Understanding the Factors Controlling CLM-CN Spin-up

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Outline

- Background
- Motivation
- Data and Methodologies
- Preliminary Results
- Conclusion
- Future Work

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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”.

Existing Problems

The native dynamics approach typically requires thousands of years of spin-up time, which poses significant computational burden for global gridded model simulations.

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Motivation

Study the factors which can influence the spin-up time, and their spatial distributions.

Seek methods which can reduce the computational cost, and retain or improve the simulation results.

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Data and Methodology

Model

- Model: Community Land Model with explicit consideration of carbon and nitrogen processes (CLM-CN).

Data

- National Centers for Environmental Prediction/National Center for Atmospheric Research (NCEP/NCAR) reanalysis.
- Based on this dataset Qian et al (2006) produced forcing dataset for CLM; it is a global, 3-hourly dataset with the resolution T62.
- This experiment use this data from time period 1975-2004.

The spin-up process

- Run CLM-CN continuously looping through reanalysis 70 times (2100 years) with the resolution of $1.875° \times 2.5°$.
- The spin-up methods in this study include the native dynamic (ND) and accelerated decomposition (AD) (Thornton et al 2005).

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The controlling factors of Spin-up

Factors that may influence the spin-up process	These factors are related to
Size of the carbon pools at the steady-state	Initial conditions of the model
Nutrition availability	Litters and soil organic matters (SOM)
Fluxes exchange rate	The climate conditions which can influence the photosynthesis and respiration rate.

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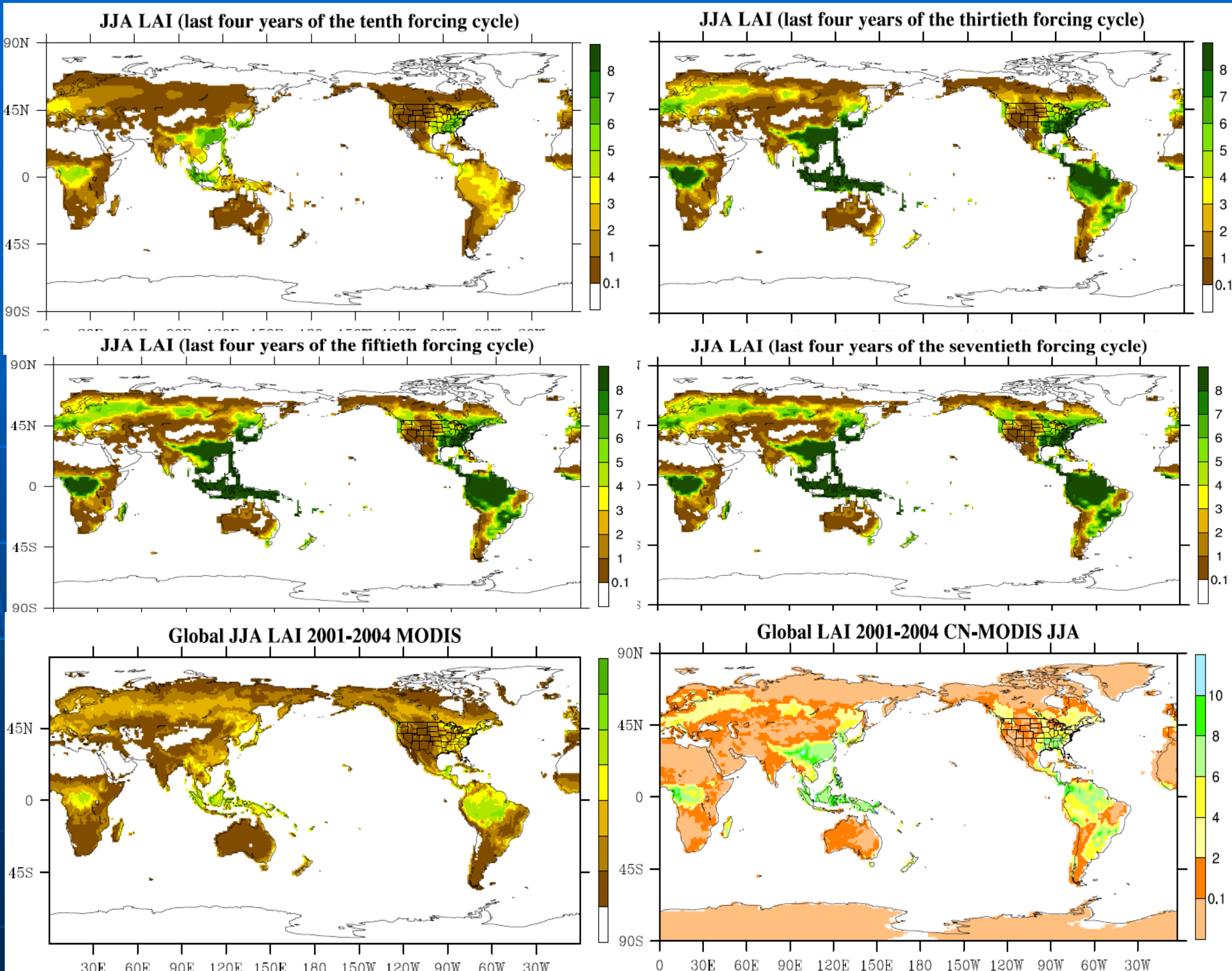
Analyses focus on

Regions	Amazon	Congo Basin	African Savanna	Great Plains	Russian Boreal forest	North American Boreal forest
Dominated vegetation type	Evergreen Broadleaf	Evergreen broadleaf	Grassland	Grassland	Evergreen & deciduous needleaf	Evergreen & deciduous needleaf

Variables that chosen to judge the steady-state:			
Leaf area index (LAI)	Gross primary Production (GPP)	Total ecosystem carbon (Ctot)	Total ecosystem nitrogen (Ntot).



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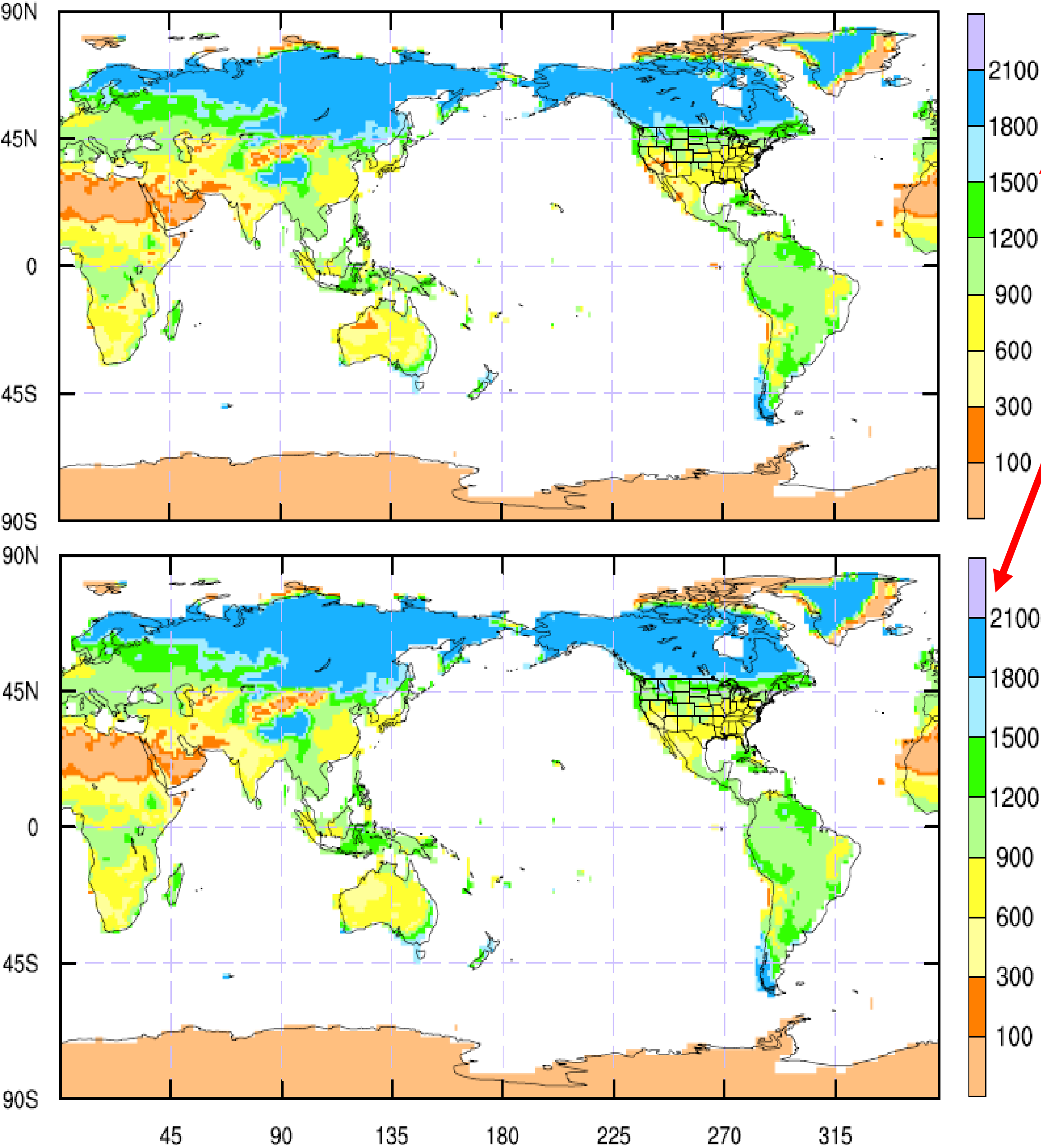
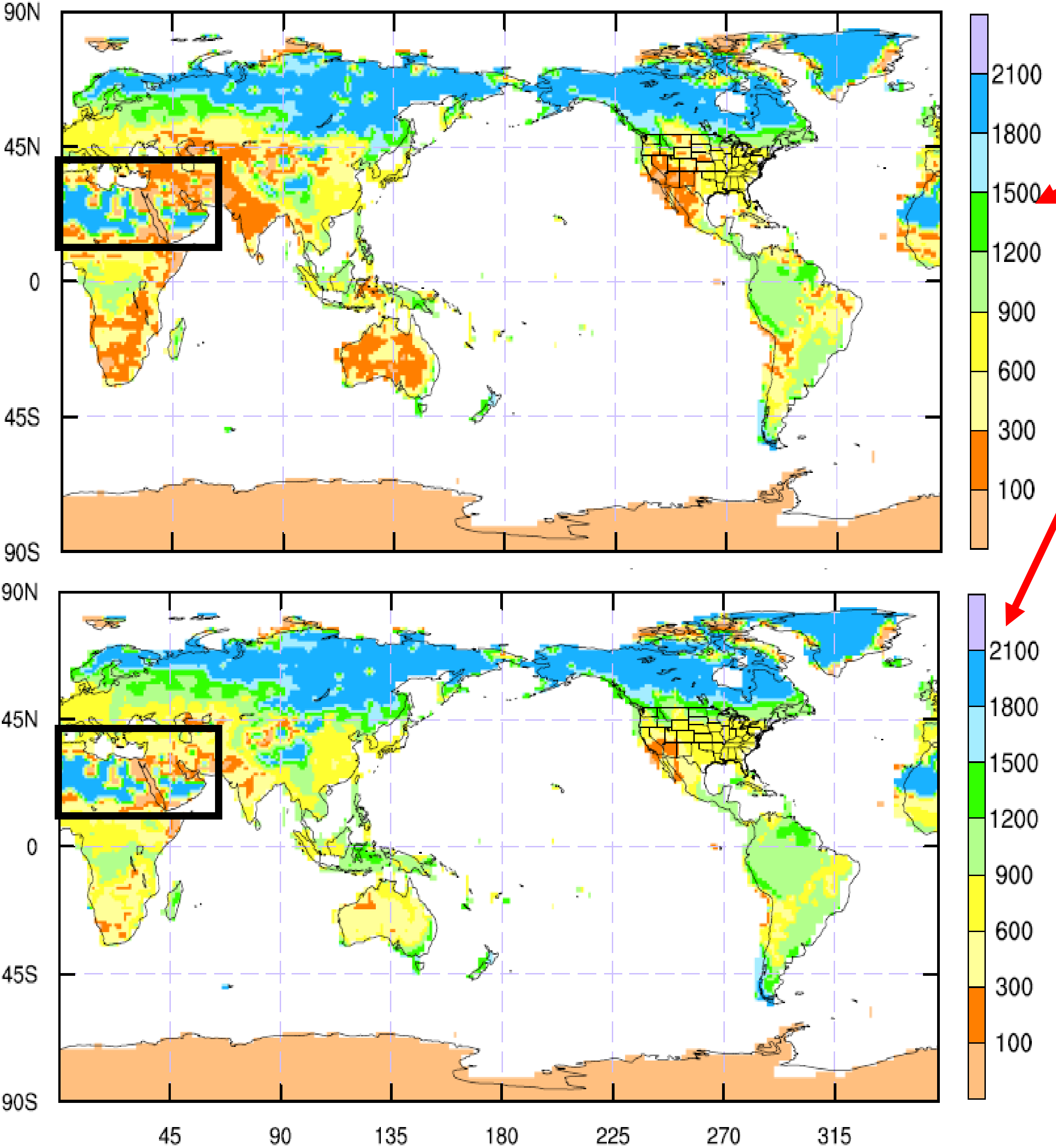


$$\Delta Ctot(\%) = \frac{100 \times (Ctot(i) - Ctot(i-1))}{Ctot(i-1)} \% \le 1.0\%$$

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

- The spin-up time of Ctot and Ntot has similar global distribution.
- Grassland take the Shortest time to spin-up, and high latitude regions takes the longest time to Spin-up.

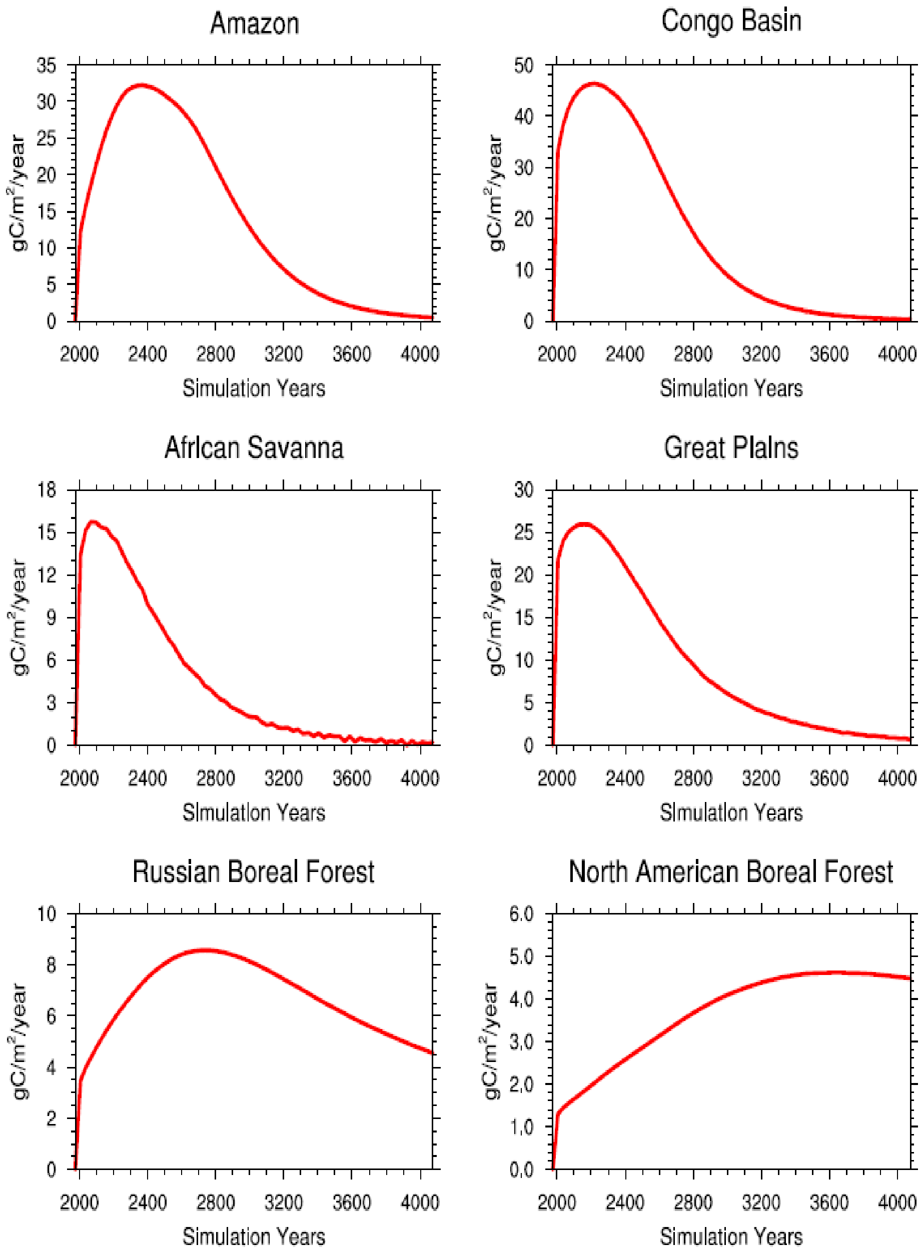


$$\Delta LAI(\%) = \frac{100\times(LAI(i)-LAI(i-1))}{LAI(i-1)}\% \le 1.0\%$$

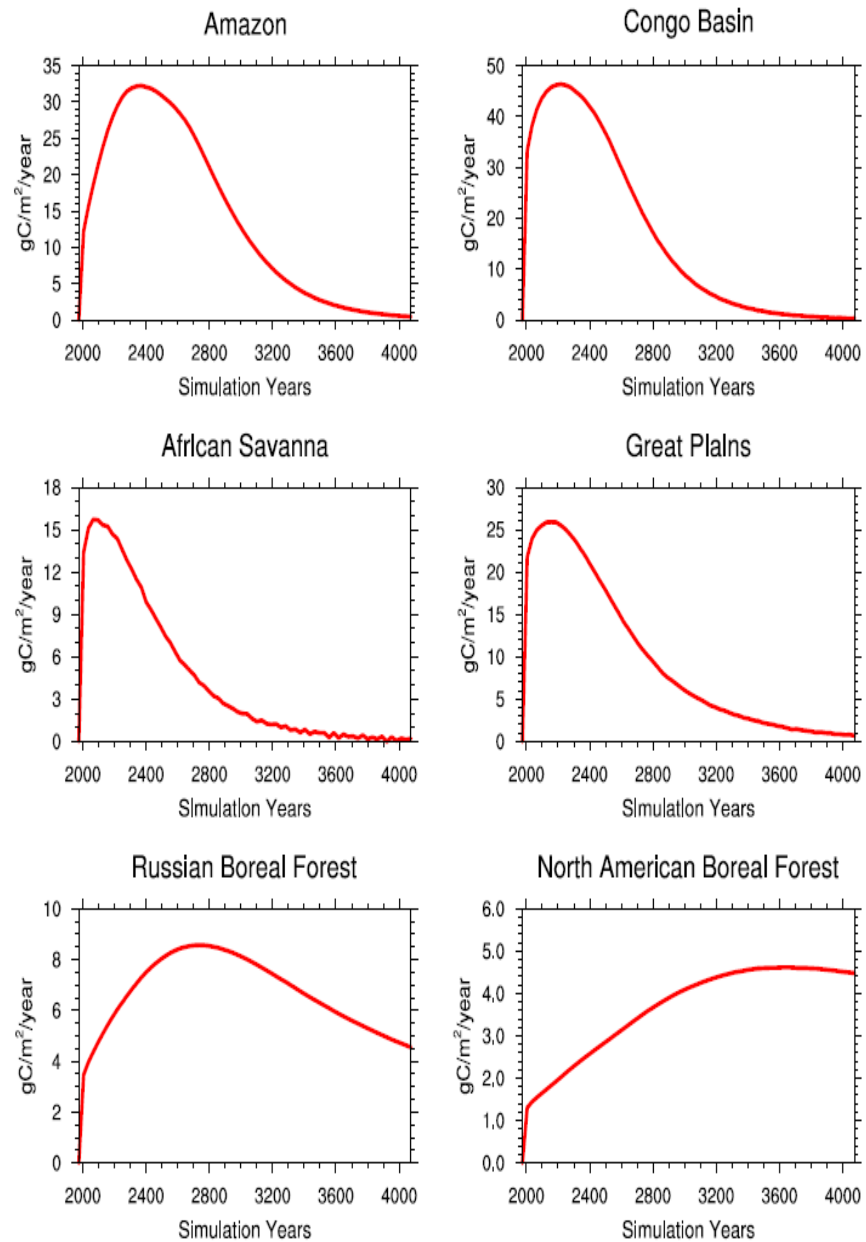
$$\Delta GPP(\%) = \frac{100\times(GPP(i)-GPP(i-1))}{GPP(i-1)}\% \le 1.0\%$$

- ➢The global distribution of the spin-up time of GPP Is similar to that of the Ctot and Ntot.
- ➢The spin-up time of LAI and GPP has some "odd“ features.
- ➢All these four variables have great spatial variability.

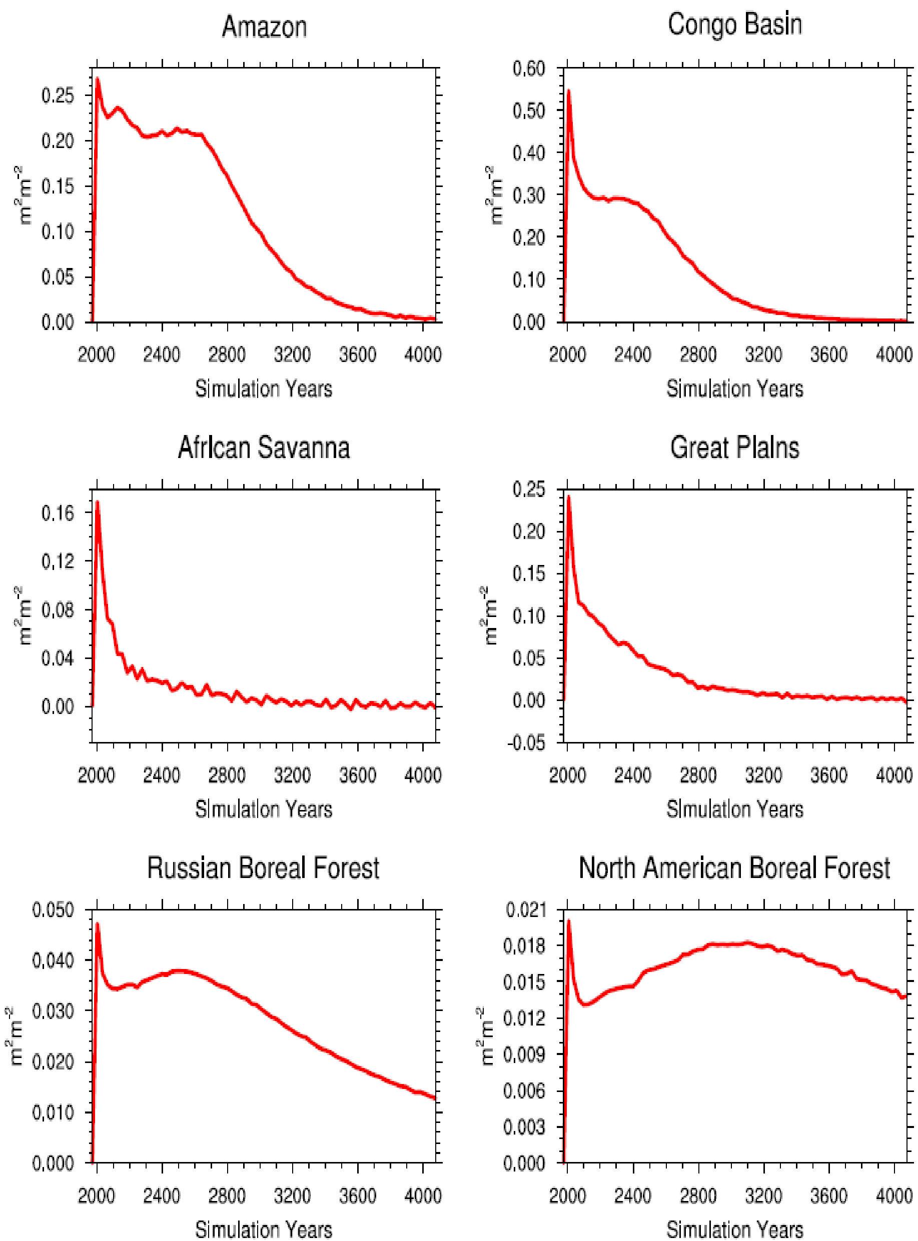
Total Ecosystem Nitrogen (Differences between each forcing cycle)



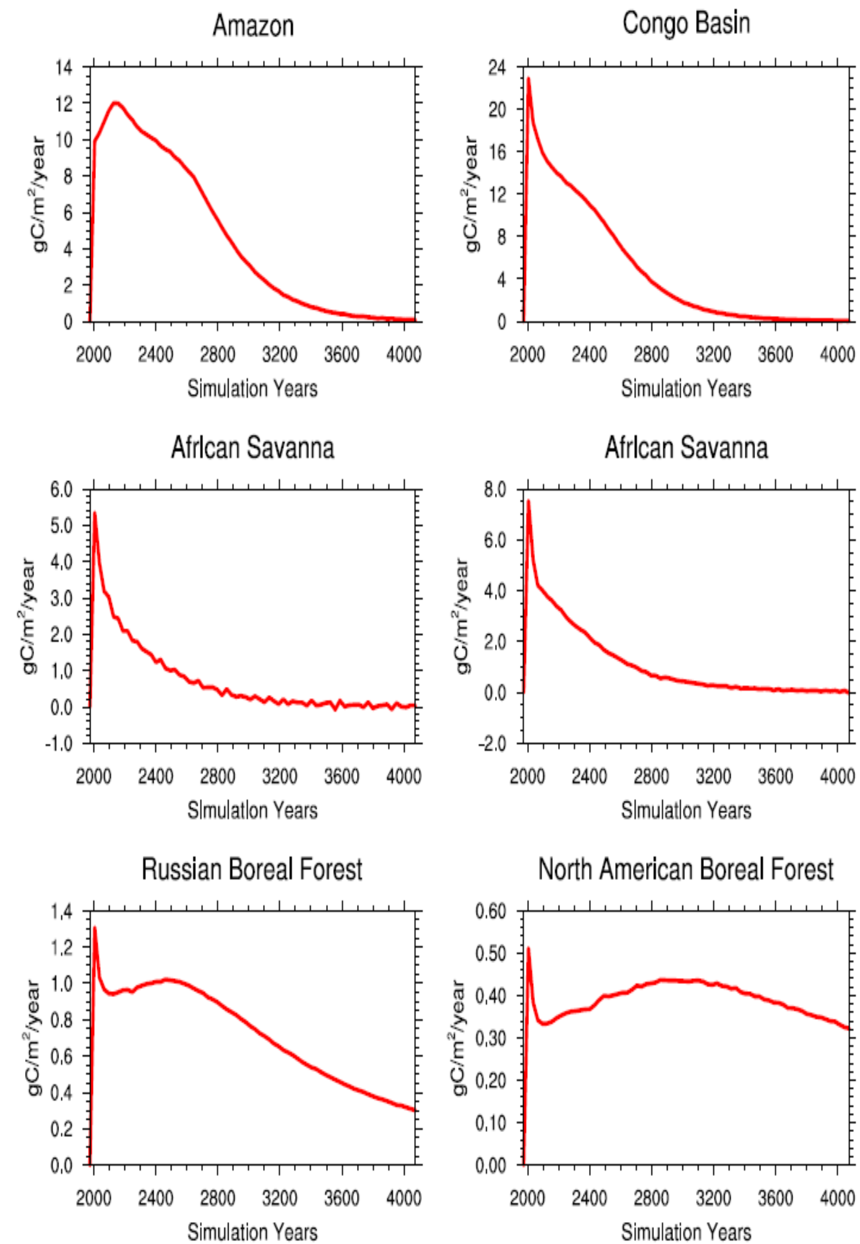
Total Ecosystem Carbon (Differences between each forcing cycle)



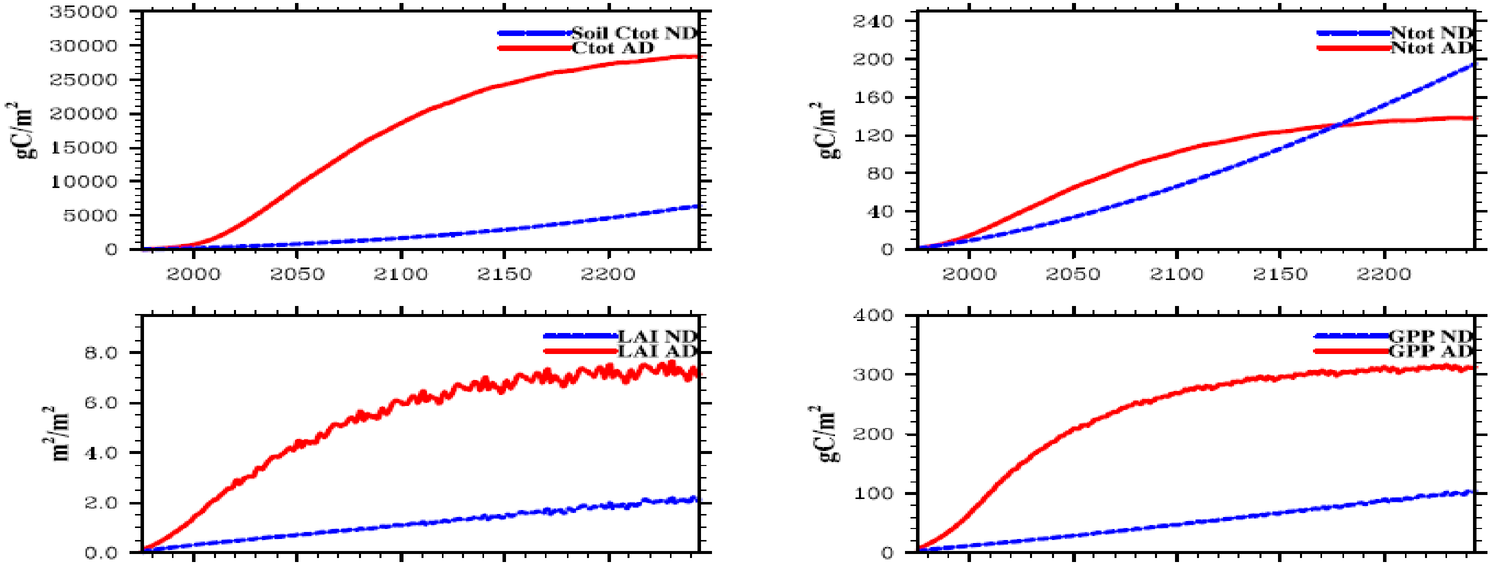
Leaf Area Index (Differences between each forcing cycle)



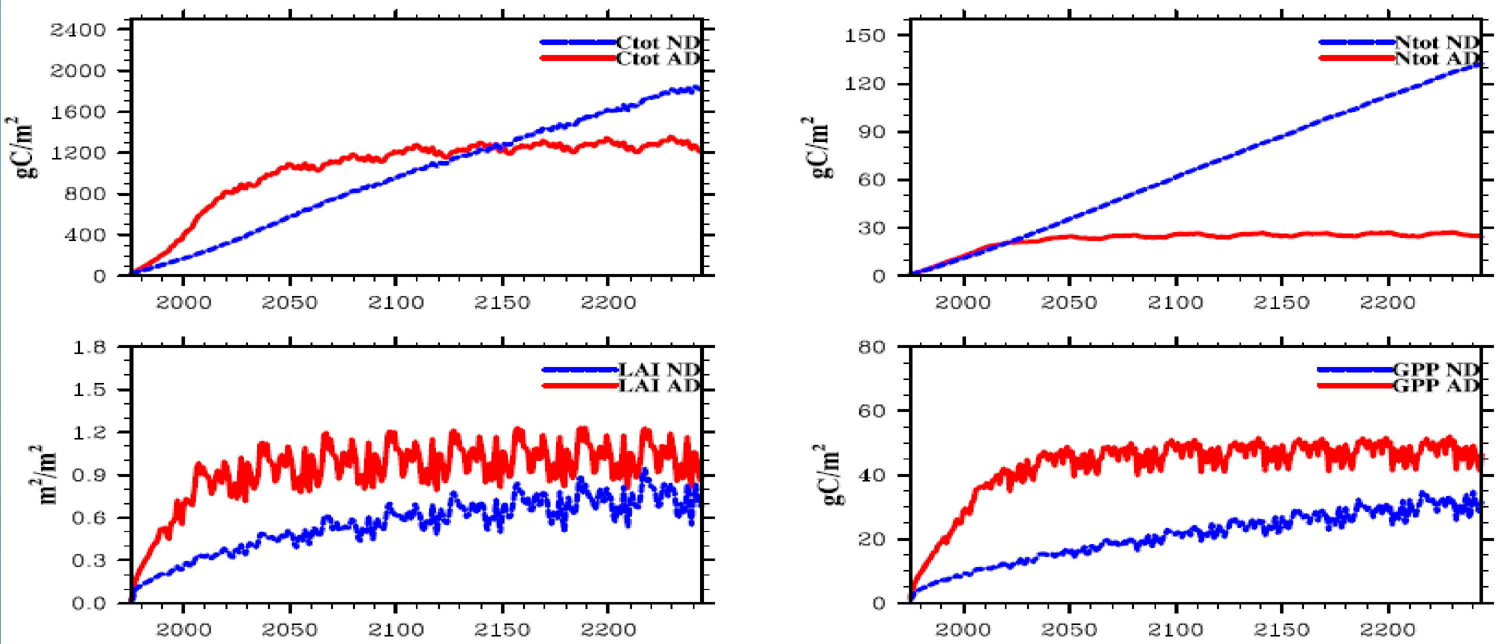
Gross Primary Production (Differences between each forcing cycle)



CLM-CN Spin-up Process at Amazon



CLM-CN Spin-up Process at African Savanna



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Conclusion

1. The spin-up time shows a great spatial variability. Regions where the carbon pools are relatively small have shorter time period spin-up.

2. Tropical rain forest has larger carbon pools than boreal forest, but warm environments accelerate its nitrogen deposition rate and also carbon fluxes. Totally it has faster spin-up rate than boreal forest.

3. At the beginning of the spin-up (about 100) years, the increase speed of LAI and GPP is faster than that of Ctot and Ntot.

4. By using AD method, the spin-up speed increases significantly, but some of the results may be quite different from the ND run.

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Future Work

I. Initialize the carbon pools with observed data;

II. Modify the parameters which can significantly influence carbon and nitrogen dynamics.

Reference:

- 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.

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Thank you and questions?

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