

The CCSM Carbon-Land Model Intercomparison Project (C-LAMP)

Forrest M. Hoffman (1), Inez Fung (2), Jim Randerson (3), Peter Thornton (4), Reto Stöckli (5), Faith Ann Heinsch (6), Steve Running (6), Kathy Hibbard (4), Jasmin John (2), Curt Covey (7), Jon Foley (8), W. Mac Post (1), William W. Hargrove (1), David Erickson (1), Natalie Mahowald (4)

(1) Oak Ridge National Laboratory, (2) University of California-Berkeley, (3) University of California-Irvine, (4) National Center for Atmospheric Research, (5) Colorado State University, (6) University of Montana, (7) Lawrence Livermore National Laboratory/Program for Climate Model Diagnosis and Intercomparison, (8) University of Wisconsin-Madison

Introduction

As general circulation models (GCMs) evolve and improve, there is increasing interest in applying them to understand the potential for global climate change. The global carbon cycle is of particular importance since it is thought to have a significant impact on global temperatures. A wide array of carbon models have been coupled to GCMs, and recent work has shown that coupled interactive biogeochemical models can yield useful results for climate change studies (e.g., Friedlingstein et al. 2005). Described here are intercomparison experiments using three such models coupled to the Community Climate System Model (CCSM). Two of these models, CASA' and IBIS, were previously coupled to GCMs, and a brand new model—called CN and also running in the CCSM framework—are part of a more-directed model intercomparison project specific to CCSM. It is expected that the results of this intercomparison will lead to the deployment of a production terrestrial biogeochemistry capability within the CCSM for use with runs supporting the Intergovernmental Panel on Climate Change Fifth Assessment Report.

CCSM Carbon Land Model Intercomparison Project (C-LAMP)

- An intercomparison of terrestrial biogeochemistry models running in the CCSM3 framework is being organized by the CCSM Biogeochemistry Working Group (BGCWG)
- The objectives are to compare model capabilities and effects in the coupled climate system and to understand processes important for inclusion in the coupled model for simulations supporting the IPCC Fifth Assessment Report
- Current terrestrial models running within the CCSM framework are
 - CLM3-CASA' - Carnegie/Ames/Stanford Approach model previously run in CSM1.4 for C4MIP Phase 2 (Fung et al.)
 - CLM3-CN - coupled carbon and nitrogen cycles based on the BIOME-BGC model (Thornton)
 - LSX-IBIS - Integrated Biosphere Simulator from U. Wisconsin previously run in the Parallel Climate Transitional Model (PCTM) for C4MIP Phase 2 (Thompson, Foley, Mirin, Post, Erickson)
- The experimental protocol is being developed by Inez Fung, Jim Randerson, and Peter Thornton with input from all members of the CCSM BGCWG
- The protocol involves a series of simulations at T42_gx1v3 resolution that borrows from but improves upon the C4MIP Phase 1 protocol
 - Experiment 1 - "offline" biosphere model runs (CCSM I configuration) forced with new NCEP/NCAR Reanalysis datasets (A. Dai et al.)
 - Spin-up
 - Control run (1798-2004)
 - Climate varying run (1948-2004)
 - Climate and carbon dioxide varying with nitrogen deposition (1798-2004)
 - Climate and carbon dioxide varying with nitrogen deposition and landuse
 - Experiment 2 - coupled land-atmosphere model runs (CCSM F configuration) with prescribed SSTs, sea ice and carbon dioxide
 - Spin-up
 - Control run (1800-2004)
 - Climate varying run (1800-2004)
 - Climate and carbon dioxide varying with nitrogen deposition (1800-2004)
 - Climate and carbon dioxide varying with nitrogen deposition and landuse
 - Complete protocol, metrics, and output approach are described and available for comment at <http://www.climatemodeling.org/bgcmip/>

C-LAMP Datasets and Model Output

- Special attention is being given to the development of intercomparison metrics and diagnostics relevant to the carbon cycle
- Seasonal and diurnal cycles will be analyzed and compared with observational datasets from AmeriFlux/Fluxnet towers, MODIS/satellites, and GlobalView
- Model output and post-processing data will be rewritten using PCMDI's Computer Model Output Rewriter (CMOR)
- Model output and post-processing data will be made available to the wider science community by PCMDI via the Earth System Grid (ESG) for further analysis
- The first model output datasets will soon be available on the ESG server at <http://esg2.ornl.gov/>

Computational Climate Science End-Station A Leadership Computing Facility (LCF) Project

- C-LAMP is a subproject of the Computational Climate Science End Station (Dr. Warren Washington, PI), a Leadership Computing Facility (LCF) project at the National Center for Computational Sciences (NCCS) located at ORNL
- Experiments 1 and 2 outlined above, along with corresponding ocean biogeochemistry runs, are presently being performed on the Cray X1E



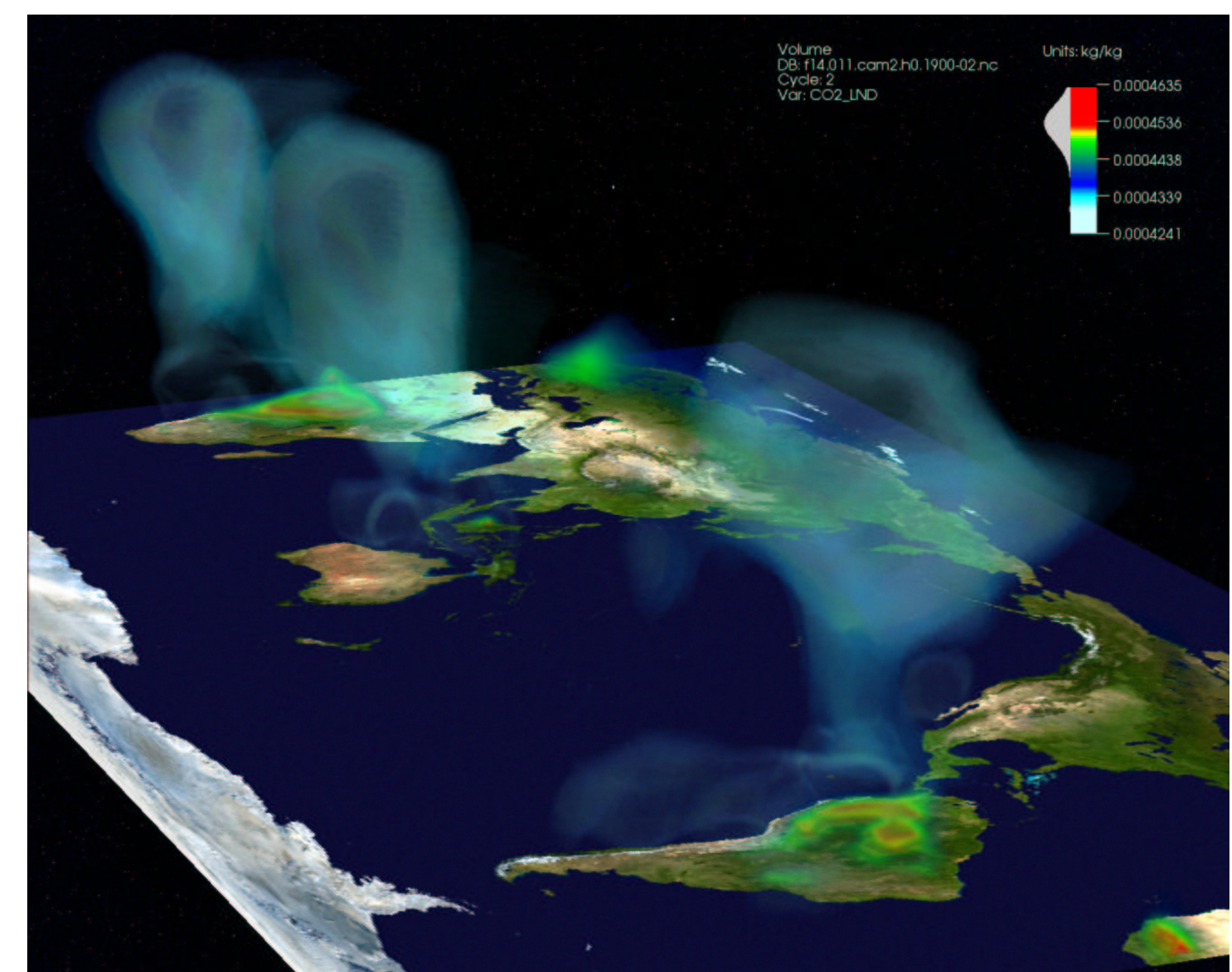
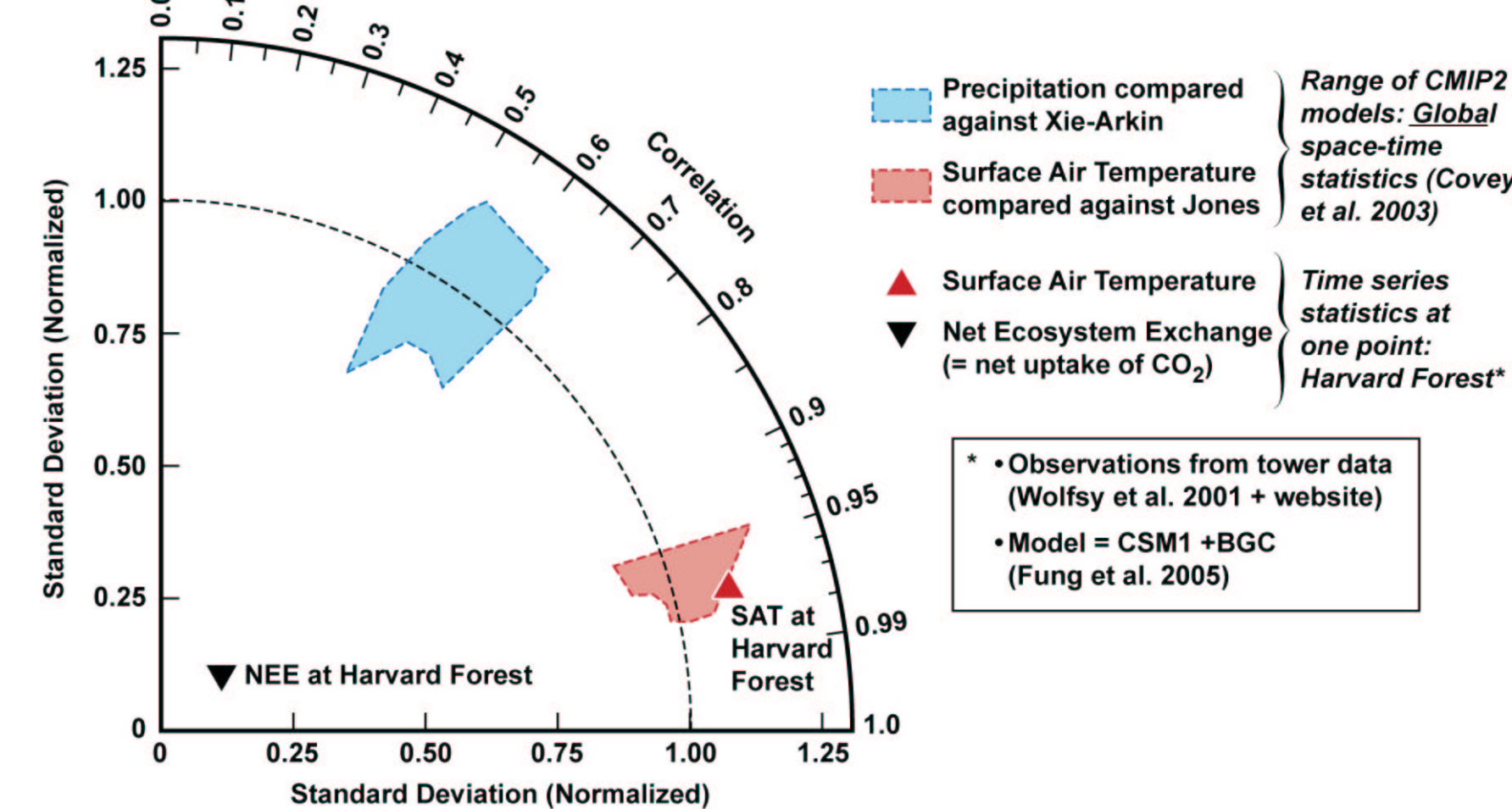
Cray X1E

- 256 interleaved "dual-core" SMP nodes
- 4 Multi-Streaming Processors (MSPs) per node
- 4 Single Streaming Processors (SSPs) per MSP
- Two 32-stage, 64-bit wide vector units running at 1.13 GHz and one 2-way superscalar unit running at 400 MHz per SSP
- 2 MB E-cache per MSP
- 8 GB of memory per interleaved node (partitioned)

1024 processors (MSPs), 2048 GB of memory, and 18.08 TFlop/s peak

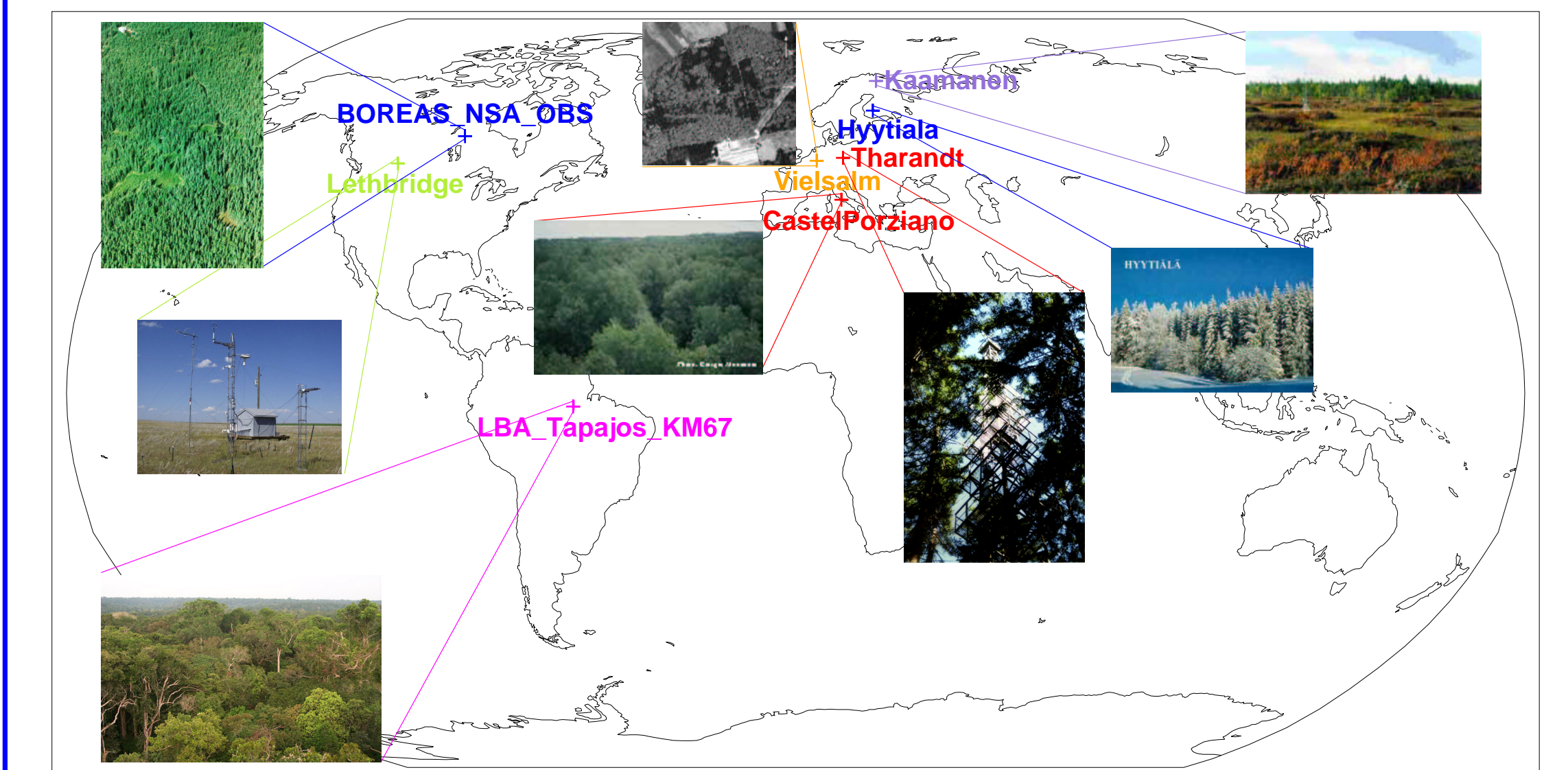
Diagnostics and Visualization

Taylor (2001) Diagrams will be used to statistically show the degree to which model results agree with observational datasets, like those shown here.



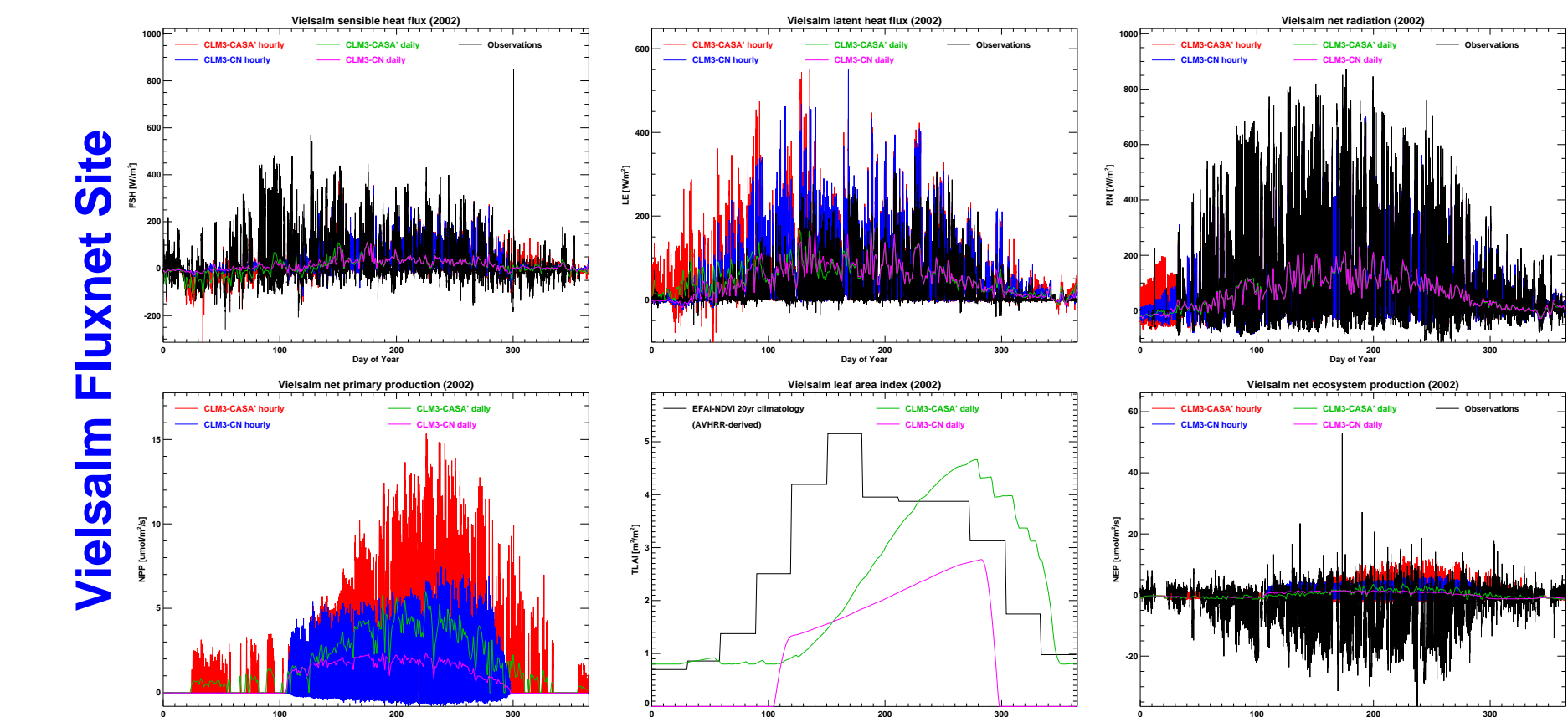
In these simulations, the carbon dioxide from various sources is advected individually as tracers in the atmosphere model. Here, carbon dioxide from the land (net ecosystem exchange) is shown as plumes during Feb. 1900.

Fluxnet Tower Verification/Validation Experiments



- needleleaf evergreen temperate tree
- needleleaf evergreen boreal tree
- needleleaf deciduous boreal tree
- broadleaf evergreen temperate tree
- broadleaf deciduous temperate tree
- broadleaf evergreen tropical tree
- broadleaf deciduous tropical tree
- broadleaf deciduous boreal tree
- broadleaf evergreen shrub
- broadleaf deciduous temperate shrub
- broadleaf deciduous boreal shrub
- c3 non-arctic grass
- c4 grass
- c3 arctic grass
- corn
- wheat

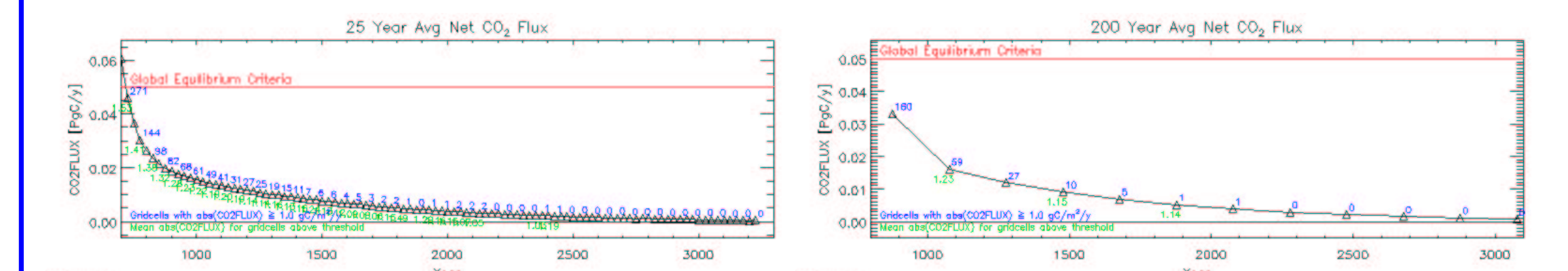
A series of offline experiments are being performed using FluxNet site meteorology data over a range of land cover types, following the C-LAMP Experiment 1 protocol, to gain additional early insights into the differences between these three land biogeochemistry models. To date, eight sites have been run with hourly output using CLM3-CASA' and CLM3-CN. IBIS runs will be forthcoming once the NCEP driver code is added to that model.



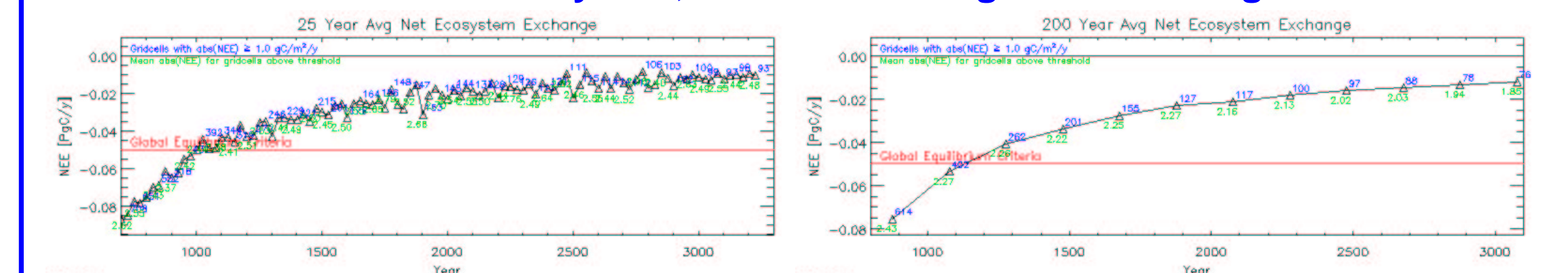
Diagnostics of radiation and carbon balance from all models as compared with observations will be produced for all the chosen FluxNet sites.

C-LAMP Current Status and Plans

- Spin-up runs for Experiment 1 have been completed on the Cray X1E.



25-yr (left) and 200-yr (right) average net ecosystem exchange (NEE) plots from Experiment 1 Spin-up runs show that CLM3-CASA' (above) & CLM3-CN (below) had both reached the global equilibrium criterion by year 1000. Both models have been run over 3200 years, further reducing their exchange of carbon.



- Experiment 1 Control and Climate varying runs are now beginning.
- Experiment 2 Spin-up runs, which begin with the C pools from Experiment 1, are now beginning as well.

Acknowledgements

Research partially sponsored by the Climate Change Research Division (CCRD) of the Office of Biological and Environmental Research (OBER) and the Mathematical, Information, and Computational Sciences (MICS) Division of the Office of Advanced Scientific Computing Research (OASCR) within the U.S. Department of Energy's Office of Science (SC). This research used resources of the National Center for Computational Sciences (NCCS) at Oak Ridge National Laboratory (ORNL), which is managed by UT-Battelle, LLC, for the U.S. Department of Energy under Contract No. DE-AC05-00OR22725. The National Center for Atmospheric Research is operated by the University Corporation for Atmospheric Research (UCAR) and receives research funding primarily from the National Science Foundation (NSF).

