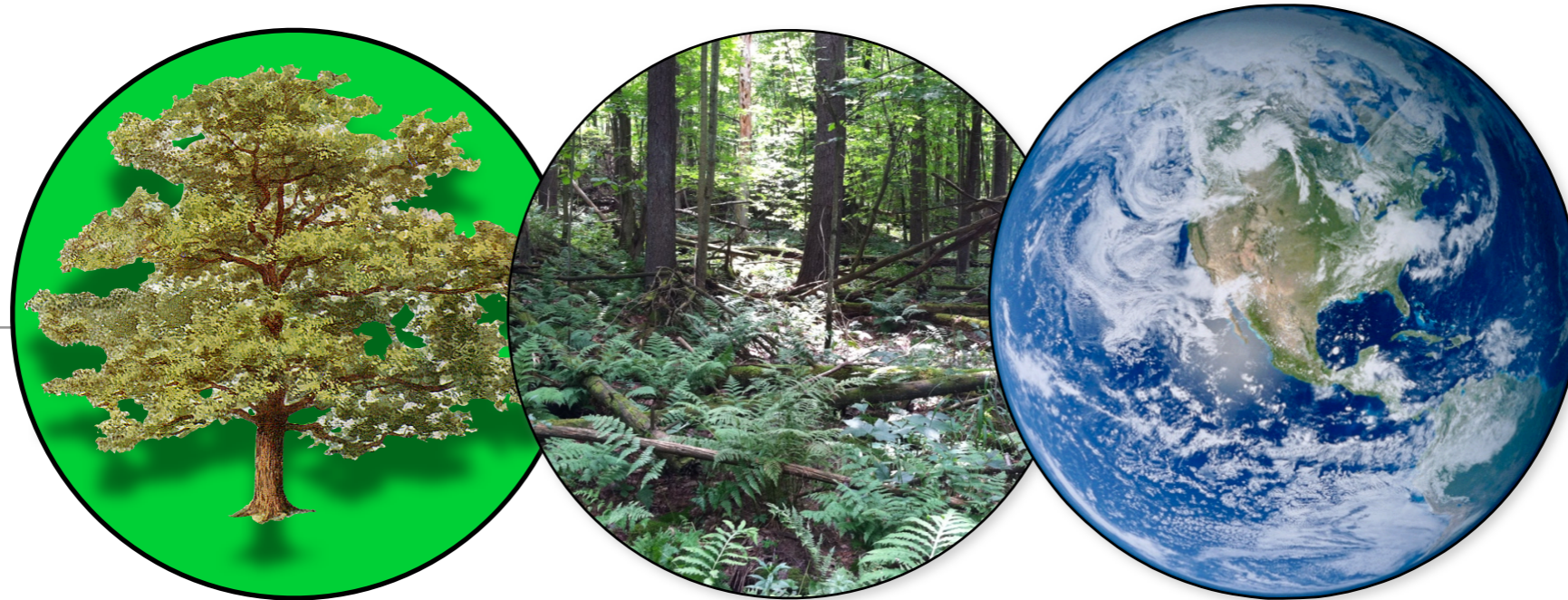


Insights into mechanisms governing forest carbon response to nitrogen deposition: a model-data comparison using observed responses to nitrogen addition



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¹National Center for Atmospheric Research

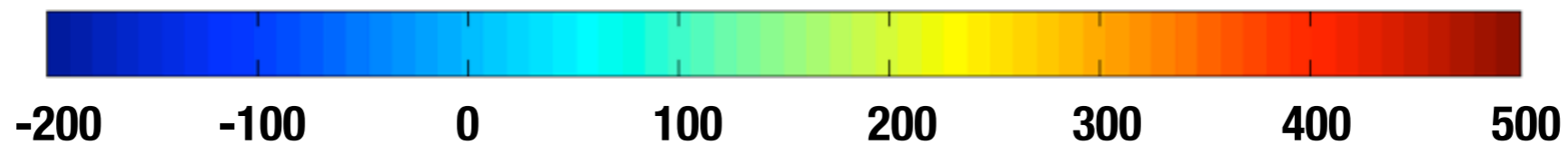
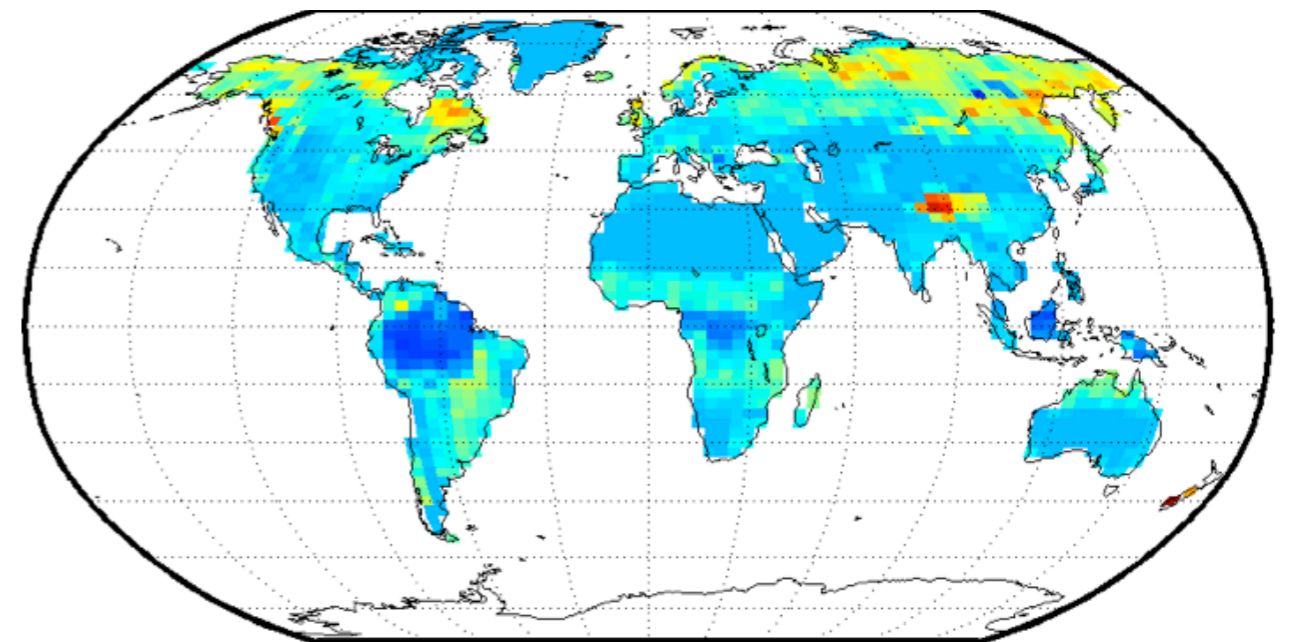
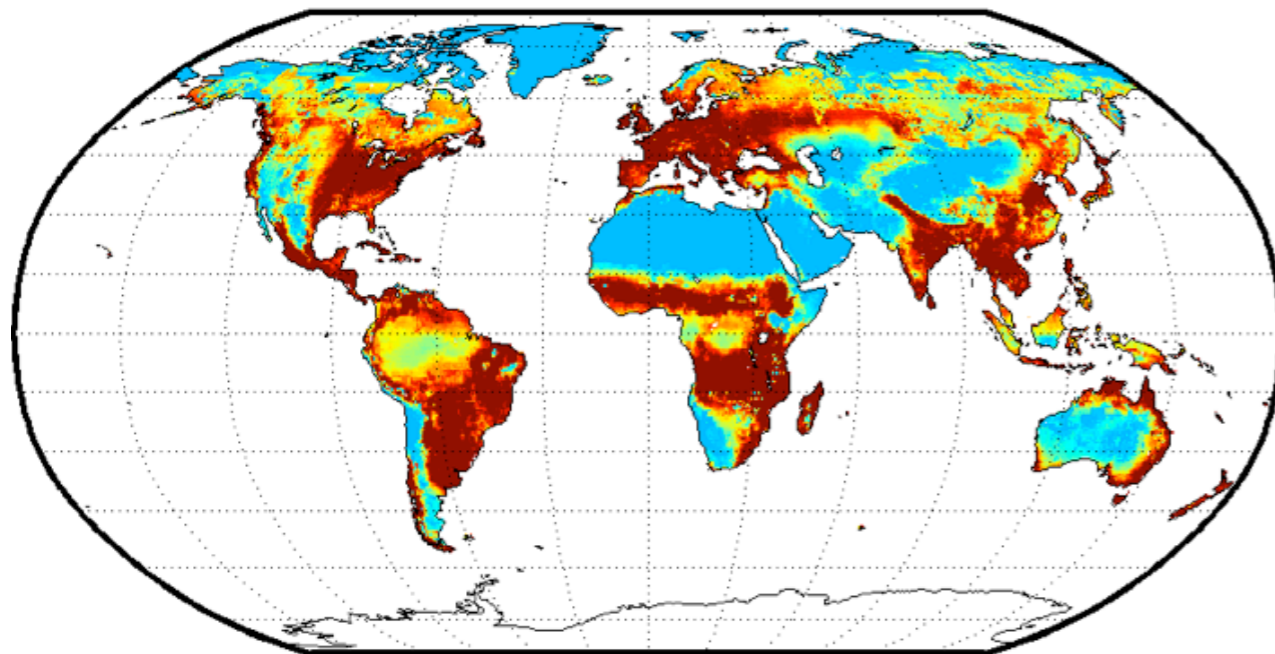
²Cornell University

Different model structures, different predictions for carbon-interactions

Example: N fertilization response in CLM-4.0 and O-CN models

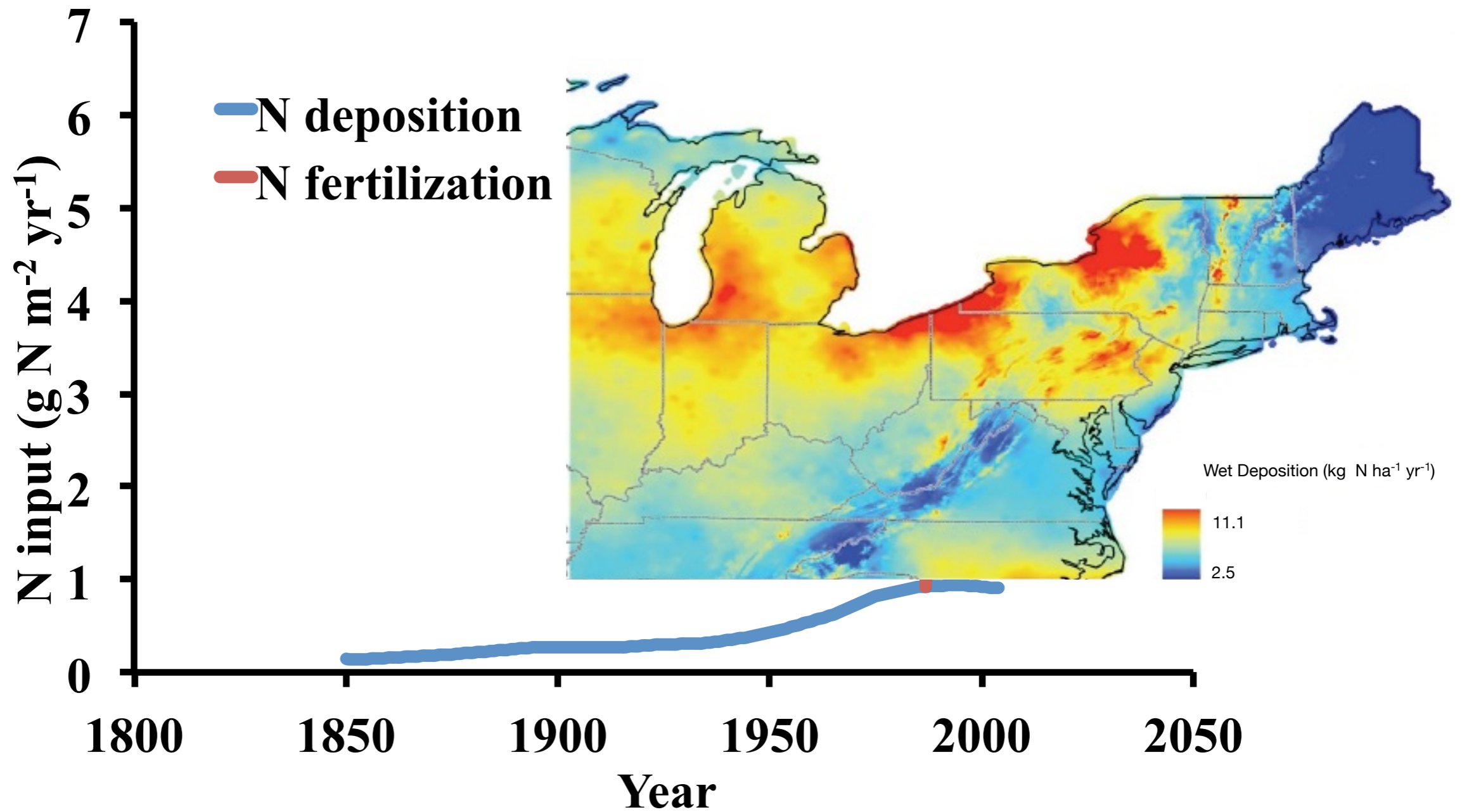
CLM-CN Δ Net Primary Productivity

O-CN Δ Net Primary Productivity

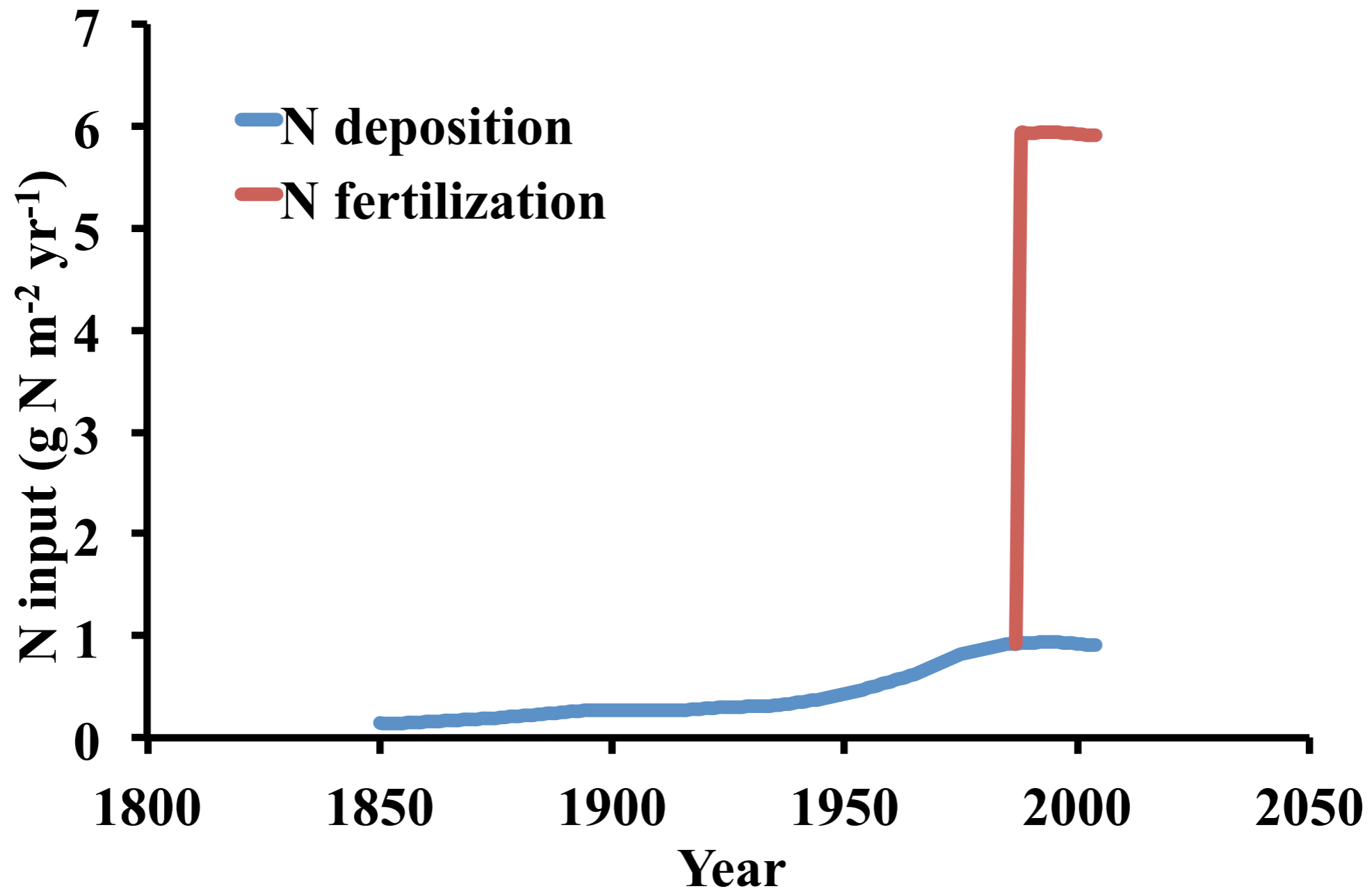


$\text{g C m}^{-2} \text{ yr}^{-1}$

Carbon response to N addition: Nitrogen deposition vs. nitrogen fertilization



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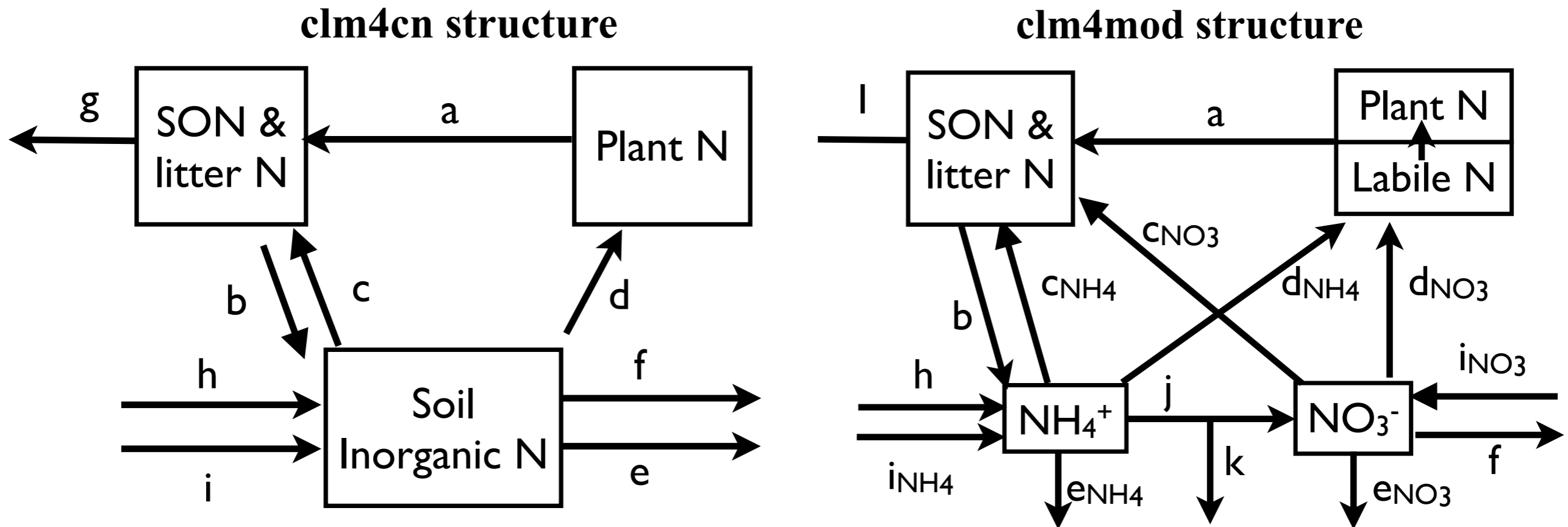


Questions

How do predictions of ecosystem carbon response to N fertilization and N deposition in the CLM-CN compare to observations?

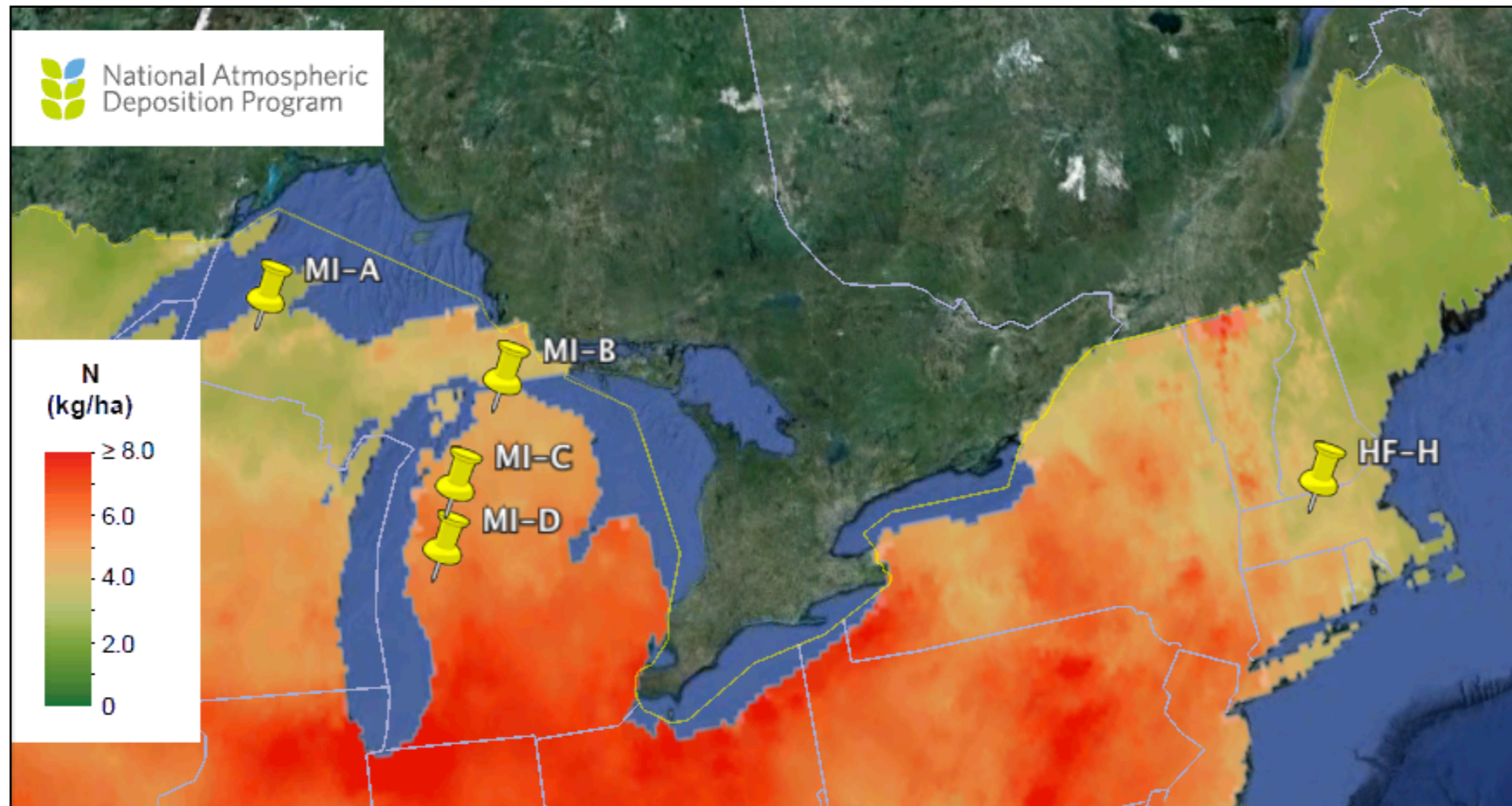
How sensitive is the response to assumptions about the structure of the nitrogen cycle in the CLM-CN?

Alternative versions of the CLM-CN



- Michaelis-Menten plant N uptake
- Reduced N fixation in mature extra-tropical forests
- Removed N gas loss that is 1% of net mineralization
- Denitrification based on environmental conditions
- Soil NH_4^+ and NO_3^- pools

Model simulations: site-level



5 sites, 6 fertilization experiments
(4 in Michigan, 1 in Massachusetts)
10+ years of observations

Model simulations: site-level

- 1850-2004 transient simulations for each site
- Simulation with transient N deposition
- Simulation holding N deposition at 1850 levels
- Simulation with transient N deposition and N fertilization to match the study
- Transient CO₂, land-use, and climate
- Used 1850 steady-state as initial conditions

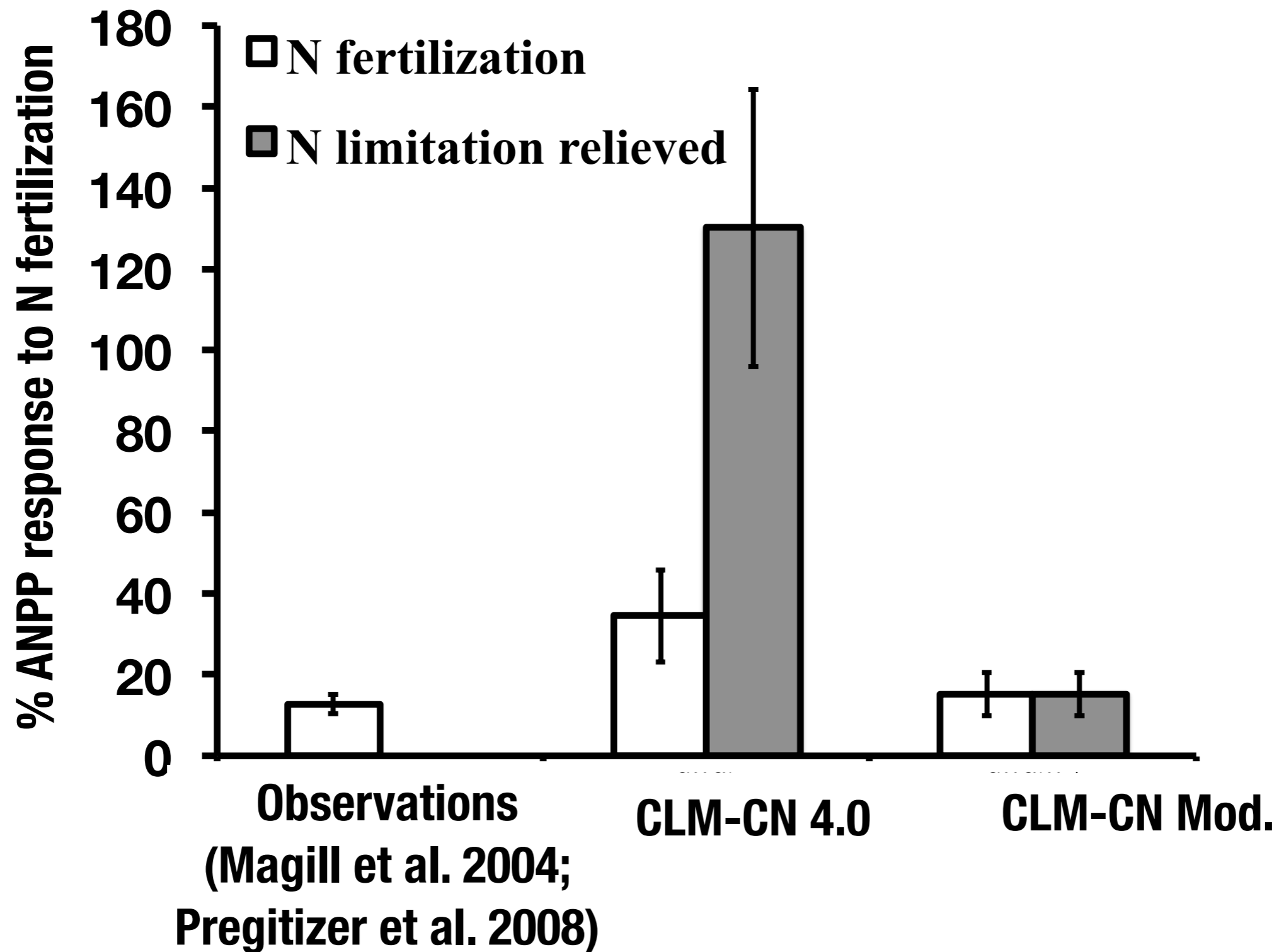
N budget:

1850 steady-state averaged across 5 sites

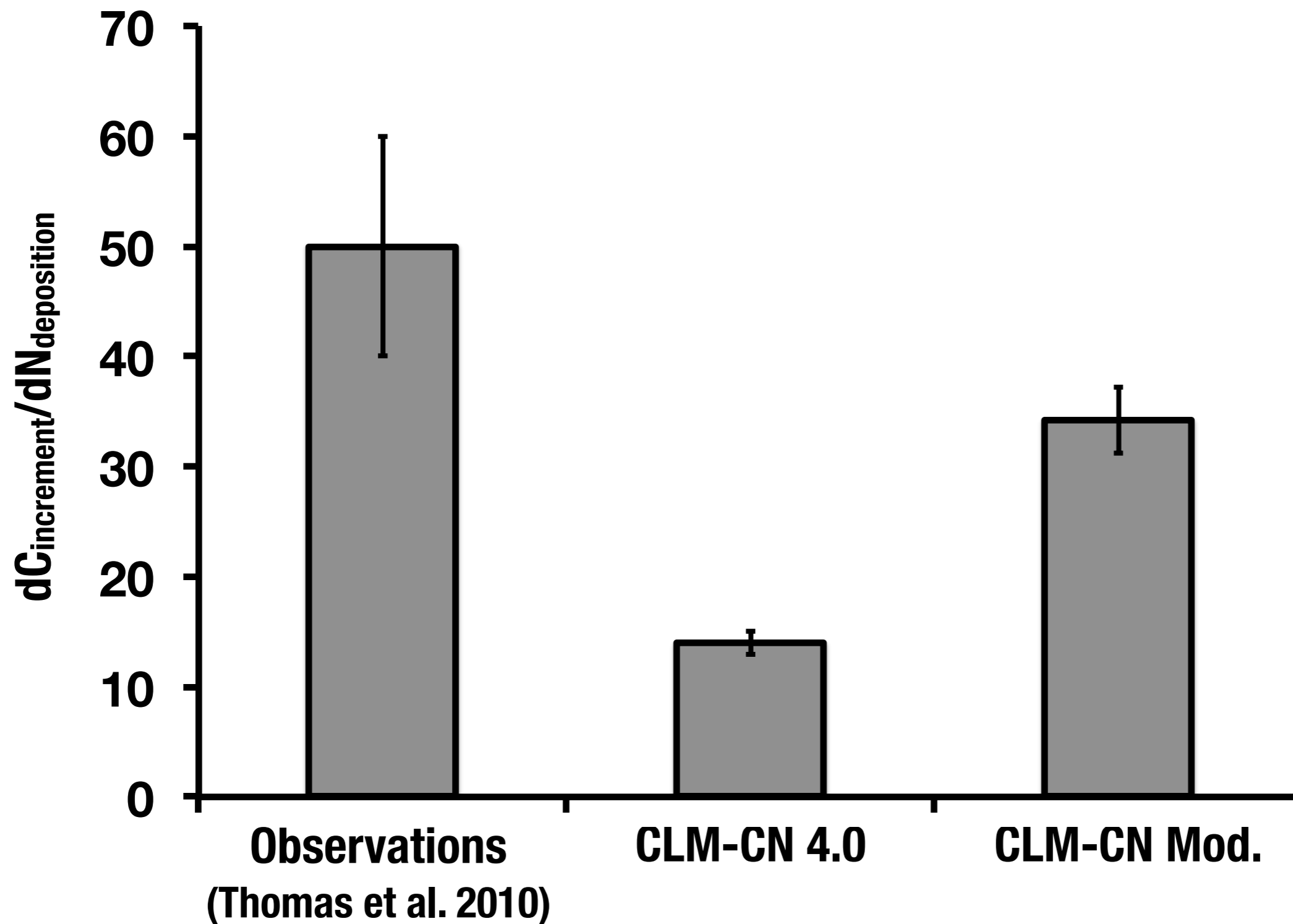
Flux	clm4cn	clm4mod
Nitrogen fixation	1.3 ± 0.1	0.26 ± 0.01
Nitrogen deposition	0.15 ± 0.01	0.15 ± 0.01
Nitrogen gas loss	1.4 ± 0.1	0.26 ± 0.01
Mineral nitrogen leaching	0 ± 0	0.07 ± 0.01
DON leaching	NA	0.1 ± 0.004
Plant nitrogen uptake	6.2 ± 0.67	6.9 ± 0.29
Net nitrogen mineralization	6.1 ± 0.66	6.5 ± 0.25
Nitrification	NA	3.6 ± 0.06

$\text{g N m}^{-2} \text{ yr}^{-1}$

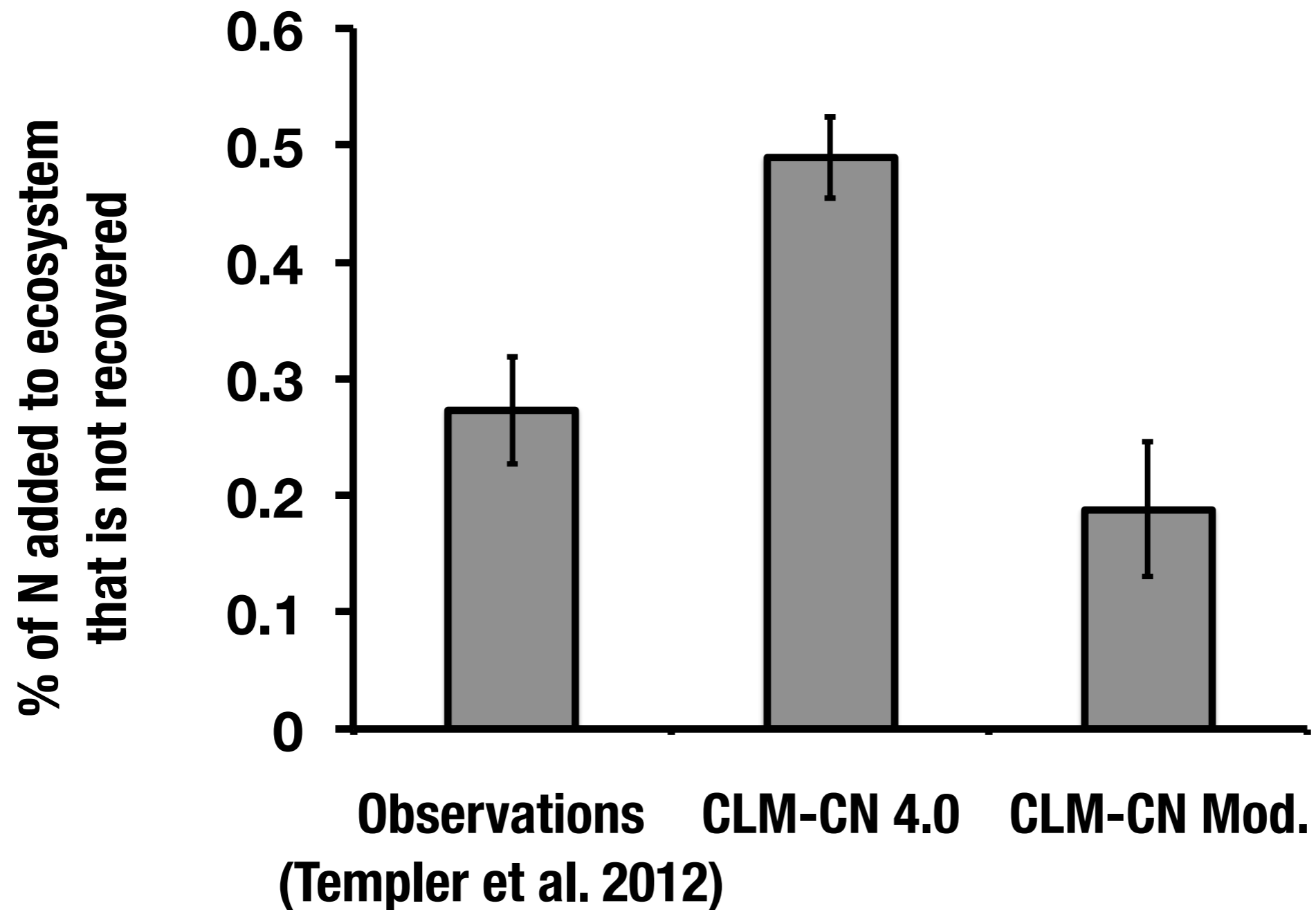
Model comparison to data: NPP response to N fertilization



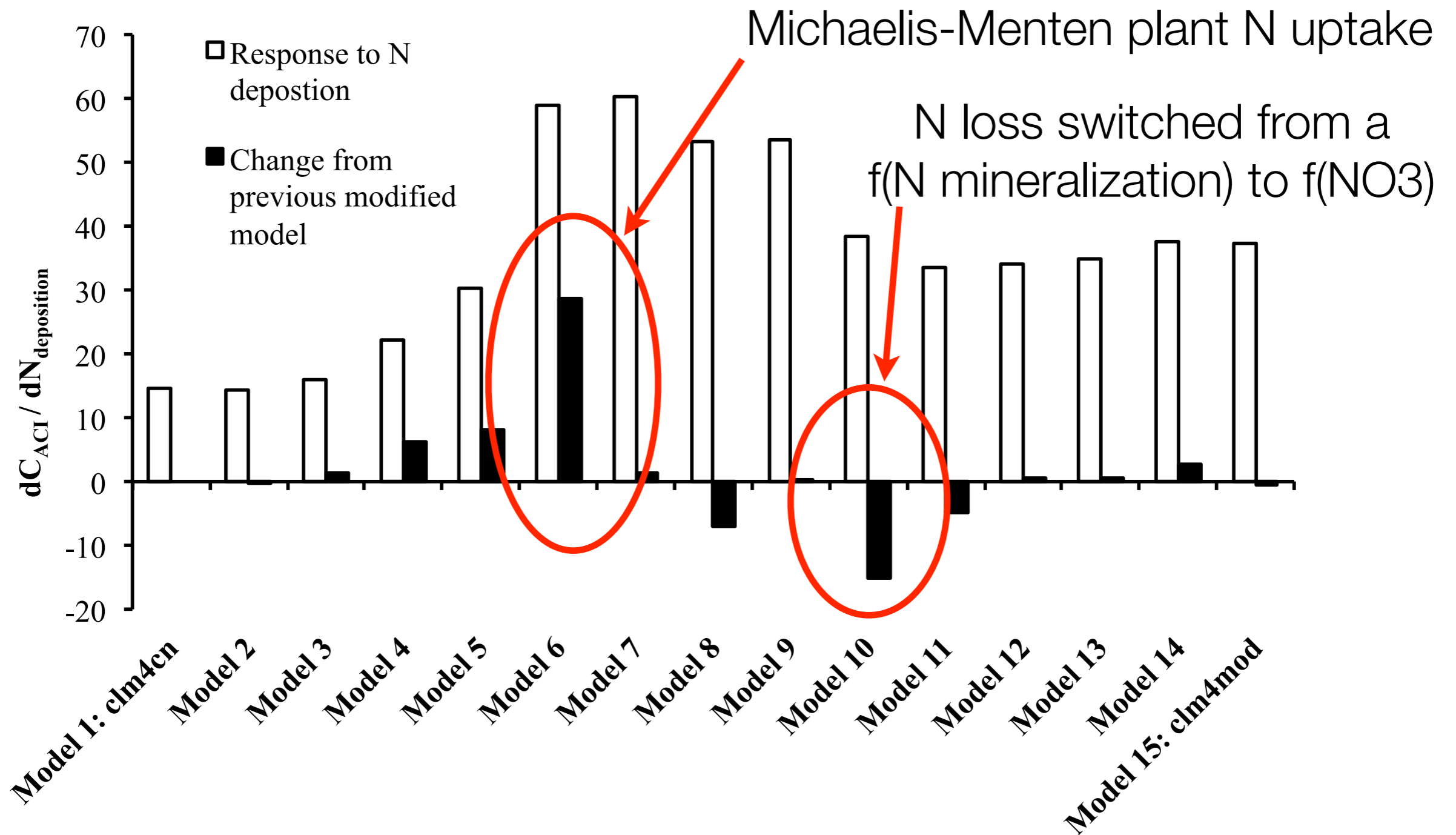
Model comparison to data: C increment response to N deposition



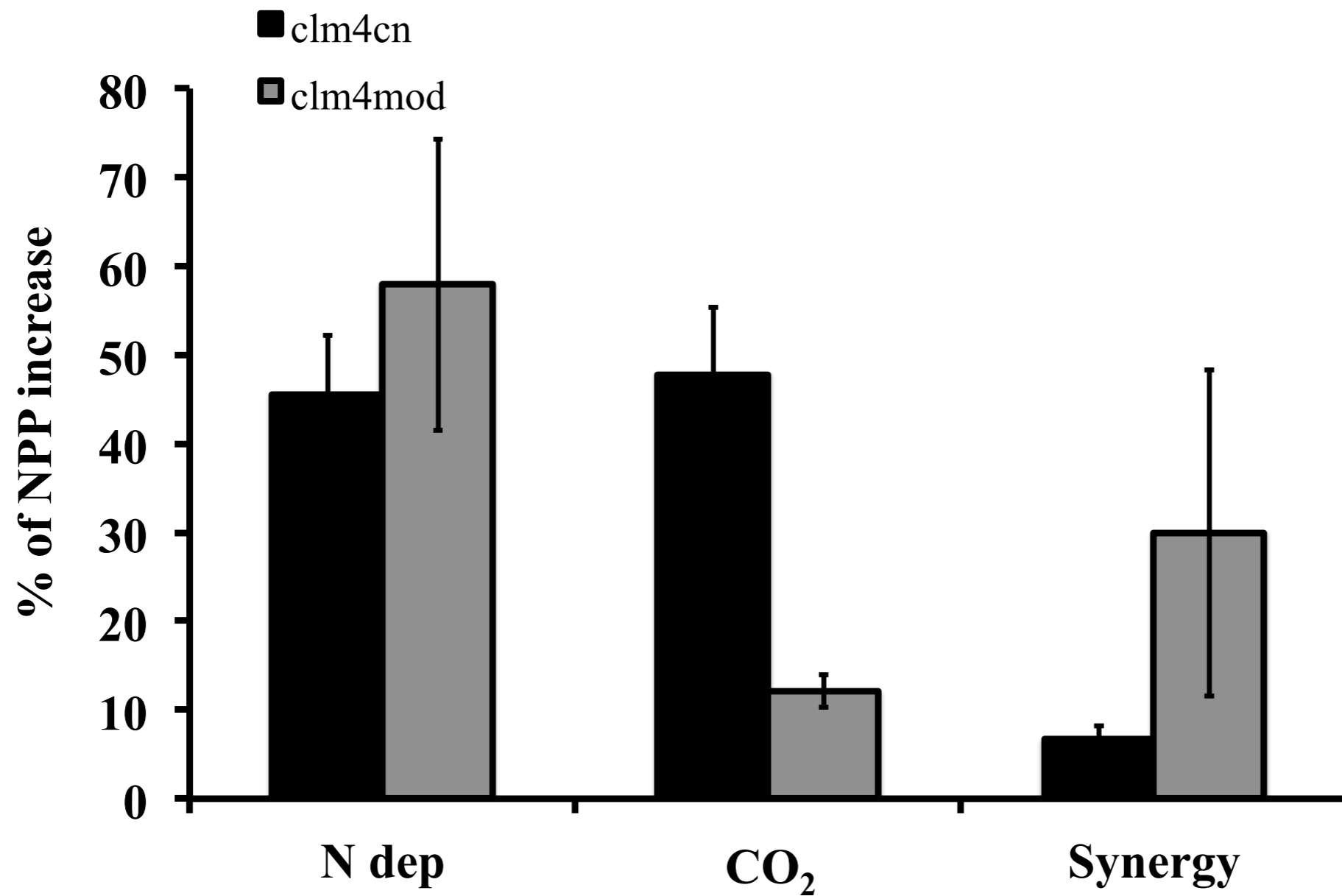
Model comparison to data: Retention of ^{15}N Tracer studies



Response to N deposition: Which modifications were most important?



Larger role of synergy between CO₂ and N deposition



Conclusions and Implications

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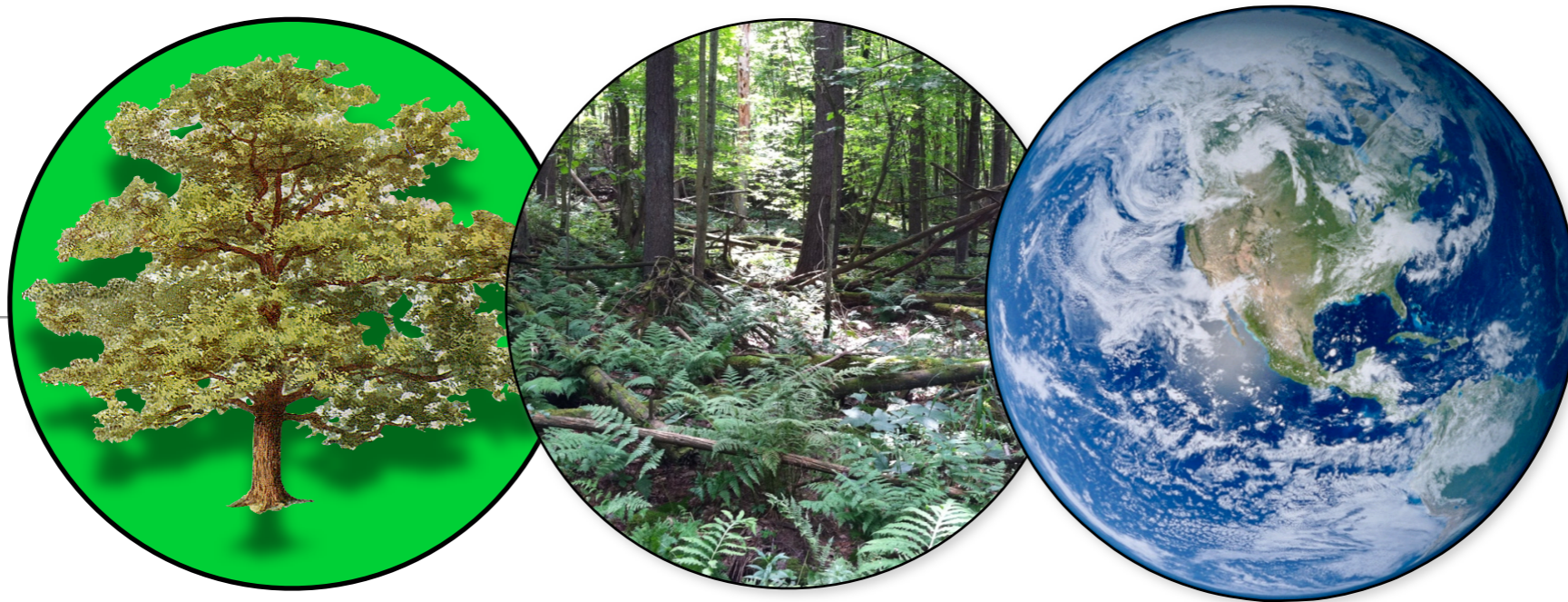
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- Currently adding M-M N uptake to CLM-CN 4.5

Questions?



Thomas, R Q, G. B. Bonan, and C. L. Goodale. 2013. Insights into mechanisms governing forest carbon response to nitrogen deposition: a model-data comparison using observed responses to nitrogen addition. *Biogeosciences Discussions* 10:1635–1683.