Studies on Biogeochemistry Model Spin-up in CLM-CN

Mingjie Shi[1], Zong-Liang Yang[1],
David Lawrence[2]
[1] The University of Texas at Austin,
[2] National Center for Atmospheric Research

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Background

The Definition of Model Spin-up

- Model spin-up refers to the process by which a steady-state solution is estimated.

- Terrestrial biogeochemistry models usually spin-up from the bare ground to "equilibrium" vegetation to establish realistic steady-state values for their various “pools” (carbon pools, nitrogen pools, etc).

Motivation

- Testing methods which can reduce the computational cost, and retain or improve the simulated results.

Data and Methodologies

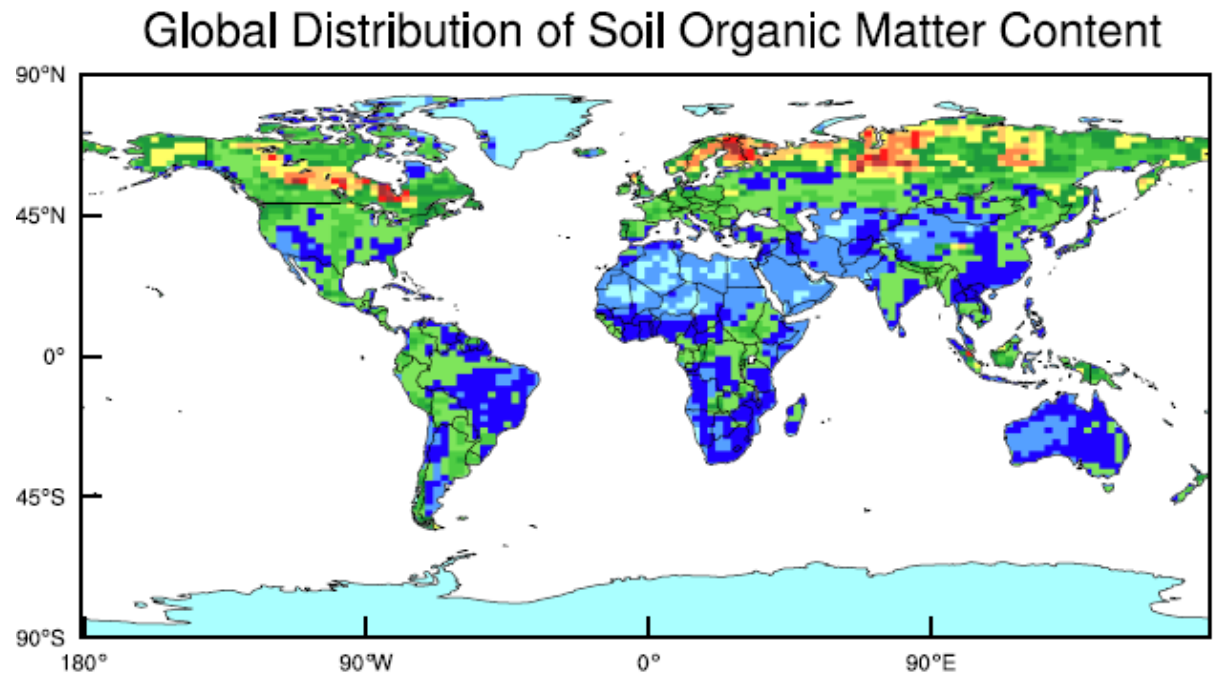
- **Model:** Community Land Model with explicit consideration of carbon and nitrogen processes (CLM-CN).
- **Spin-up methods included:**

1) Native dynamic (ND): the system of coupled plant, litter, and soil carbon and nitrogen pools develops on a "monotonic" path from the null state to the stable steady state (Thornton and Rosenbloom 2005).

2) Accelerated decomposition (AD): 600 years AD-spinup which gives nitrogen decomposition rate a factor of 20; 1 year exit-spinup which skips C and N balance checking; at least 50 years run in normal mode (Thornton and Rosenbloom 2005);

Data and Methodologies

3) Soil initialization (SI) of carbon and nitrogen pools: Initialize the soil carbon pools by reading in organic matter at soil levels; it is assumed that per kilogram organic matter contains 0.58 kilogram carbon, and soil nitrogen pools depend on the C:N ratio.



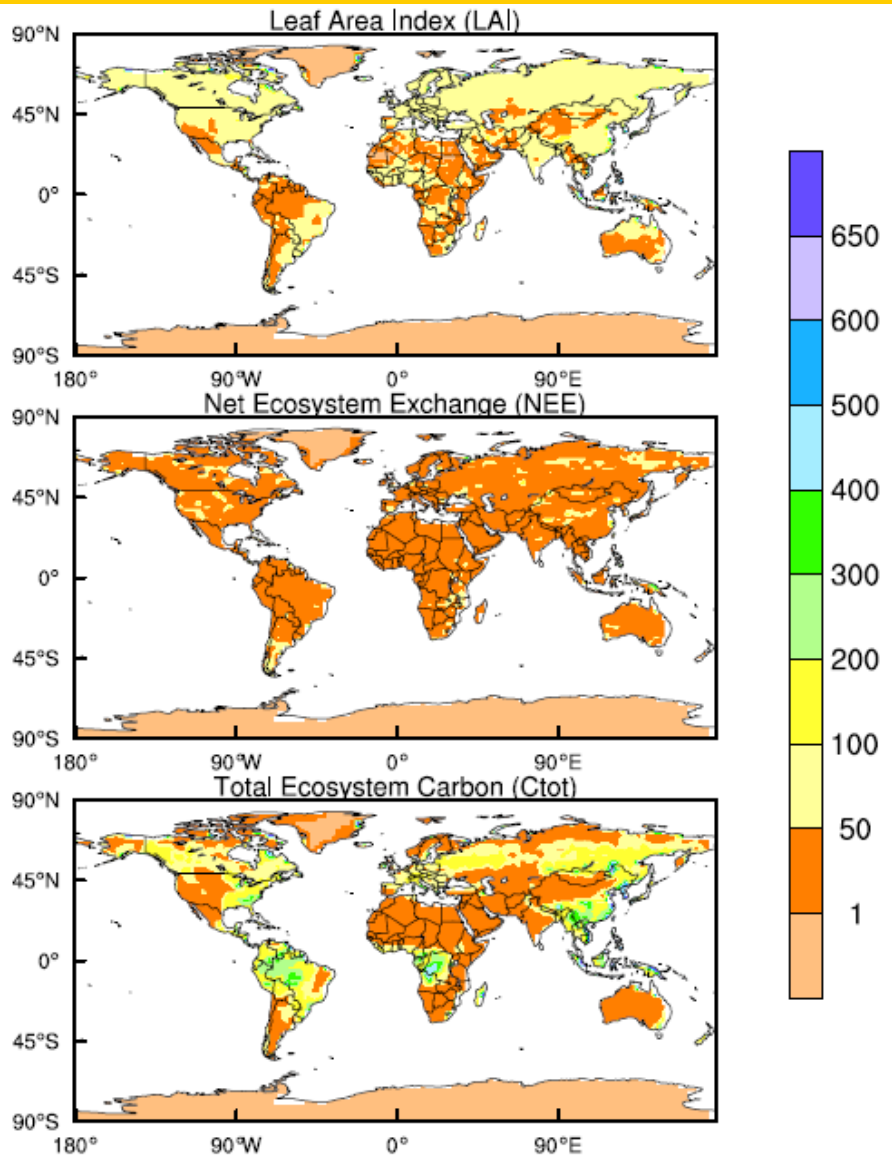
- ✓**Global Soil Data Task soil organic matter content, has been gridded onto CLM.**
- ✓**Soil carbon has its vertical distribution.**

Lawrence L. M., Slater A. G., 2008 (originally in http://www.daac.ornl.gov)

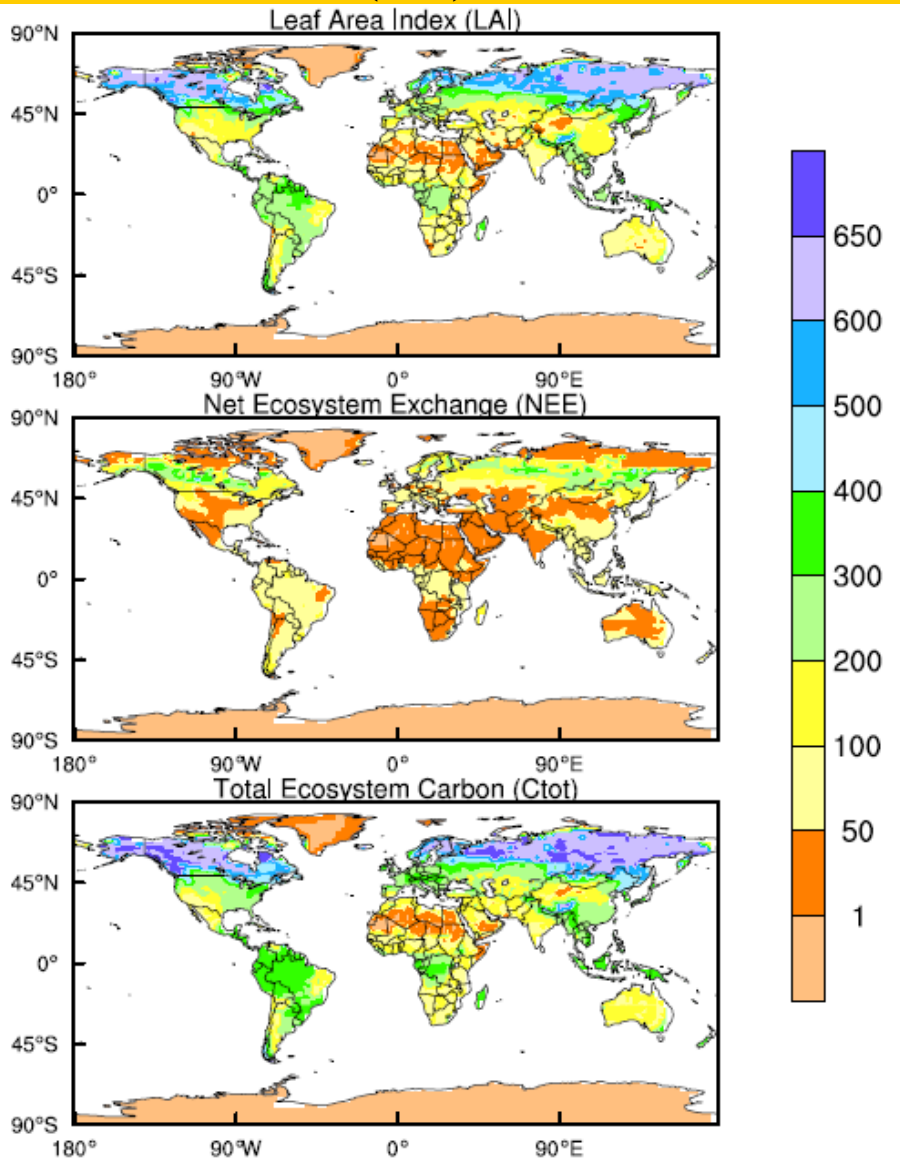
Results

Spin-up time (years needed to reduce the differences between each 30-year forcing cycle less than 1%) by using these methods.

$$\Delta Ctot(\%) = \frac{100 \times (Ctot(i) - Ctot(i-1))}{Ctot(i-1)}\% \leq 1.0\%$$



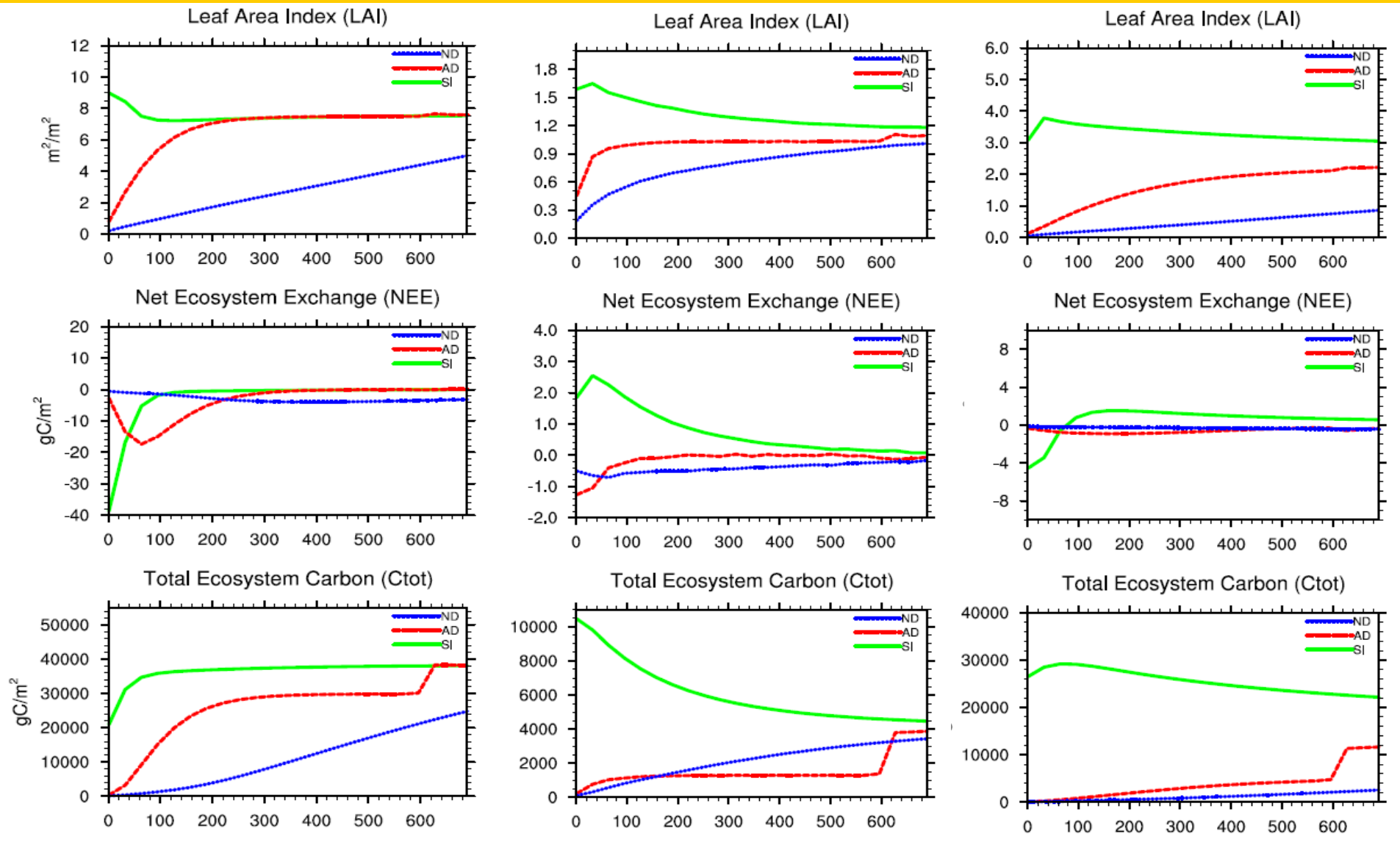
SD method



AD method

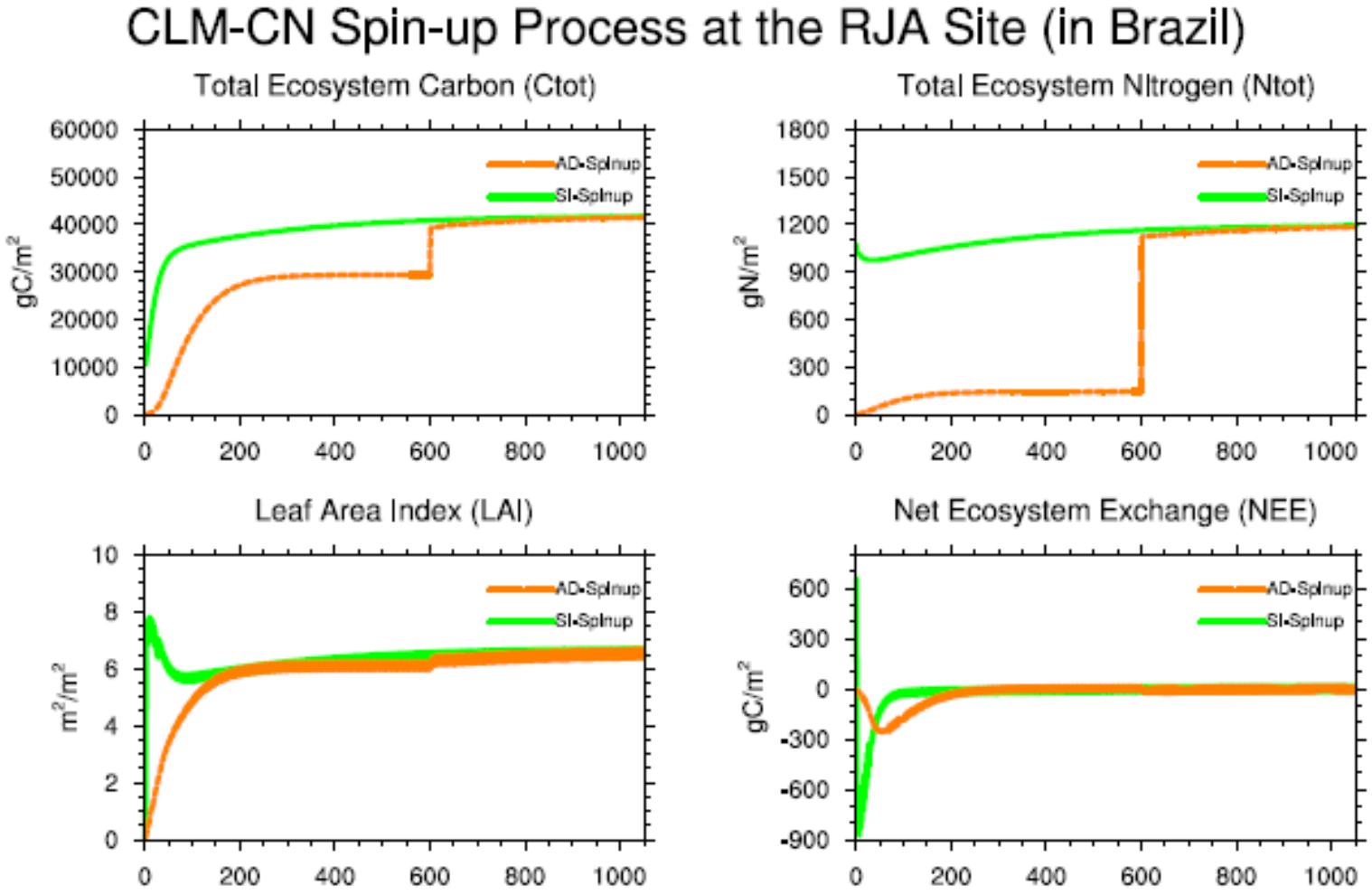
Results

Comparison of spin-up time of three methods at three regions.



Amazon | **African Savanna** | **Russian Boreal forest**

Results



The position of Reserva_Jaru (RJA) site: latitude -10.08, longitude -61.93, and it is a LBA site. The surface vegetation here is tropical rain forest.

Conclusion

1) The spin-up time shows a great spatial variability, and this variability strongly depends on the initial conditions of the model.

2) Comparing with the ND-spinup method, the AD-Spinup method can significantly reduce the computational time (up to 70%), and this result is similar to Thornton's result based on the model Biome-BGC (Thornton and Rosenbloom 2005).

3) The SI-spinup method is also an efficient spin-up method; in the tropical rainforest, the simulated variables can quickly reach to the levels which are close to the steady-state.

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- Thornton, P. E., Rosenbloom, N. A., 2005: Ecosystem model spin-up: Estimating steady state conditions in a coupled terrestrial carbon and nitrogen cycle model. *Ecological Modeling*, 189, 25-48.


Thank you for your attention!
Mingjie Shi:
mingjieshi@mail.utexas.edu