The Carbon-Land Model Intercomparison Project (C-LAMP): A Protocol and Metrics for Model-Data Comparison

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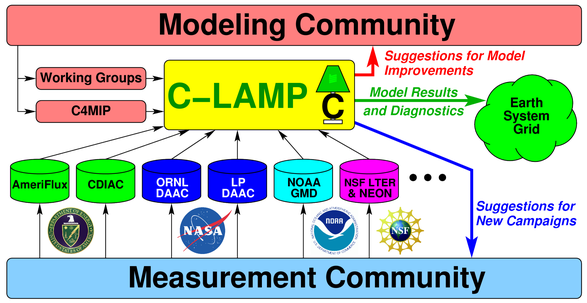
Introduction

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 may create a significant positive feedback on global warming. A wide array of carbon models have been coupled to GCMs, and recent work has shown that coupled interactive biogeochemical models can yield useful, but wide-ranging, results for climate change studies (*e.g.*, Friedlingstein *et al.* 2006).

Described here are model-data intercomparison experiments of general use for measuring the scientific performance of global biosphere models. Originally designed to test the performance of three such models coupled to the Community Climate System Model Version 3 (CCSM3), the Carbon-Land Model Intercomparison Project (C-LAMP) has evolved into an international protocol and a growing set of metrics for scoring the performance of models by comparison with best-available observational datasets, from satellite-based to leaf-scale measurements. C-LAMP is expected to serve as a prototype for biosphere model benchmarking for IPCC AR5.



By making use of the wide variety of mesaurements made, collected, and distributed by government agencies, C-LAMP identifies areas in which improvements can be made to models as well as identifying needs for new kinds of measurements. In addition, all the C-LAMP model output is distributed via the Earth System Grid (ESG) and model diagnostics are available on the Web for use by the wider scientific community.

C-LAMP Protocol

Experiment 1: "off-line" biosphere model runs forced with new NCEP/NCAR Reanalysis meteorological datasets (Qian *et al.* 2005)
1.1 Spin-up run
1.2 Control run (1798–2004)
1.3 Climate varying run (1948–2004)
1.4 Climate, carbon dioxide, and nitrogen deposition varying run (1798–2004)
1.5 Climate, carbon dioxide, nitrogen deposition, and land use varying run (1798–2004)

Experiment 1.4 results from the CLM3-CASA´ and CLM3-CN models are being used for the NACP Regional Interim Synthesis

Experiment 2: partially coupled land-atmosphere model runs with prescribed sea surface temperatures (SSTs) and sea ice cover
2.1 Spin-up run
2.2 Control run (1800–2004)
2.3 Climate varying run (1800–2004)
2.4 Climate, carbon dioxide, and nitrogen deposition varying run (1800–2004)
2.5 Climate, carbon dioxide, nitrogen deposition, and land use varying run (1800–2004)

C-LAMP has produced a standard set of common output quantities for climate-carbon cycle models and recommendations for carbon accounting. These have been proposed as additions to the NetCDF Climate and Forecast (CF) Metadata Convention for output field names and units to be produced by terrestrial biogeochemistry components of Earth System Models for IPCC AR5.

The complete protocol, metrics for evaluation, and output approach are described at http://www.climatemodeling.org/c-lamp

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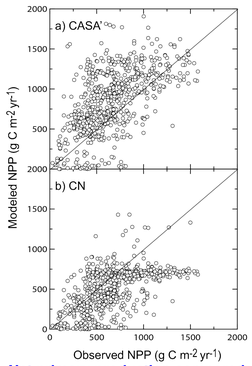
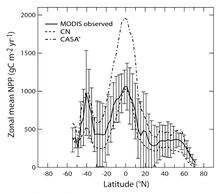
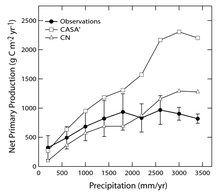
Experiment 1: Intercomparisons with Observations



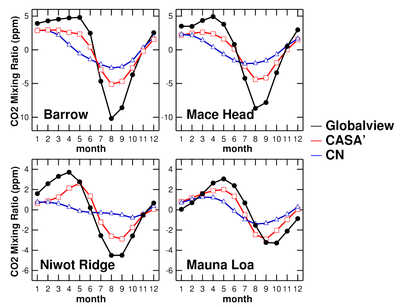
Net primary production compared with observations compiled by the Ecosystem Model-Data Intercomparison (EMDI). Shown is a comparison with Class B measurements. NPP was extracted for each model grid cell corresponding to a measurement location.



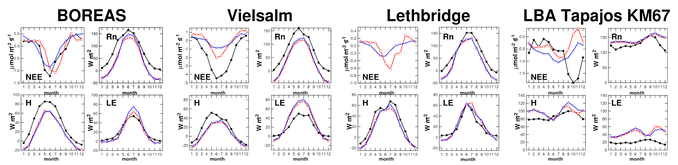
Zonal mean net primary production compared with MODIS satellite observations



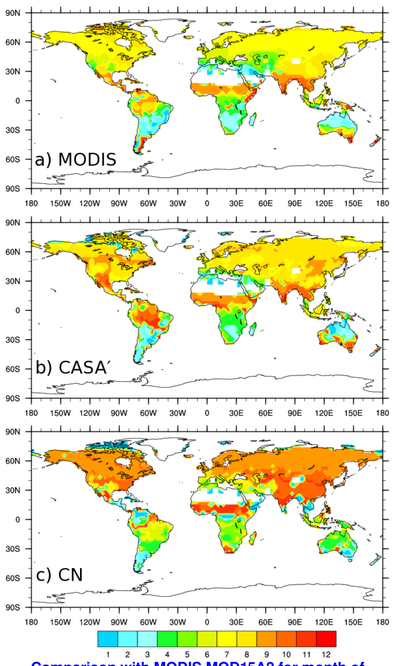
Net primary production by precipitation compared with EMDI measurements



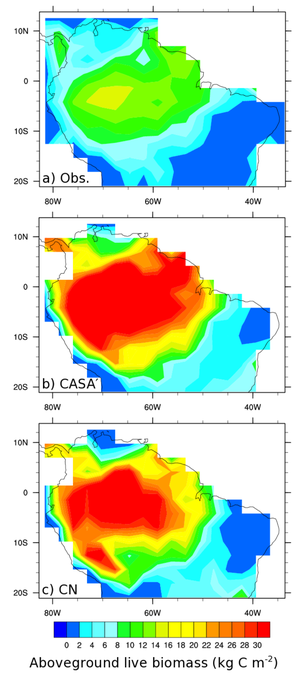
Seasonal cycle of carbon dioxide compared with NOAA GMD's Globalview measurements



Net ecosystem exchange (NEE), net radiation (Rn), sensible heat (H), and latent heat (LE) compared with global Fluxnet observations for selected sites

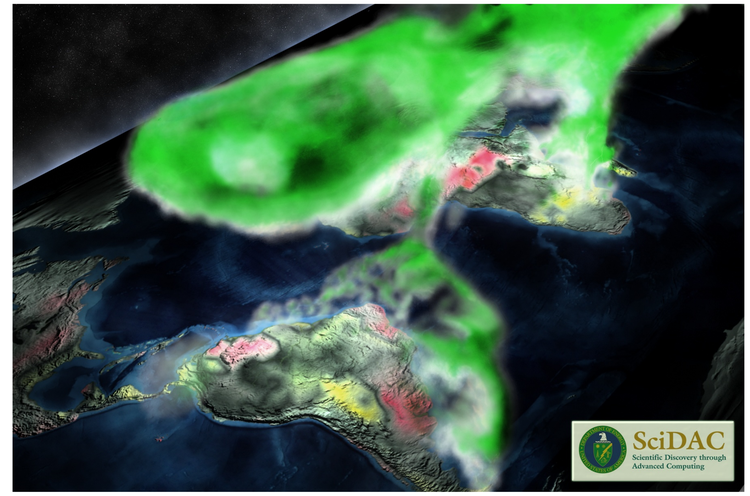


Comparison with MODIS MOD15A2 for month of maximum leaf area index (LAI). While direct comparison of model results with MODIS LAI values is problematic, it is expected that the month of maximum LAI from MODIS has a much lower uncertainty.



Comparison of aboveground live biomass with estimates provided by Saatchi *et al.* 2006.

Climate/Carbon Cycle Visualization



In these simulations, the carbon dioxide from various sources is advected individually as tracers in the atmosphere model. Here, carbon dioxide from land, originating as the net ecosystem exchange shown in color on the land surface, is separately advected in the atmosphere, shown as plumes above the land.

The Computational Climate Science End-Station: A DOE INCITE Project

C-LAMP simulations performed using CCSM3 are a part of a subproject of the Computational Climate Science End Station (Dr. Warren Washington, PI), a U.S. Department of Energy Innovative and Novel Computational Impact on Theory and Experiment (INCITE) Project using resources at the National Center for Computational Sciences (NCCS) located at Oak Ridge National Laboratory (ORNL).

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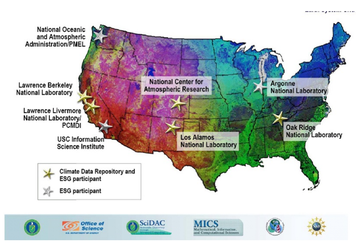
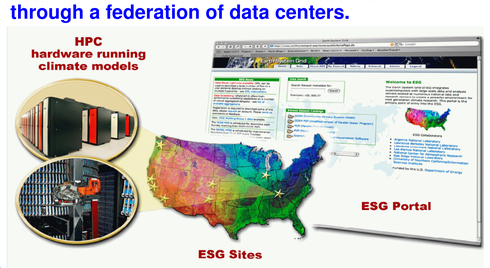
Model Output Delivered via the Earth System Grid (ESG)

The Earth System Grid is a virtual collaborative environment that links distributed centers, users, models, and data in a Grid computing environment. The primary goal of ESG is to support the infrastructure needs of the international climate community by providing technology to securely access, monitor, catalog, transport, and distribute data. The next generation ESG Center for Enabling Technologies (ESG-CET) will support petabyte dataset volume in a distributed environment through a federation of data centers.





The C-LAMP model results are available to the community on a new ESG node at Oak Ridge National Laboratory at http://esg2.ornl.gov/

This ESG node will provide the infrastructure for an international community biosphere model benchmarking activity for IPCC AR5.

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