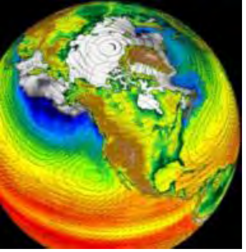
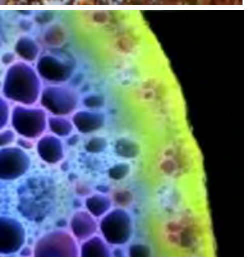
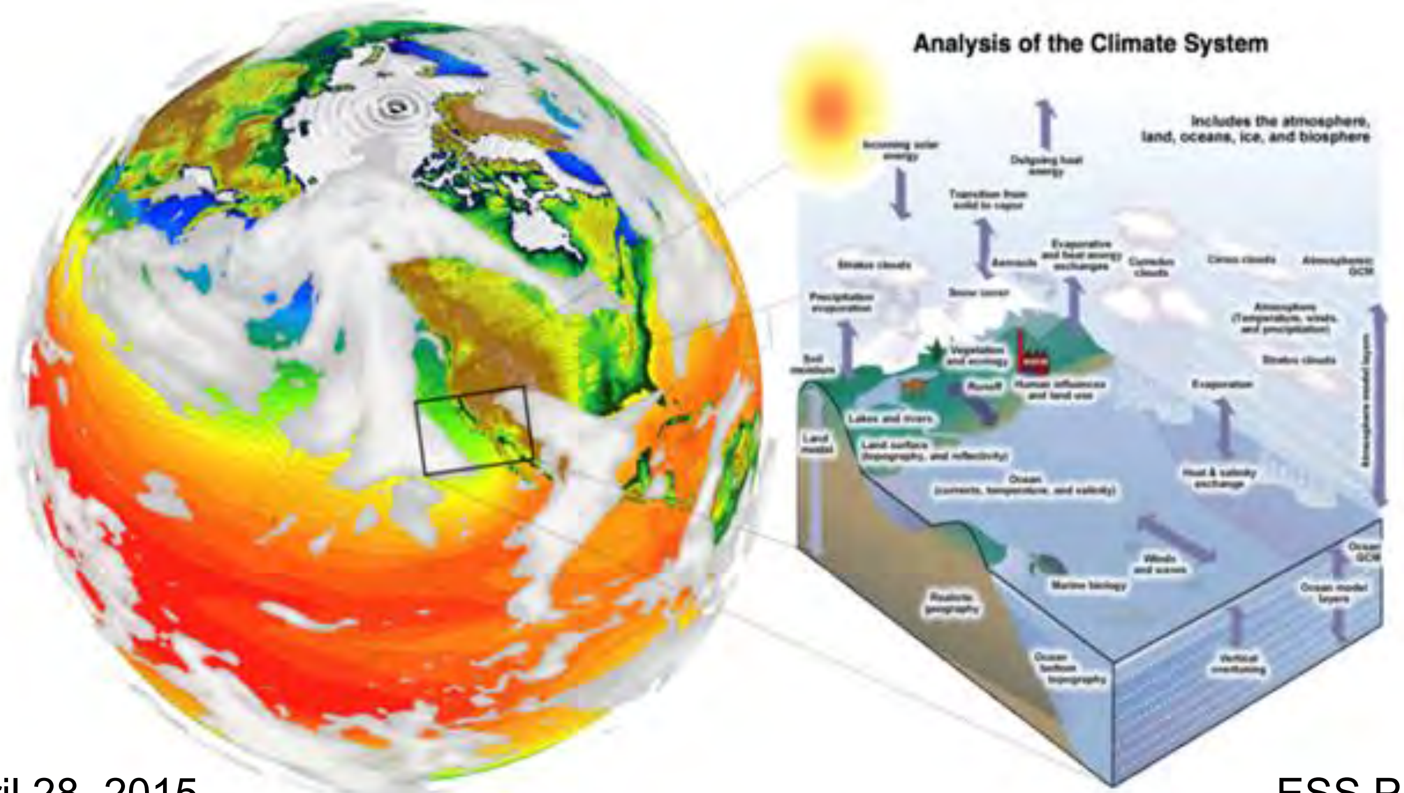



Regional and Global Climate Modeling Program

Program Manager: Renu Joseph



April 28, 2015

ESS PI Meeting

Regional and Global Climate Modeling

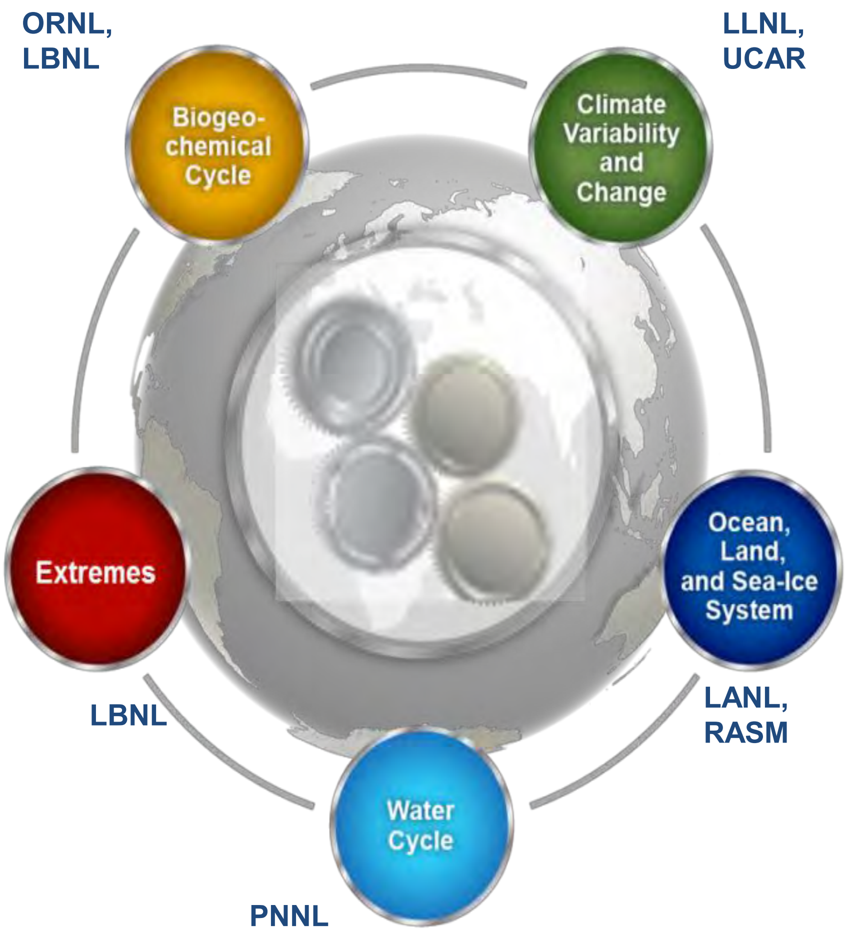
Advance a predictive and process level understanding of climate variability and change over a variety of scales, and diagnose and analyze state-of-the-science for climate and Earth system models

- Science:
  - Extremes, thresholds and tipping points
  - Feedbacks within the climate system
  - Detection and attribution of climate change
  - Decadal predictability and sea-level rise
  - Cross-cutting topics like the water and biogeochemical cycles
- Tools include:
  - Advanced (multivariate) model metrics
  - Observation-based diagnostics
  - Uncertainty quantification methods to guide model development, gauge model improvement, and establish confidence in model projections
  - Tools to facilitate analysis of model results

Regional and Global Climate Modeling
($26M – 2015)
Divided between Lab, University, and large Cooperative Agreements

5 SFA Topics

1. Climate Variability and Change – LLNL, UCAR
2. High Latitude Feedbacks – LANL/PNNL, RASM
3. Water Cycle and Climate Extremes Modeling – PNNL
4. CAlibrated and Systematic Characterization, Attribution, and Detection of Extremes – LBNL
5. Feedbacks and uncertainties of biogeochemical cycles – ORNL/LBNL



Biogeochemistry–Climate Feedbacks Scientific Focus Area

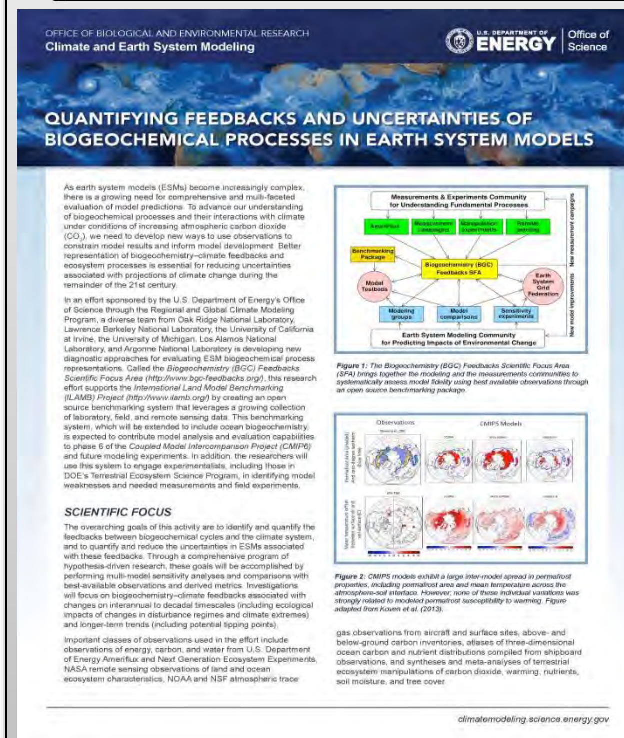
Forrest M. Hoffman (Lab Research Manger, ORNL), William J. Riley (Senior Science Co-Lead, LBNL), and James T. Randerson (Chief Scientist, University of California–Irvine)

Research Goals:

- Identify and quantify **feedbacks** between biogeochemical cycles and the climate system.
- Quantify and **reduce the uncertainties** in ESMs associated with these feedbacks.

Research Objectives:

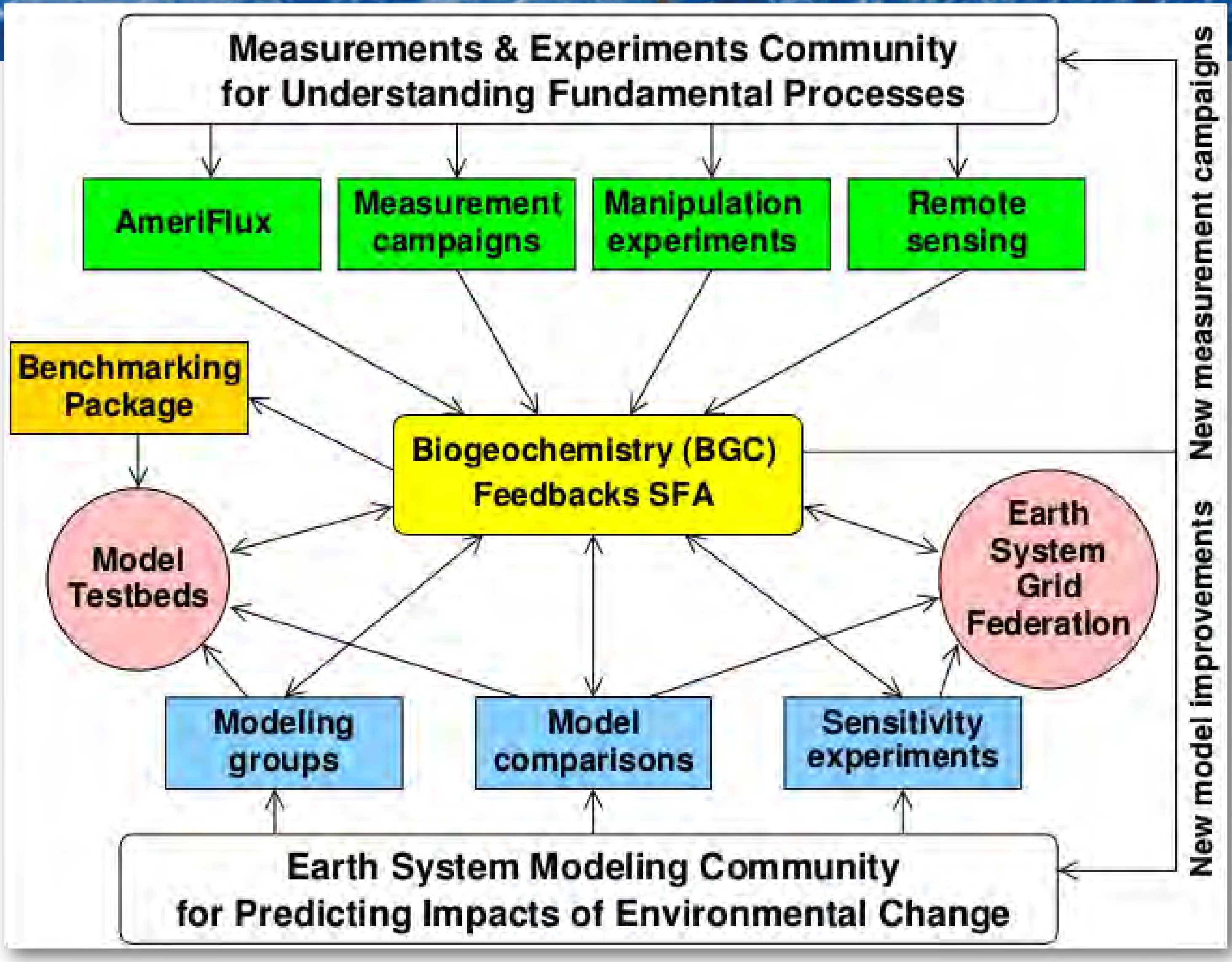
1. Develop new **hypothesis–driven approaches for evaluating ESM processes** using **observations and models** at site, regional, and global scales.
2. Investigate the degree to which contemporary **observations can reduce uncertainties**, using an "emergent constraint" approach.
3. Create an **Open Source benchmarking software** system that leverages lab, field, and remote sensing data sets.
4. **Evaluate** the performance of biogeochemical **processes and feedbacks in Coupled Model** Intercomparison Project (CMIP) ESMs, CESM, and ACME models.



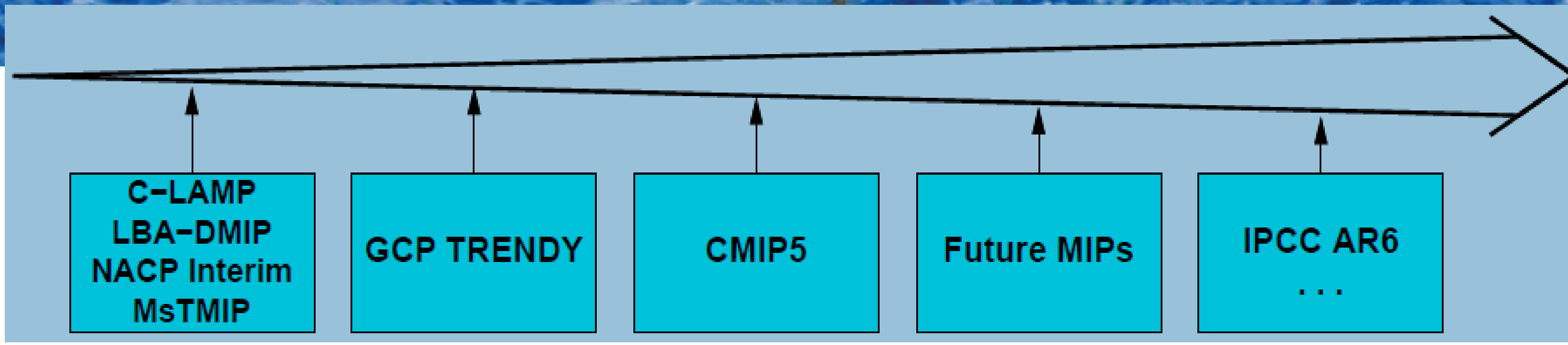
http://www.bgc-feedbacks.org/

Argonne NATIONAL LABORATORY · BERKELEY LAB · Los Alamos NATIONAL LABORATORY · OAK RIDGE National Laboratory · UCI · MICHIGAN

Biogeochemistry–Climate Feedbacks Scientific Focus Area



Why do we need Benchmarks?



- – Human capital costs of making rigorous model–data comparisons is considerable and constrains the scope of individual MIPs.
- – Many MIPs spend resources "reinventing the wheel" in terms of variable naming conventions, model simulation protocols, and analysis software.

- **An ideal benchmarking tool should:**
  - – **Provide each new MIP access to the model-data comparison modules from past MIPs (e.g., MIPs use one common modular software system).**
  - – **Standardized international naming conventions also increase MIP efficiency.**
  - – **An Open Source Benchmarking Software System**

Adopting ILAMB as the benchmarking software

Built from the C-LAMP prototype (Randerson et al., 2009; Luo et al., 2012)

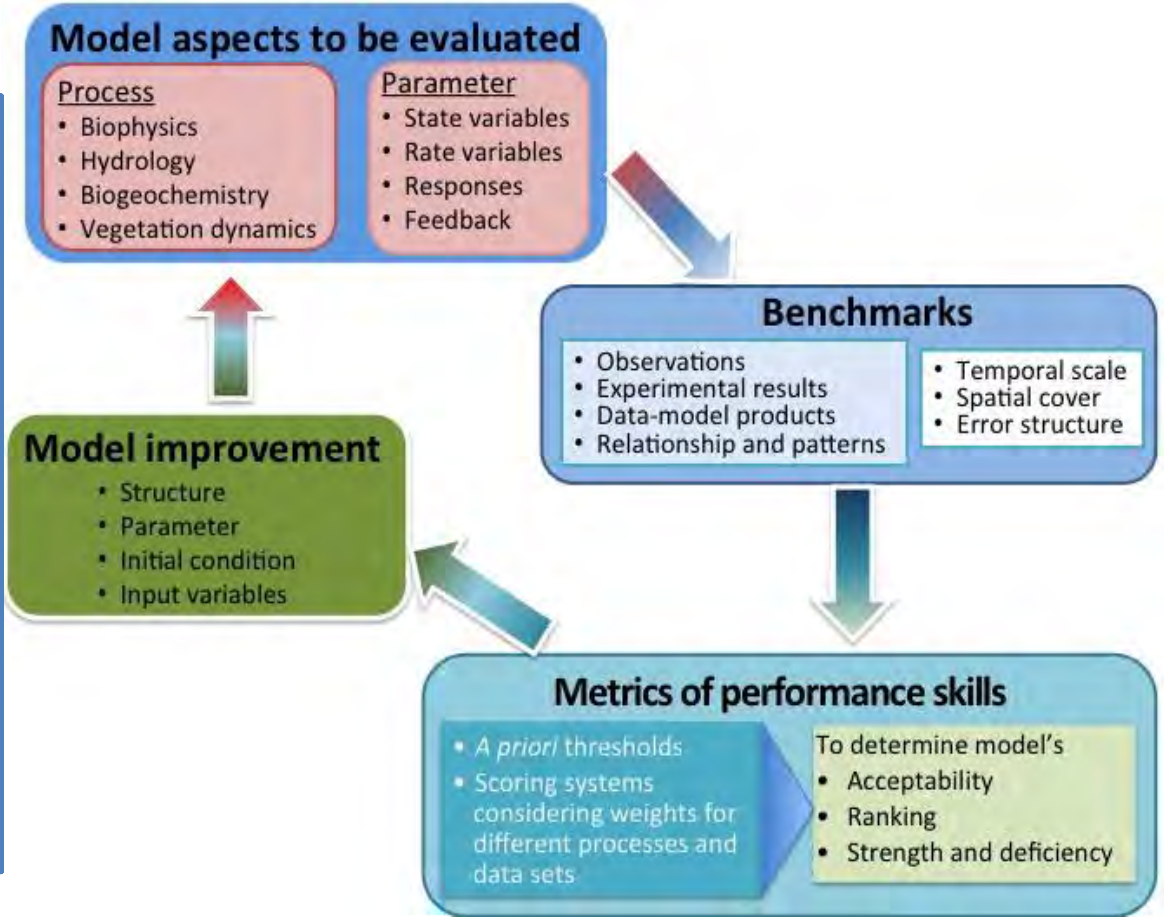
- Initial prototype with efforts within DOE, community involvement, NASA, NSF, and data from other agencies.

- **Now the core support for ILAMB comes from DOE funding.**

ILAMB Package

- ILAMB Goals: Develop internationally accepted benchmarks for model performance, advocate design of open-source software system, and strengthen linkages between experimental, monitoring, remote sensing, and climate modeling communities.

- Software engineering is co-led by ORNL and LBNL, in collaboration with UCI and the CESM and ACME Land Model Working Groups.
- New version will be in python to improve extensibility and maximize use in DOE software tools being developed.
- Will be incorporated into PCMDI Metrics Package and the WGNE/WGCM Climate Model Metrics Panel.



Luo et al. (2012)

Community Engagement

- **ILAMB will be used by the C4MIP group for CMIP6**, and we are working to include it in standard diagnostics for all CMIP6 models at PCMDI.
- Connections with modeling centers, measurement activities, and MIPs, including GEWEX, iLEAPs, MAREMIP, MsTMIP, TRENDY/RECCAP/GCP, GSWP3, and future FACE-MIP and LBA-DMIP.
- **Looking for community participation** in the regular telecons and in the development phase of the activity. **[Contact: Forrest Hoffman/Bill Riley]**
- Will be **convening community workshops** to offer training sessions on using the benchmarking system.

Current Participants:

Forrest Hoffman, Bill Riley, Jim Randerson, David Lawrence, Charlie Koven, Gretchen Keppel-Aleks, Sean Swenson, Mingquan Mu, Nate Collier, Gautam Bisht, Keith Moore, Umakant Mishra, Erik Kluzek, Scott Elliott, Jitendra Kumar (and others)

Friends of ILAMB:
(your name)

Backup

Metrics

- Large-scale state and flux estimates
  - LH, SH, total water storage, albedo, river discharge, SCF, LAI, soil and veg C stocks, GPP, NEE, ER, burnt area, permafrost distribution, T_{2m}, P, …
  - RMSE, spatial pattern corr, interannual variance, annual cycle phase, trends
- Functional relationships and emergent properties
  - soil moisture – ET, soil moisture – runoff, precip – GPP, stomatal response to VPD, precip – burnt area, transient carbon storage trajectory, runoff ratio, spring albedo transition
- Experimental manipulation (testing model functional responses)
  - Nitrogen additions, FACE, artificial warming, rainfall exclusion

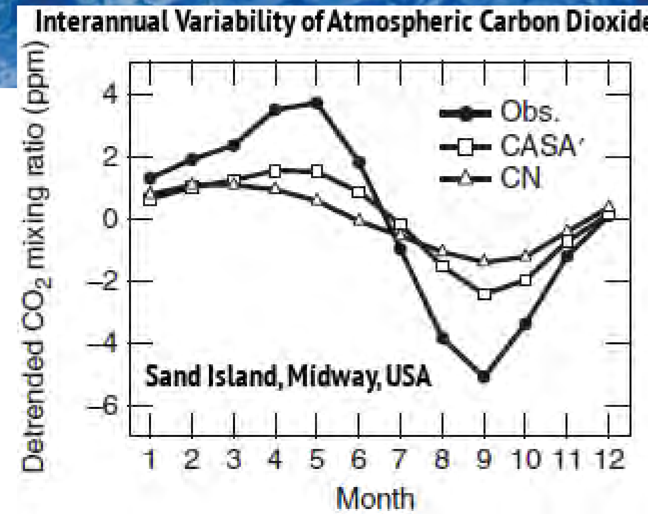
Example Carbon Cycle Metrics

Global Variables

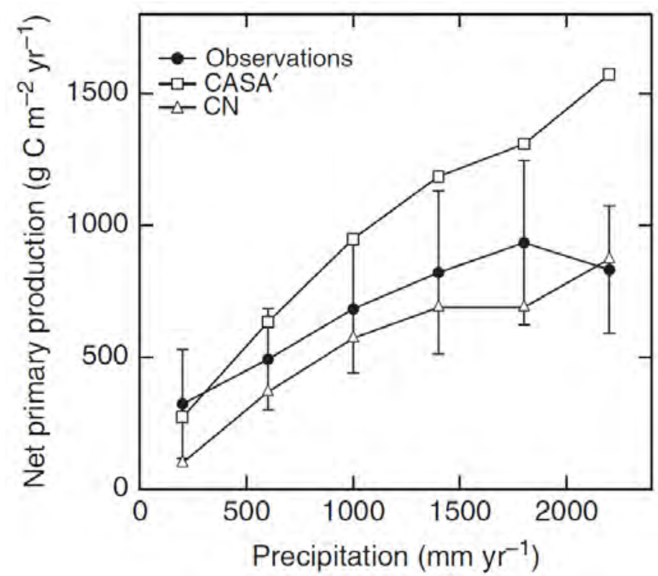
	MeanModel	CLM40cn	CLM45bgc
Aboveground Live Biomass	0.72	0.65	0.76
Burned Area	0.45	0.33	0.58
Gross Primary Production	0.58	0.54	0.57
Leaf Area Index	0.44	0.41	0.42
Net Ecosystem Exchange	0.37	0.36	0.37
Global Net Land Flux	0.80	0.27	0.39
Ecosystem Respiration	0.52	0.49	0.52
Soil Carbon	0.67	0.37	0.61
Summary	0.57	0.43	0.53

What is a Benchmark?

- **A Benchmark** is a quantitative test of model function achieved through comparison of model results with observational data.
- Acceptable performance on benchmarks **is a necessary but not sufficient condition** for a fully functioning model.
- **Functional benchmarks** offer tests of model responses to forcing and yield insights into ecosystem processes.
- **Effective benchmarks** must draw upon a broad set of independent observations to evaluate model performance on multiple temporal and spatial scales.



Models often fail to capture the amplitude of the seasonal cycle of atmospheric CO_2.



Models may reproduce correct responses over only a limited range of forcing variables.

Why Benchmark?

- to demonstrate to the science community and public that the representation of coupled climate and biogeochemical **cycles in Earth system models (ESMs) is improving;**
- to quantitatively diagnose impacts of model development in related fields on carbon cycle processes;
- **to guide synthesis efforts**, such as the CMIP efforts, in the review of mechanisms of global change in models that are broadly consistent with available contemporary observations;
- to **increase scrutiny of key datasets** used for model evaluation;
- **to identify gaps in existing observations** needed for model validation;
- **to accelerate incorporation of new measurements** for rapid an widespread use in model assessment;
- to provide a quantitative, application-specific set of minimum **criteria for participation in model intercomparison** projects (MIPs);