The North American Carbon Program Multi-Scale Synthesis and Terrestrial Model Intercomparison Project (MsTMIP)

Deborah N. Huntzinger (dnhuntzi@umich.edu)[1], Anna M. Michalak[1,2], Kevin Schaefer[3,4], Wilfred M. Post[5], Andrew Jacobson[3,6], Robert Cook[5]

[1]Department of Civil & Environmental Engineering, University of Michigan; [2]Department of Atmospheric, Oceanic & Space Sciences, University of Michigan; [3]University of Colorado; [4]National Snow & Ice Data Center; [5]Oak Ridge National Laboratory, Environmental Sciences Division; [6]National Oceanic & Atmospheric Administration, Earth System Research Laboratory.

Acknowledgments:
Funding for this project is provided by NASA through the ROSES-2009 A.4 Terrestrial Ecology Program

Overview of MsTMIP

The new **multi-scale synthesis and intercomparison project (MsTMIP)** has an overall goal of providing feedback to the terrestrial biospheric modeling (TBM) community to improve the diagnosis and attribution of carbon fluxes at regional and global scales. This project builds upon current and past synthesis activities by developing an integrative framework that all TBMs can use as a tool to continually evaluate overall model performance against a consistent set of observational constraints. There are five main steps of this study: (1) recruit and develop a modeling cohort for participation in this study; (2) assemble high quality driver data sets to be used by participating modeling teams to ensure consistent and comparable model results; (3) develop a detailed model simulation protocol; (4) evaluate model performance against observations, inversions, and other model estimates through a set of quantitative performance measures and metrics based on inventory and flux tower-based observations; and (5) develop an infrastructure to support the model simulations, model comparison, and evaluation. **By prescribing standard spin-up procedures, input data sets, and output parameter formats, the intercomparison will quantify and diagnose any biases and uncertainties in TBM estimates of regional and global carbon budgets resulting from differences in model formulation and parameterization.**

Building on Interim Synthesis Activities

In December of 2007, the **North American Carbon Program (NACP) organized the regional and continental interim-synthesis (RIS) activities*** to evaluate and compare model estimates of land-atmosphere carbon flux for the period 2000 to 2005. Thus far, the RIS have collected existing simulations results for 19 terrestrial biospheric models (TBMs), and over 20 inversions. While using in-hand model results has limited the conclusions that can be drawn from the interim synthesis activities, the project has provided a unique forum for summarizing the current status of terrestrial carbon modeling and initiated the evaluation of model performance against spatial data sets.

*http://nacp.ornl.gov/int_synth_contreg.shtml

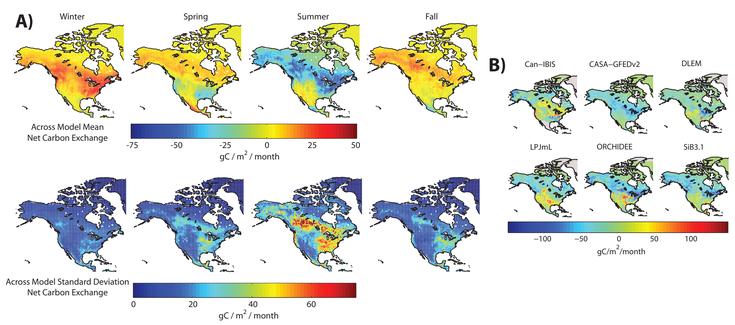

Figure 1. **A)** Across-model mean and standard deviation in net carbon exchange for 2002, for Winter (December, January, February), Spring (March, April, May), Summer (June, July, August), and Fall (September, October, November); **B)** Average 2002 summer (June, July, August) net carbon exchange predicted by 6 of the 19 models participating in the NACP regional interim synthesis activities. A negative (-) sign indicates net uptake of carbon from the atmosphere, while a positive (+) sign signifies a net release of carbon back to the atmosphere.

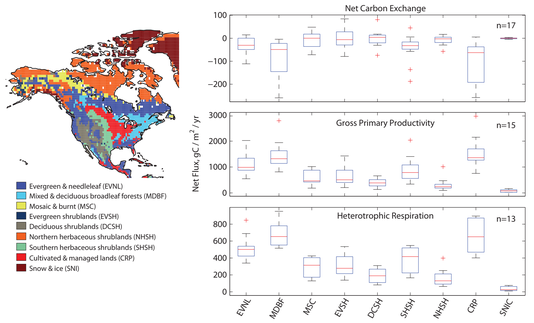

Figure 2. 2004 across-model mean estimates of net carbon exchange (**NCE**) gross primary productivity (**GPP**) and heterotrophic respiration (**Rh**) by GLC2000 biome. Models vary considerably in their estimates of annual fluxes, with the greatest differences in more productive regions.

Formal Multi-Scale Synthesis and Intercomparison Project (MsTMIP)

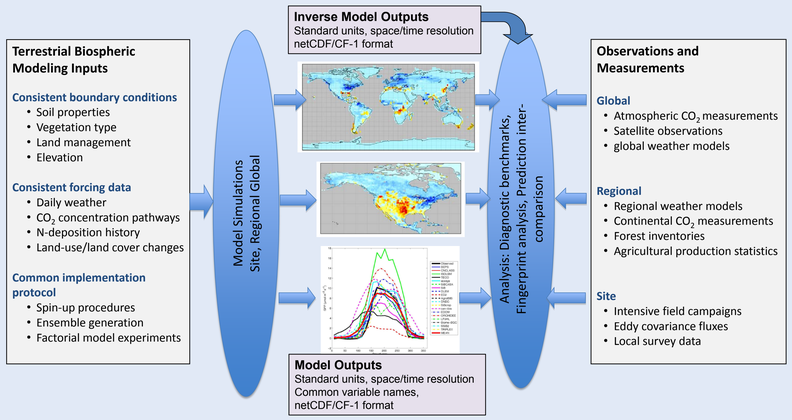

Figure 3. Schematic of MsTMIP

The goal of the project is to provide feedback to the terrestrial biospheric modeling community to improve the diagnosis and attribution of carbon sources and sinks across regional and global scales. The MsTMIP will be conducted as part of the NACP and builds upon current and past synthesis activities. The project will develop an integrative framework that all TBMs can use as a tool to continually evaluate overall model performance against a complete set of observational constraints.

MsTMIP Objectives and Planned Approach

Infrastructure for model development
- FTP server maintained by MAST-DC.
- Wiki for project documentation, reports, presentation, and analysis results
- Web-interface for auto-checking of submission format, real-time feedback to modelers on simulation performance against evaluation metrics.
- Data policy
- Model survey database with information about each model
- Workshops.

Develop modeling cohort
- Recruit modeling teams
- Competitive mini-grants for modeling teams to support participation.
- Computer resource support for simulations and data storage

Assemble benchmark reference driver data sets
- Identify high quality data available for simulations
- Process and redistribute benchmark driver datasets (MAST-DC)
- Provide regular updates for non-static environmental drivers (MAST-DC)
- *Collaborator*: Ramakrishna Nemani, NASA Ames Research Center

Develop detailed model simulation protocol
- Spin-up procedures and boundary conditions
- Simulation setup
- Sensitivity analysis
- *Collaborator*: Peter Thornton, Oak Ridge National Laboratory

Model performance evaluation against observations
- Adapt and expand C-LAMP
- Compare simulated fluxes to reference data
- Evaluate transported TBM fluxes compared to atmospheric CO2 concentration measurements.
- Detailed model-model intercomparison evaluation.
- *Collaborator*: Forrest Hoffman, Oak Ridge National Laboratory

MAST-DC (Modeling and Synthesis Thematic Data Center; http://nacp.ornl.gov/index.shtml)

Detailed Simulation Protocol

The simulation protocol will detail all aspects of the simulations and analyses. Completion of the protocol is one of the first priorities of the project, along with identifying and assembling standard driver variables. **The final protocol will be the product of the first workshop and based on input from the modeling community**.

Participants will be asked to run two sets of simulations: **Global** simulations at 1 degree resolution and **Regional** (i.e., North America) simulations at a quarter degree resolution. In addition, we will extract model output for pixels corresponding to the 31 eddy covariance flux tower sites in North America used as part of the NACP Site Synthesis+.

In combination with the multi-scale approach, **simulations will also be run with different environmental driving data sets and levels of disturbances** for the period 1980 to 2008.

Evaluating Model Performance

Metric	Metric Components	Scale Applied
NPP	Matching EMDI NPP observations EMDI comparison, normalized by PPT Correlation with MODIS (r^2) Latitudinal Profile (r^2)	Global, Regional
LAI	Matching MODIS Phase* Mean* Maximum* Growing season length*	Global, Regional
Atmospheric CO_2 cycle	Matching phase & amplitude of GlobalView measurements ***Matching interannual variability of GlobalView measurements*** ***Aircraft measurements***	Global
Carbon Stocks	Aboveground vegetation within Amazon Basin Belowground carbon (top 30 cm) ***Forest inventories*** ***Soil carbon inventories*** ***Agricultural production***	Global Regional
Eddy Covariance Energy & CO_2 Fluxes	Net radiation Latent heat (annual mean) Sensible heat (annual mean) CO_2 fluxes	Global, Regional, Site
Inversely Derived NEE	***Matching phase and amplitude of seasonal cycle*** ***Interannual Variability*** ***Long-term mean***	Global, Regional

Table 1. Example of the expanded C-LAMP score sheet for forward terrestrial biospheric model evaluation.

*Derived separately for major biome classes

Bold signifies those components added to the existing C-LAMP metrics

We will adapt and expand C-LAMP++ in order to compare the different model estimations against observations, satellite-based products, and other model estimates. Overall model evaluation will comprise of four components: (1) **model-observation comparison** of NEE and component fluxes; (2) **TBM and inverse model intercomparison** in terms of the amplitude and phase of the seasonal cycle, mean annual estimates of NEE, and interannual variability; (3) comparison of **transported TBM fluxes to CO_2 concentration** measurements; and (4) **TBM model-model intercomparison** of NEE and component flux estimates.

+http://nacp.ornl.gov/int_synth_site.shtml

++http://www.climatemodeling.org/c-lamp/

Table 2. The MsTMIP project begins **March, 15th 2010**. The planned timeline is shown below. Dark green indicates periods of primary focus. Light green indicates periods of secondary focus or lighter activity.

Work Plan

		2010			2011				2012				2013
		Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1
Protocol and Infrastructure Development / Model Comparison and Evaluation													
1. Develop model cohort	Identify potential teams												
	Select "mini-grant" recipients												
2. Assemble benchmark drivers*	Indentify high quality drivers												
	Process and redistribute												
3. Develop simulation protocol	Initial draft												
	Finalized protocol												
4. Develop/compile evaluation metrics	Adapt C-LAMP												
	Transport TBM fluxes												
	Evaluation of model results												
5. Develop infrastructure*	Develop netcdf building tool												
	Create web tools for output evaluation												
Simulations & Workshops													
First round of model simulations													
Second round of model simulations													
Workshop #1: Protocol evaluation													
Workshop #2: Simulation requirements/briefing													
Workshop #3: Preliminary results evaluation/feedback													

This project is just beginning and we would like to involve a set of terrestrial models that represent the breadth of biospheric modeling activities in the community. If your group is interested in participating please contact **dnhuntzi@umich.edu**.