North American Carbon Program (NACP) regional interim synthesis: Terrestrial biospheric model intercomparison

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Objectives:

- This work synthesizes and compares estimates of land-atmosphere carbon exchange from nineteen prognostic and diagnostic terrestrial biosphere models (TBMs) used from 2000-2005 in order to assess the current understanding of the terrestrial carbon cycle in North America.

Significance:

- Estimates of the North American biosphere carbon sink vary widely, and not all of the mechanisms responsible for the controls of the carbon cycle are well understood.
- Understanding the basic questions and dynamics of the carbon cycle is critical for successful management and prediction of the future evolution of carbon dynamics, as well as informing policies addressing fossil fuel emission.
- Terrestrial biosphere models (TBMs) have become an integral tool for understanding carbon exchange between terrestrial ecosystems and the atmosphere and are often used to extrapolate local understandings to much larger terrestrial regions, as well as for testing hypotheses of ecosystem response to changes in climate and nutrient availability.
- In addition, TBMs are used to provide a better understanding of the mechanisms currently controlling carbon exchange, and this is used as a basis of prediction and, ultimately, to inform the development of carbon management plans.
- Many models have been created to improve the understanding of carbon exchange, and, because each model is a complex combination of scientific hypotheses and choices, the models vary widely in their approaches and goals, as well as in their resultant estimates of carbon flux.
- Understanding how TBM estimates of ecosystem photosynthesis, respiration, and net carbon exchange vary spatially and temporally is extremely important not only to improve the TBMs, but also to understand their contribution to uncertainty in the global climate stimulations.

New Science:

- There is considerable disagreement between current estimates of carbon flux across North America, including whether North America is a carbon source or carbon sink.
- This large disagreement highlights the need for further analysis through use of model runs following a common simulation protocol. This is required in order to isolate the influences of the formulation, structure and assumptions of the model on the flux estimates of the various models.
- Prognostic models exhibit greater overall range in their estimates and predict larger net uptake of carbon over North America relative to diagnostic models.
- Photosynthetic formulation, the source and variability of climatic driver data, and how phenology is described all appear to influence the across-model difference in estimated fluxes, and the magnitude of overall carbon uptake predicted by the models.
- The scaling of respiration based on estimates of photosynthesis, which occurs in most of the models, may be appropriate for forested regions where GPP and Rh are closely linked, but this assumption is probably not appropriate for more managed land (agricultural and forest plantations).
- The study reveals the large variation in TBM estimates of long-term mean net ecosystem productivity, as well as discrepancies in the magnitude and timing of the seasonal cycle.
- The results also provide a sobering picture of the current lack of consensus among model estimates of land-atmosphere carbon exchange across North America.
- Some of this variation has been attributed in this synthesis to model structure and aspects of model driver data.
- A more formal model-data comparison is required to more definitively quantify the impact of model formulation and supporting and driver data on the accuracy of the simulation outputs.
- This intercomparison is currently being conducted via the NACP Multi-Scale Synthesis and Terrestrial Model Intercomparison project. For more information go to: http://www.nacarbon.org/cgi-bin/web/investigations/inv_pgp.pl?pgid=533

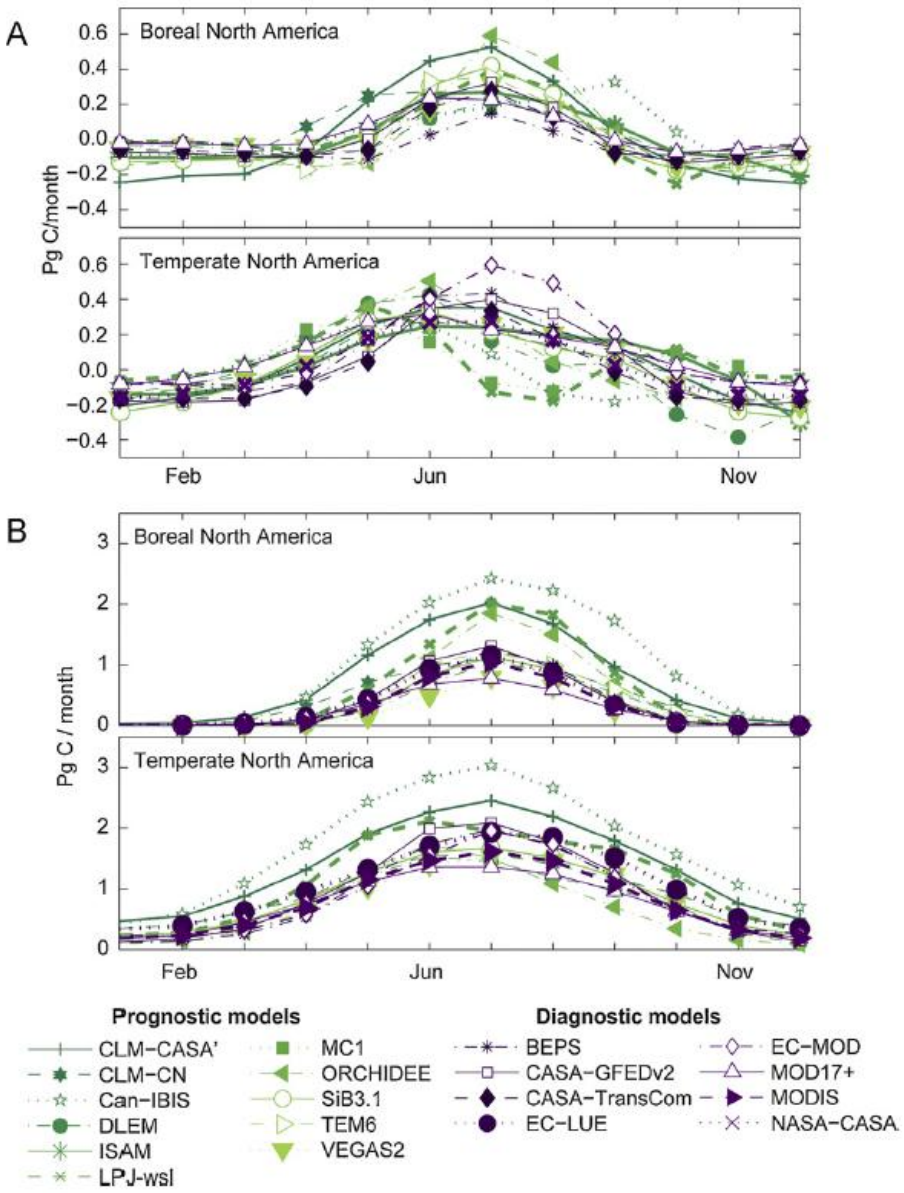

Fig. 3. Model estimates of the long-term mean (2000–2005) seasonal cycle of (A) net ecosystem productivity and (B) gross primary productivity for boreal and temperate North America.

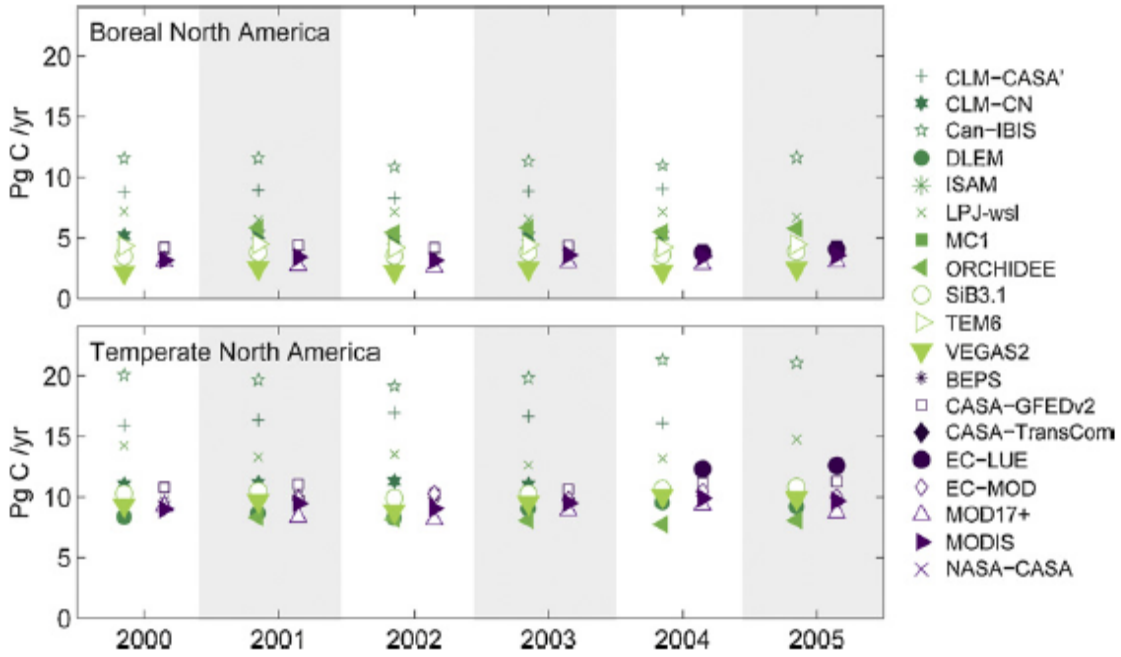

Fig. 4. Model estimates of annual gross primary productivity (GPP) for 2000 through 2005 for Boreal and Temperate North America. Prognostic models are shown in shades of green; diagnostic models are shown in purple.