical mechanisms**
  - **Climate variability and abrupt transitions**
  - **Ice and ocean processes with long timescales but small characteristic length scales**
- **Quantify nature and timing of biogeochemical feedbacks**
  - **Atmosphere, ocean, and land**
  - **Impacting global carbon cycle**

Unique value of the Climate Computational End Station

- Coordination of development and simulations
- Priority setting in climate-change research simulations
- Sharing of software expertise
- Development of scalable solutions

Roles within the Climate Science Computational End Station

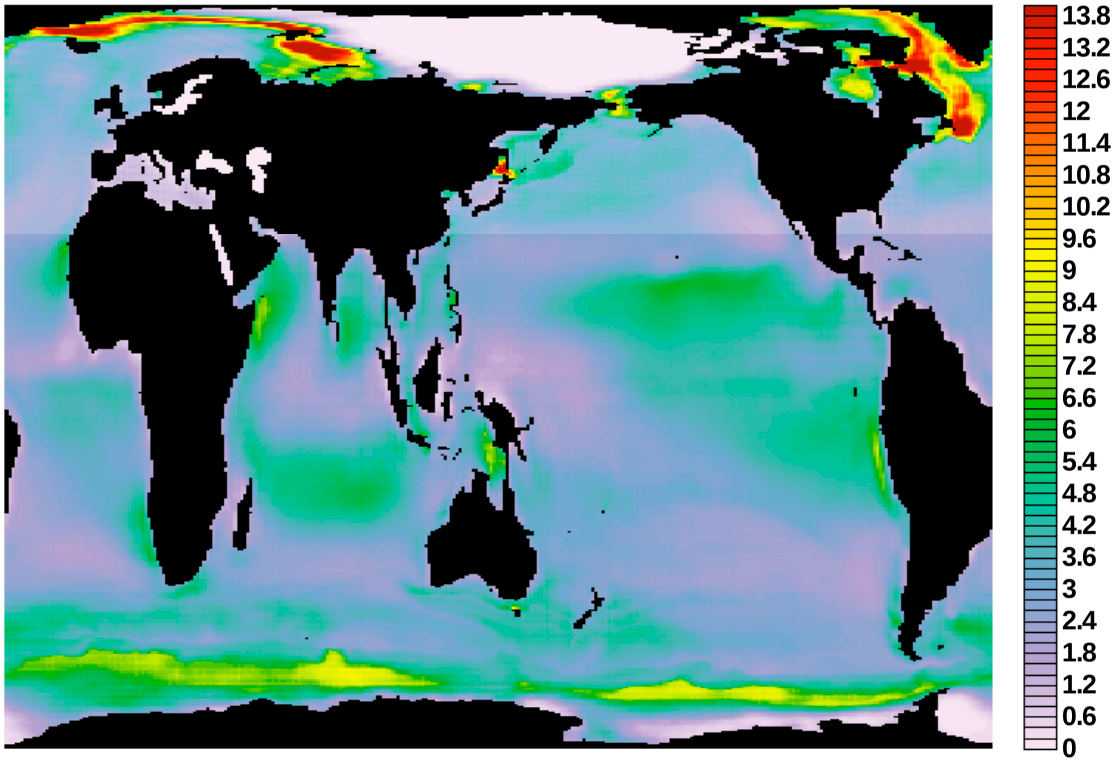
- National Center for Atmospheric Research
  - Higher-resolution atmosphere models
  - Improved physical processes that remove biases
  - Climate-change studies
- Los Alamos National Laboratory
  - Increased resolution of ocean and sea-ice models
  - High-resolution coupled experiments
  - Ocean biogeochemistry models
- Lawrence Livermore National Laboratory
  - Comparison and validation of new models
  - Scaled, distributed analysis infrastructure
  - Development and testing of high-resolution atmosphere models
- Argonne and Sandia National Laboratories
  - Porting to Blue Gene
  - Development of next-generation scalable (100 K processes) atmospheric dynamical cores

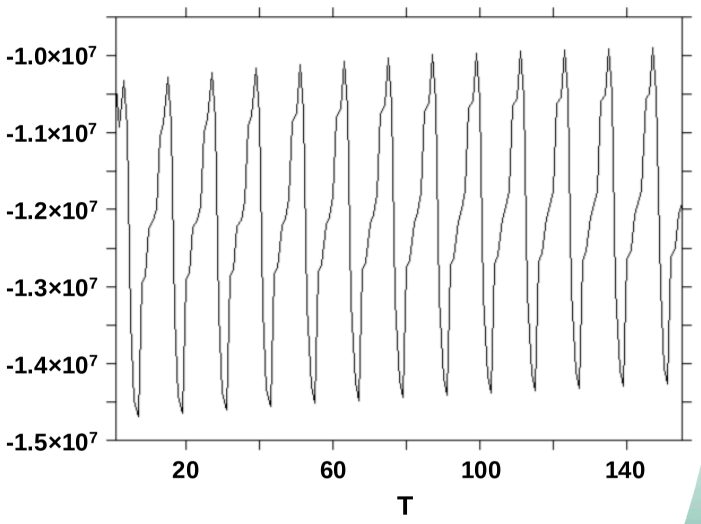
Roles within the Climate Science Computational End Station

- **Pacific Northwest National Laboratory**
  - Downscaling to investigate regional water resources
  - Embedded cloud-resolving models
  - Physically based replacements for cloud parameterizations
- **NASA Goddard Space Flight Center**
  - New observations and measurements to evaluate models
  - Advanced data-assimilation technologies
  - Improvements for policy formulation and impact planning
- **Oak Ridge National Laboratory**
  - Performance analysis and optimization
  - Software integration
  - Coupled carbon-cycle simulation
  - Biogeochemistry feedbacks
- **Additional experiments by university partners**

CCSM development (Peter Gent, NCAR)

- CCSM4: first Earth System Model
- Model development **done**
- June 2009 scheduled release

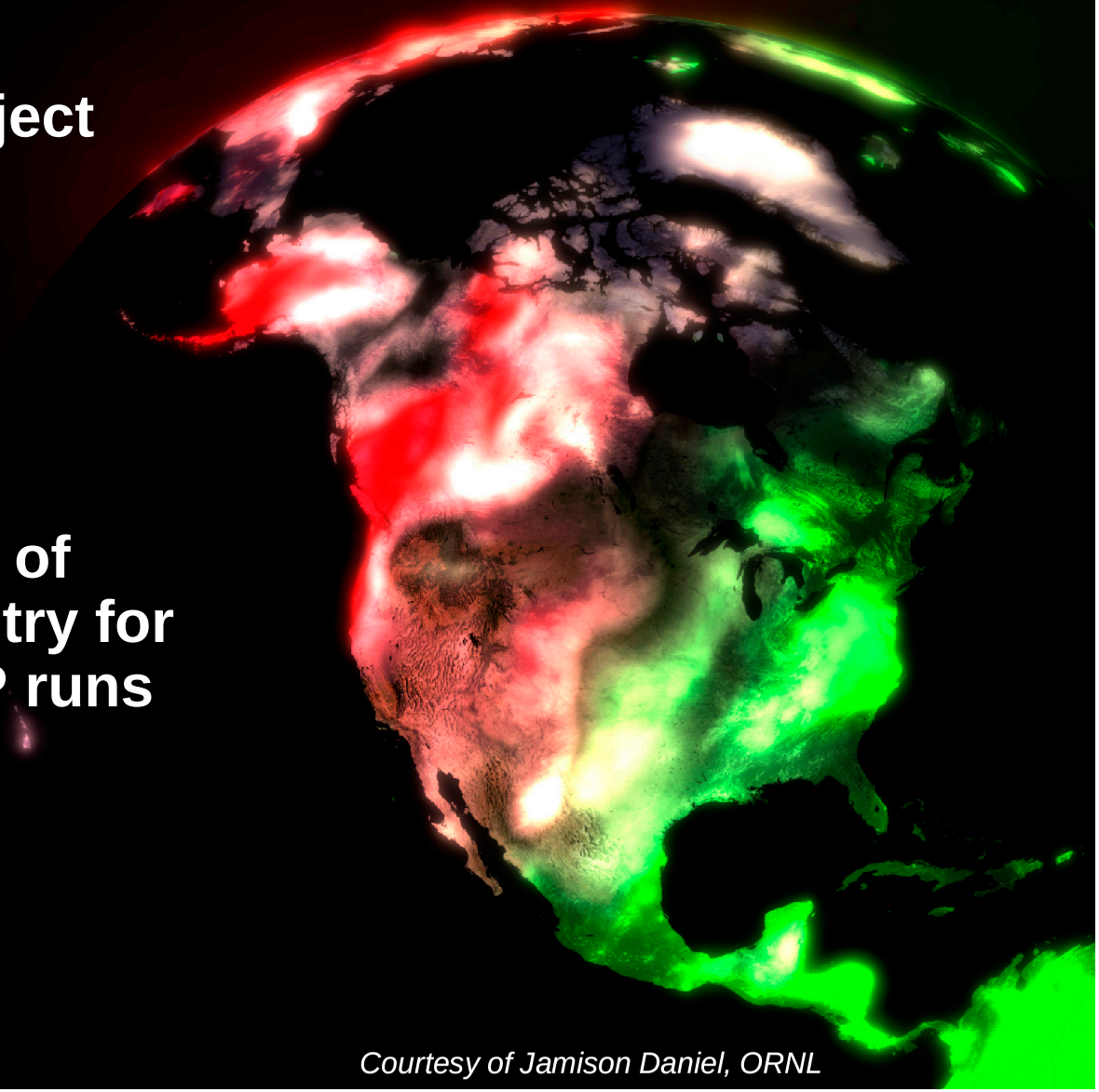




Sulphur cycle spun up

Dynamic-ecosystem feedback simulation (Forrest Hoffman, ORNL)

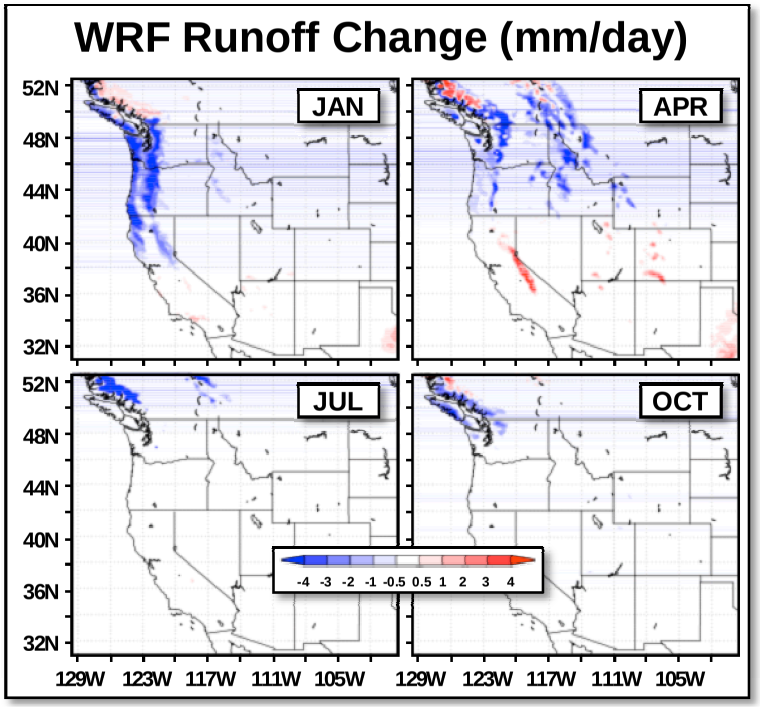
- Carbon Land Model Intercomparison Project (C-LAMP) runs completed
- Results scored against satellite data
- Guided development of CCSM biogeochemistry for extension of C-LAMP runs

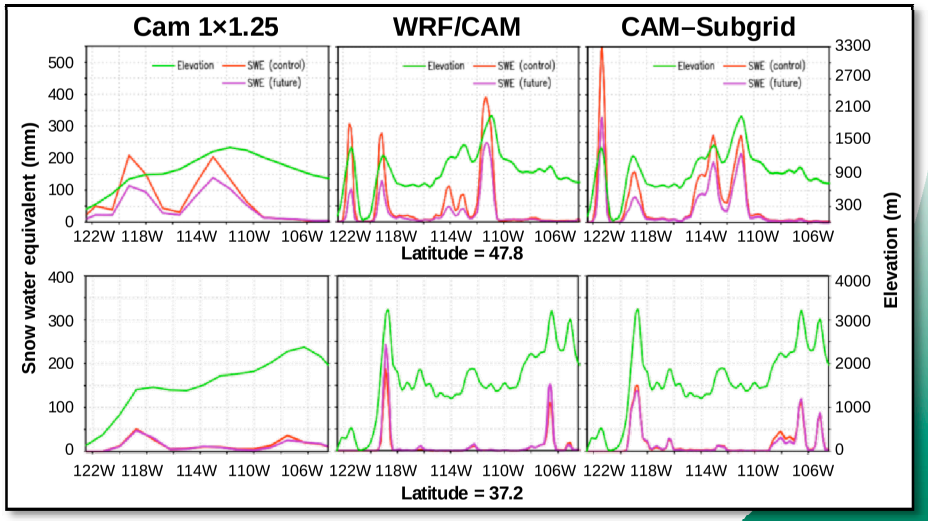


Courtesy of Jamison Daniel, ORNL

Regional downscaling (Steve Ghan, PNNL)

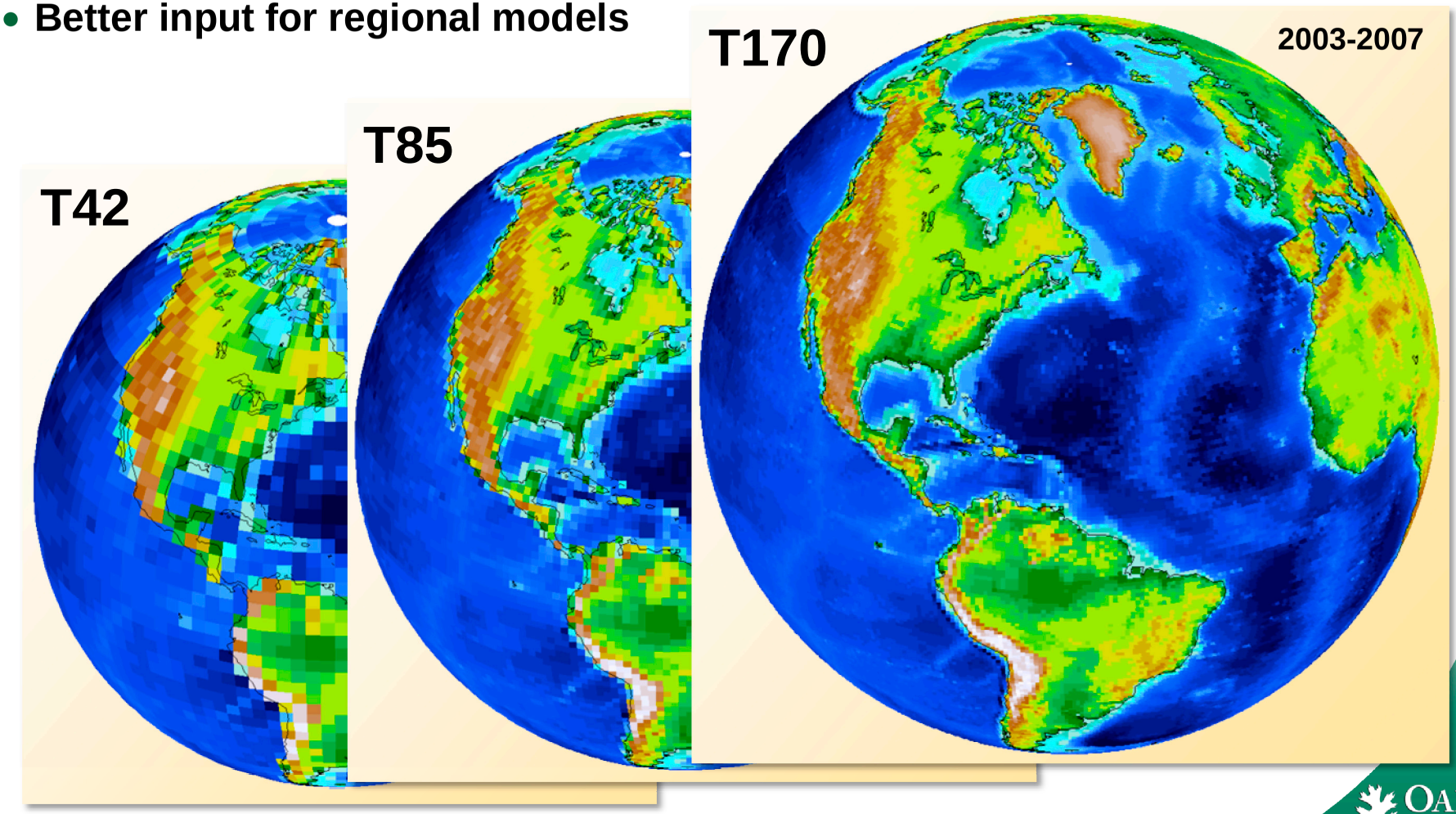
- Goal: Improve simulation and surface hydrology in regions of complex orography
- Simulations of orographic effects on western United States
  - Regional simulation with Weather Research and Forecasting (WRF) model
  - Subgrid parameterization with global Community Atmosphere Model (CAM)
- WRF showing larger changes in precipitation and snowpack
  - Diverse spacial pattern
  - Changing precipitation amount
  - More rain than snow
  - Less snowpack accumulation





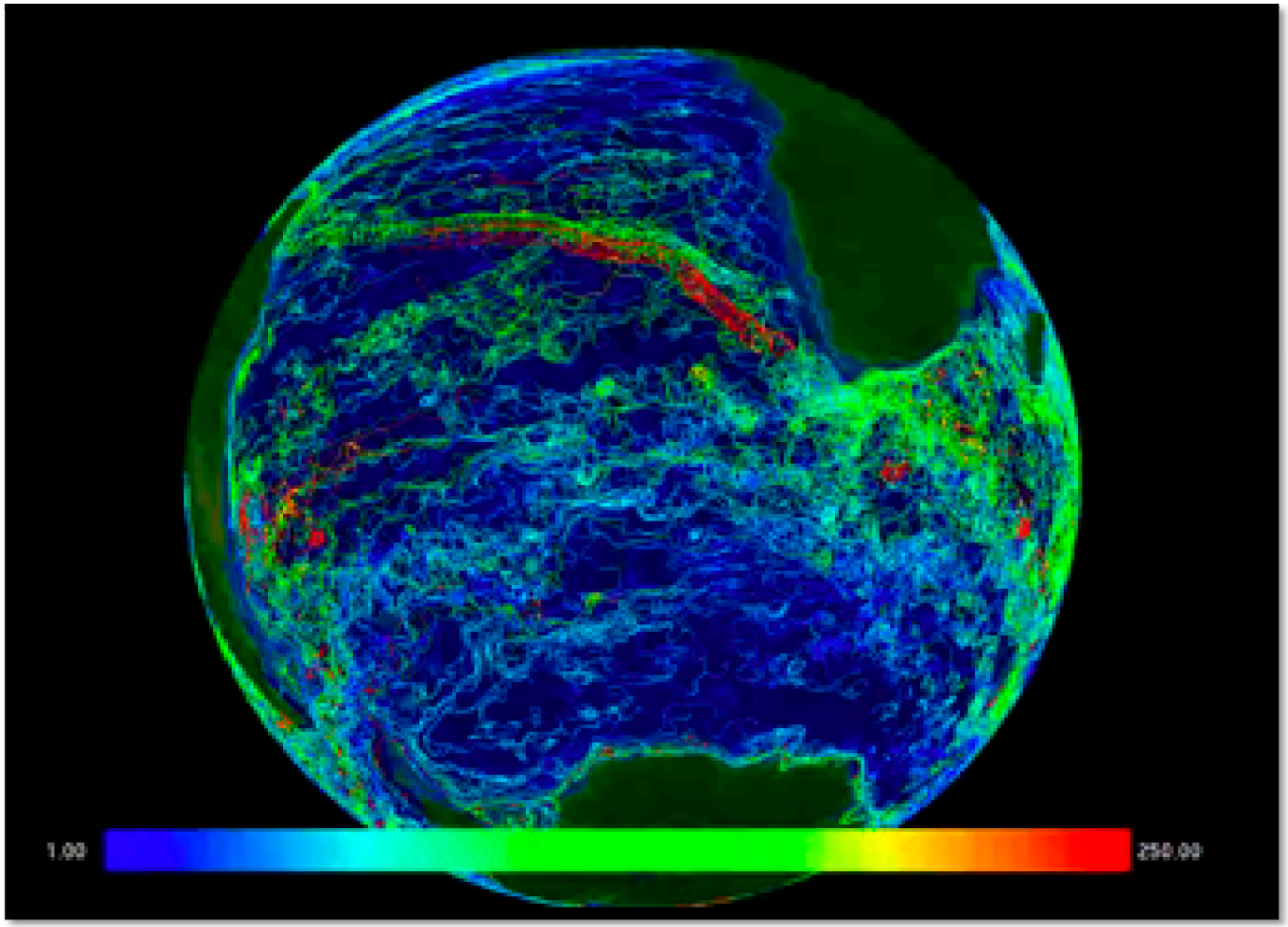
Resolution studies (Jim Hack, ORNL)

- Fully coupled simulations at T170 resolution (versus T85 for last IPCC)
- Atmosphere simulations at T340 resolution
- Improved simulation of tropical cyclones and transients
- Better input for regional models



High-resolution ocean (Phil Jones, LANL)

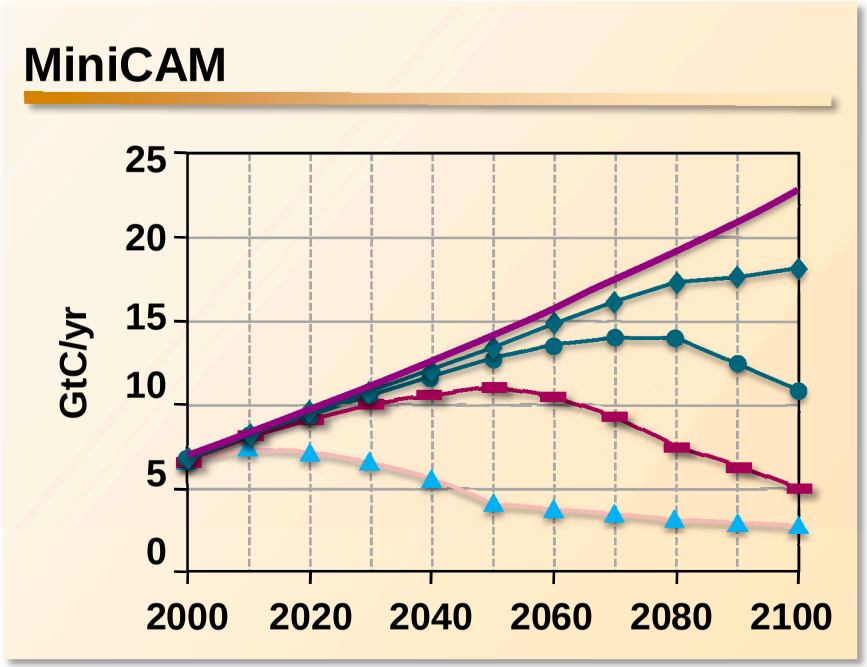
- **Spinup at 0.1° resolution complete**
- **Ready for coupling in full CCSM**



Courtesy of Mat Maltrud, LANL

Emissions-reduction scenarios

- Can we stabilize global warming using the new CCSP Report 2.1a scenarios?
- Can we limit global warming to 2°C from years 1870 to 2100?
- What are climate-change impacts on surface temperature, precipitation, and sea ice?



CCSP SAP 2.1a: CO_2 Emission Reduction Scenarios
~ 70% cut in carbon emissions by the end of century

Conclusion: It is possible to limit global warming to 2°C from 1870 to 2100 and reduce Arctic sea-ice melt; this will require a substantial decrease in the use of fossil fuels starting in the next decade or so

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