International Land Model Benchmarking (ILAMB)

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2016 NGEE Arctic All Hands Meeting
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What is ILAMB?

A community coordination activity created to:

- **Develop internationally accepted benchmarks** for land model performance by drawing upon collaborative expertise
- **Promote the use of these benchmarks** for model intercomparison
- **Strengthen linkages between experimental, remote sensing, and climate modeling communities** in the design of new model tests and new measurement programs
- **Support the design and development of open source benchmarking tools** (Luo et al., 2012)
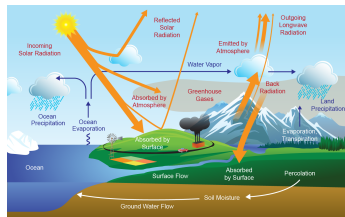

Energy and Water Cycles
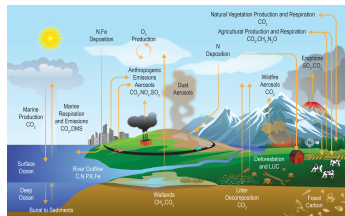

Carbon and Biogeochemical Cycles

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 forcings 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**.

Interannual Variability of Atmospheric Carbon Dioxide
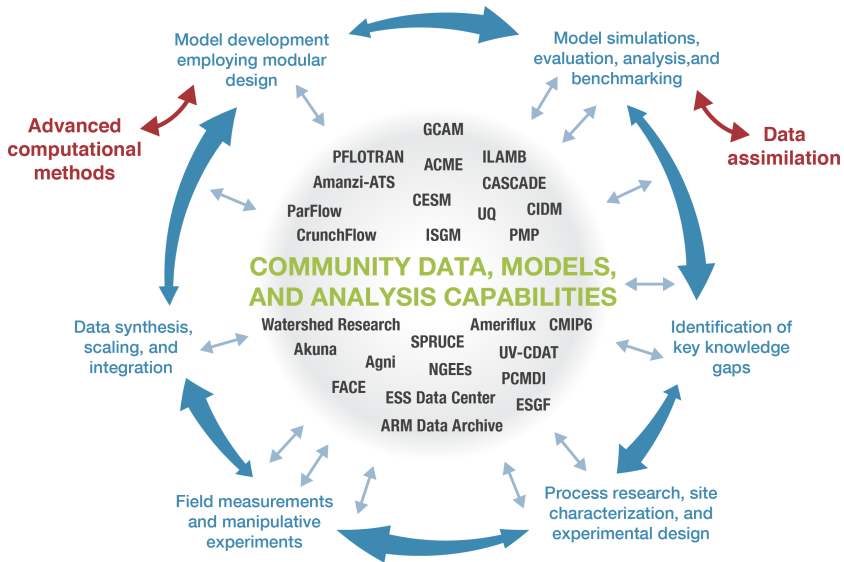
Sand Island, Midway, USA
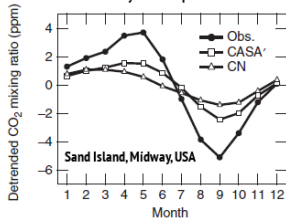
Models often fail to capture the amplitude of the seasonal cycle of atmospheric CO_2.
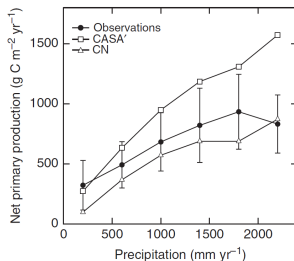
Models may reproduce correct responses over only a limited range of forcing variables.

(Randerson et al., 2009)

Model–Data–Experimentation Strategy

Why Benchmark?

- **to demonstrate model improvements** in representation of coupled climate and biogeochemical cycles

- **to quantitatively diagnose impacts of model development** in related fields on carbon cycle processes

- **to guide synthesis efforts**, such as the Intergovernmental Panel on Climate Change (IPCC), in assessing model fidelity

- **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 and widespread use in model assessment

- **to provide a quantitative, application-specific set of minimum criteria** for participation in model intercomparison projects (MIPs).

An Open Source Benchmarking Software System
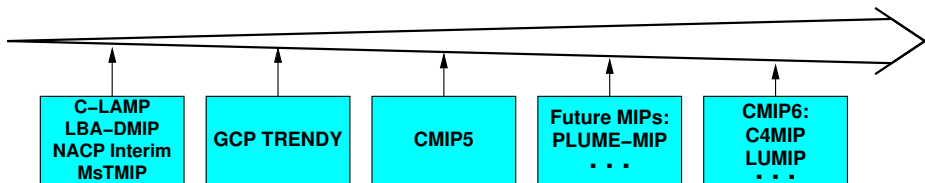
- ▶ Human capital costs of making rigorous model-data comparisons is considerable and constrains the scope of individual MIPs.

- ▶ Many MIPs spend resources "reinventing the wheel" in terms of variable naming conventions, model simulation protocols, and analysis software.

- ▶ **Need for ILAMB:** Each new MIP has access to the model–data comparison modules from past MIPs through ILAMB (*e.g.*, MIPs use one common modular software system). Standardized international naming conventions also increase MIP efficiency.

Second US ILAMB Workshop, May 16–18, 2016

Overarching Workshop Goals

Engage the research community in defining scientific priorities for

- Design of new metrics for model benchmarking
- Model Intercomparison Project (MIP) evaluation needs
- Model development, testbeds, and workflow practices
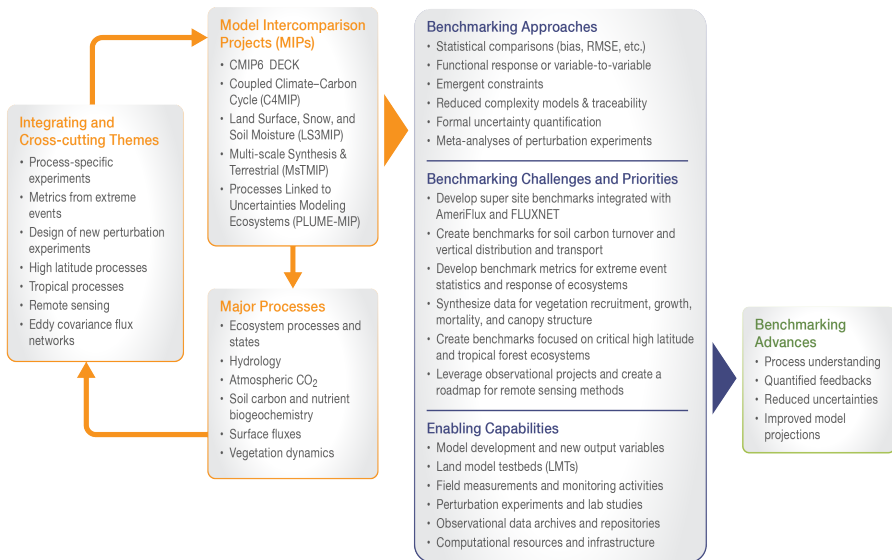- Observational data sets and needed measurements

Workshop Attendance

- 60+ participants from Australia, Japan, China, Germany, Sweden, Netherlands, UK, and US
- 10 modeling centers represented
- ~25 online attendees at any time

Date
DOE/SC-XXXX | doi:10.7249/XXXXXXXX

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2016
International Land Model Benchmarking (ILAMB)
Workshop Report

doi:10.2172/1330803

2016 ILAMB Workshop Synthesis

Integrating and Cross-cutting Themes
- Process-specific experiments
- Metrics from extreme events
- Design of new perturbation experiments
- High latitude processes
- Tropical processes
- Remote sensing
- Eddy covariance flux networks

Model Intercomparison Projects (MIPs)
- CMIP6 DECK
- Coupled Climate–Carbon Cycle (C4MIP)
- Land Surface, Snow, and Soil Moisture (LS3MIP)
- Multi-scale Synthesis & Terrestrial (MsTMIP)
- Processes Linked to Uncertainties Modeling Ecosystems (PLUME-MIP)

Major Processes
- Ecosystem processes and states
- Hydrology
- Atmospheric CO_2
- Soil carbon and nutrient biogeochemistry
- Surface fluxes
- Vegetation dynamics

Benchmarking Approaches
- Statistical comparisons (bias, RMSE, etc.)
- Functional response or variable-to-variable
- Emergent constraints
- Reduced complexity models & traceability
- Formal uncertainty quantification
- Meta-analyses of perturbation experiments

Benchmarking Challenges and Priorities
- Develop super site benchmarks integrated with AmeriFlux and FLUXNET
- Create benchmarks for soil carbon turnover and vertical distribution and transport
- Develop benchmark metrics for extreme event statistics and response of ecosystems
- Synthesize data for vegetation recruitment, growth, mortality, and canopy structure
- Create benchmarks focused on critical high latitude and tropical forest ecosystems
- Leverage observational projects and create a roadmap for remote sensing methods

Enabling Capabilities
- Model development and new output variables
- Land model testbeds (LMTs)
- Field measurements and monitoring activities
- Perturbation experiments and lab studies
- Observational data archives and repositories
- Computational resources and infrastructure

Benchmarking Advances
- Process understanding
- Quantified feedbacks
- Reduced uncertainties
- Improved model projections

Benchmarking Challenges and Priorities

- **Super site benchmarks** for AmeriFlux and FLUXNET
- **Benchmarks for soil carbon** turnover, distribution, transport
- **Metrics for extreme events** & response of ecosystems
- **Data for vegetation** recruitment, growth, mortality, phenology, canopy structure
- Benchmarks for critical **high latitude & tropical ecosystems**
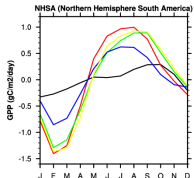- Leverage **field projects & remote sensing methods**
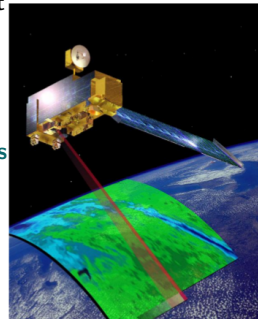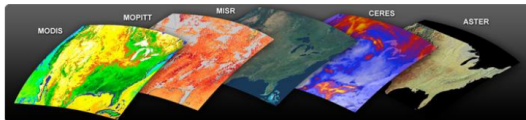
FLUXNET Representativeness

SPRUCE
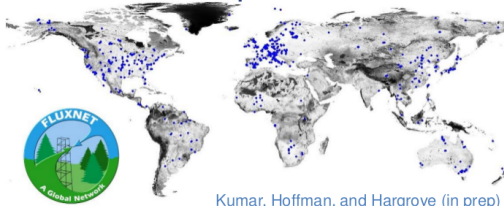
Kumar, Hoffman, and Hargrove (in prep)

Current Status of the ILAMB Packages

- **ILAMBv1** released at 2015 AGU Town Hall, doi:10.18139/ILAMB.v001.00/1251597
- **ILAMBv2** released at 2016 ILAMB Workshop, doi:10.18139/ILAMB.v002.00/1251621
- Being used for ACME and CESM evaluation
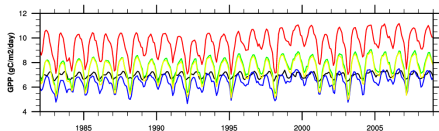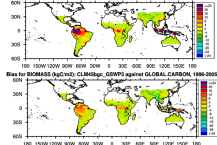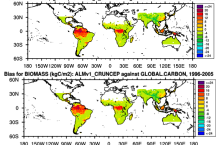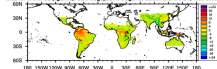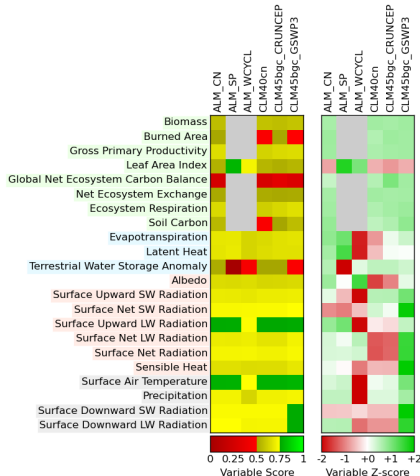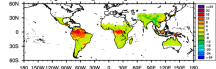
Latest ILAMB Adds Permafrost Extent
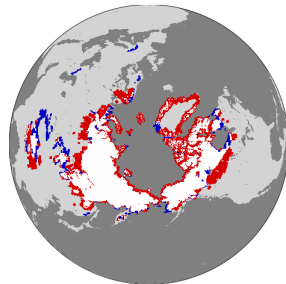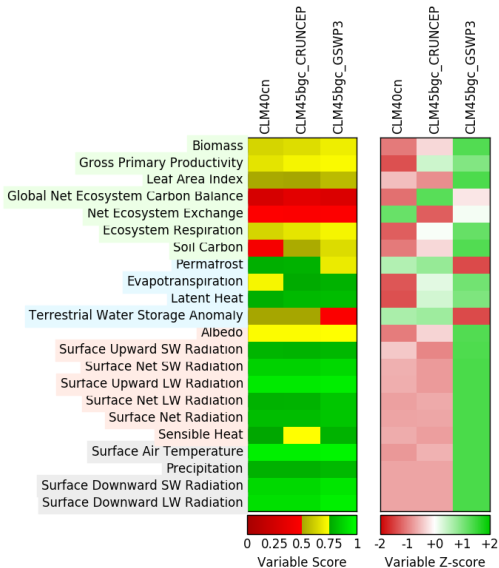
Acknowledgments

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BGC Feedbacks   Argonne   Los Alamos   NCAR   OAK RIDGE   MICHIGAN

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