Results from the Carbon−Land Model Intercomparison Project (C−LAMP)

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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 signif−icant positive feedback on global warming. A wide array of carbon models have been coupled to GCMs, and recent work has shown that coupled inter−active 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 deployment of a production terrestrial biogeochemistry capability within the CCSM for use with runs supporting the Intergovernmental Panel on on Climate Change Fifth Assessment Report.

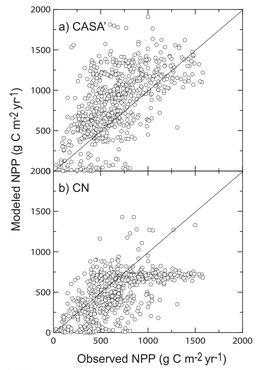
CCSM Carbon Land Model Intercomparison Project (C−LAMP)

- 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 config−uration) with prescribed SSTs, sea ice and carbon dioxide (similar to AMIP)
    - 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/c−lamp/

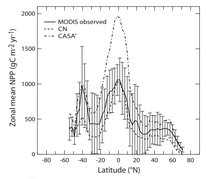
C−LAMP Datasets and Model Output

- 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 has been rewritten using PCMDI's Computer Model Output Rewriter (CMOR)
- Model output and post−processing data are available to the wider science community by PCMDI via the Earth System Grid (ESG) for further analysis
- The output datasets from Experiment 1 are available on the ESG server at http://esg2.ornl.gov/

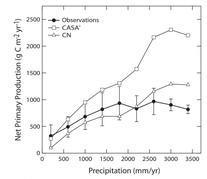
Experiment 1: Intercomparisons with Observations



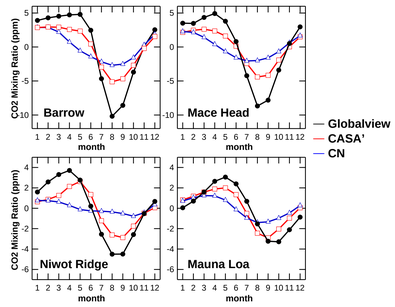
Net primary production compared with observations compiled by the Ecosystem Model−Data Inter−comparison (EMDI); Class A and B observations used; NPP extracted for each model grid cell corresponding to a measurement location



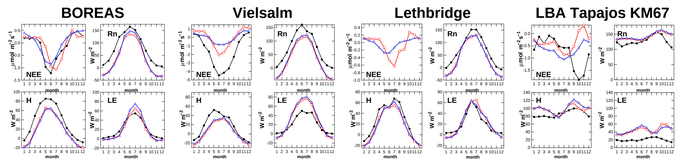
Zonal mean net primary production compared with MODIS satellite observations



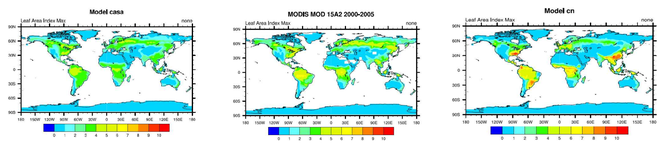
Net primary production by precipitation compared with EMDI observations



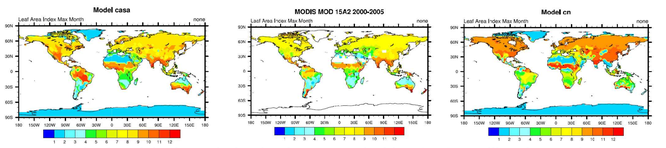
Seasonal cycle of carbon dioxide compared with NOAA GMD's Globalview observations



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

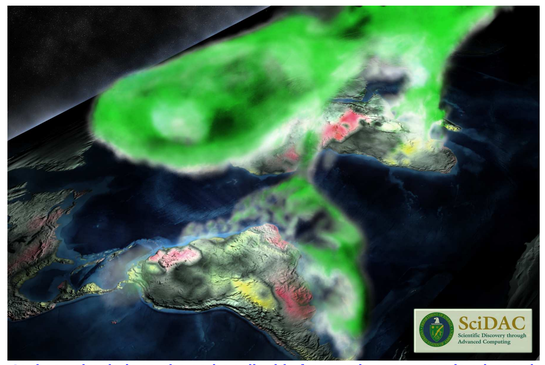


Peak leaf area index (LAI) compared with MODIS satellite observations



Month of peak leaf area index (LAI) compared with MODIS satellite observations; models peak later than observations in the U.S.

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 (net ecosystem exchange), shown on the land surface, is separately advected in the atmosphere, shown as plumes above the land

Preliminary Findings and Recommendations

- Both CASA' and CN should evaluate the sensitivity of the prognostic leaf area schemes to soil moisture and air temperatures
  - Can agreement with MODIS be improved in the Western U.S.?
  - Both models have recently been corrected for low bias in high northern latitudes
- To match NOAA Globalview observations of the seasonal cycle, CASA' may need to reduce the temperature sensitivity of heterotrophic respiration (the Q10 for soil pools)
- Including a prognostic growth and maintenance respiration model in CASA' may improve its agreement with tropical NPP observations
- Critical datasets that are missing include:
  - GPP from AmeriFlux and Fluxnet
  - Albedo from AmeriFlux and MODIS
  - Constraints on litter pools sizes and turnover rates

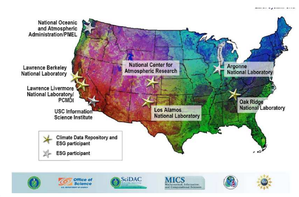
Computational Climate Science End−Station A Leadership Computing Facility (LCF) Project

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

Cray X1E

Model Output Delivered via the Earth System Grid

The Earth System Grid (ESG) 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 infrastructural needs of the national and international climate community by providing crucial 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 the federation of data centers.



http://esg2.ornl.gov/

The C−LAMP model output from Experiment 1 will soon be available to the community on the new ESG node at Oak Ridge National Laboratory.

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