

***New Theory for Ecosystem Nutrient
Competition, Representation of
Plant Traits, and Improved
Advective Solution Improves ALM
Simulations***

W.J. Riley

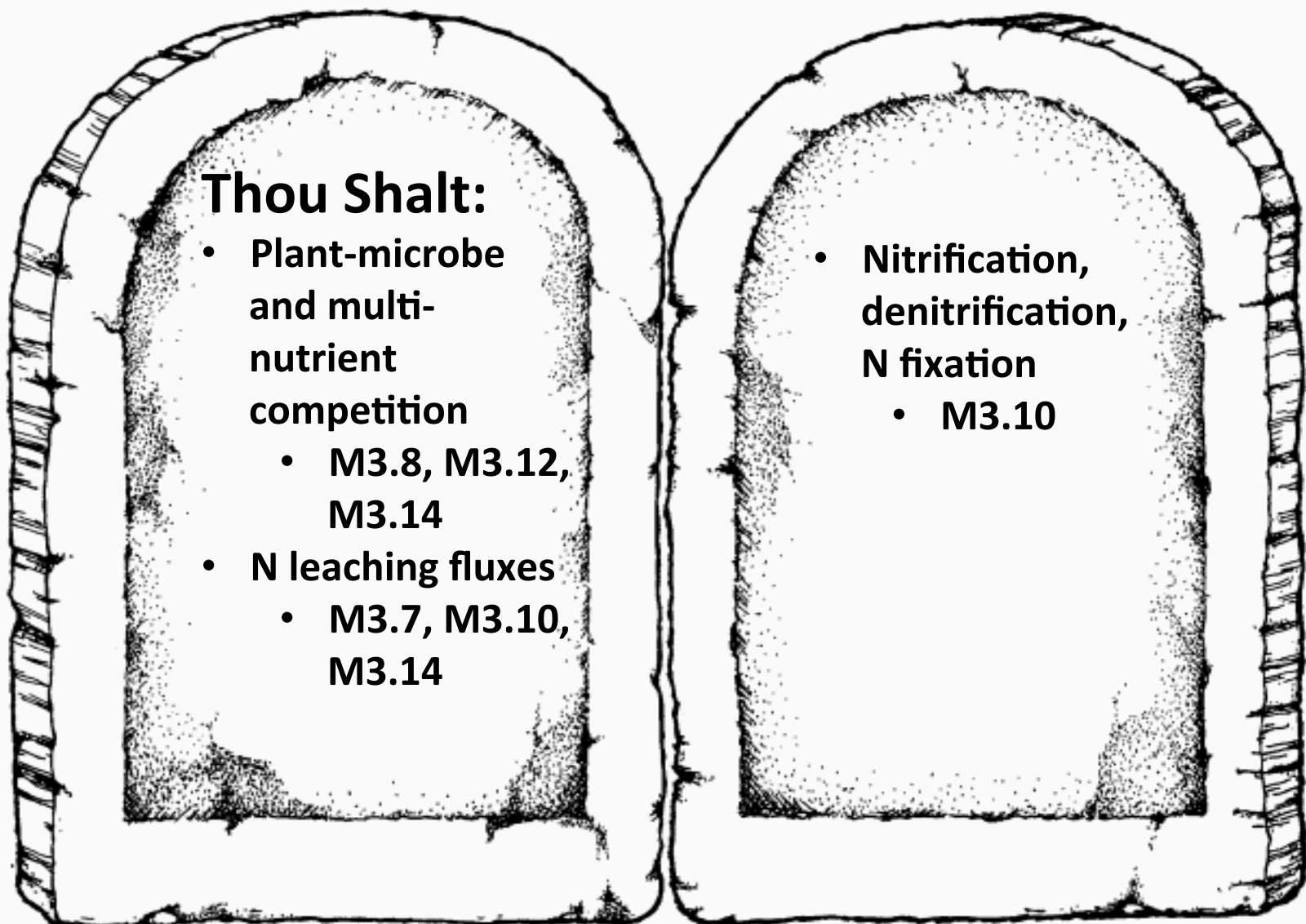
B. Ghimire, Q. Zhu, J. Tang, C.D. Koven

Berkeley Laboratory



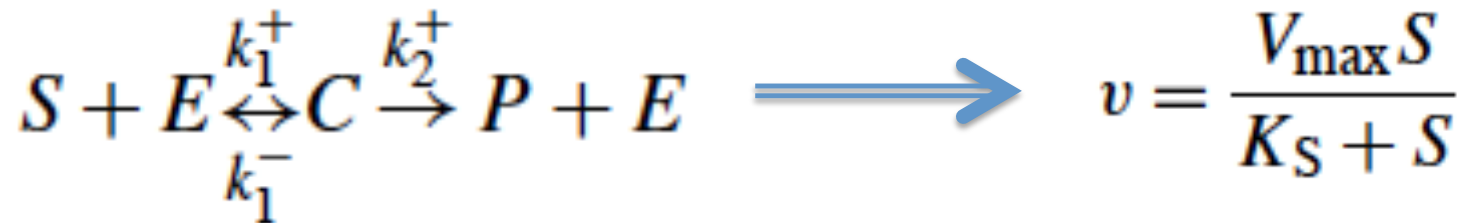


Three ACME-Supported Publications Relevant to ALM BGC Experiment



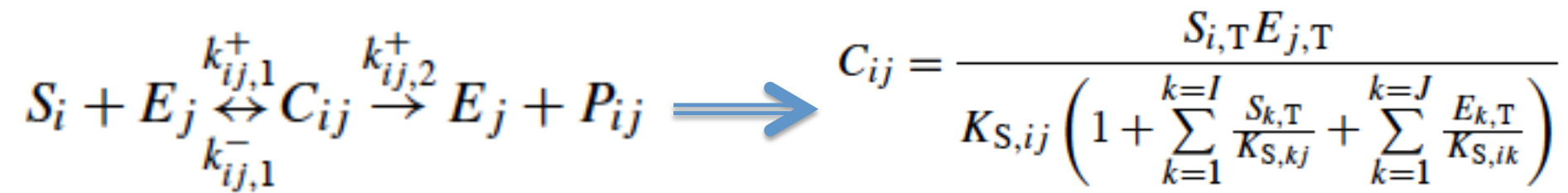
Next Generation LM's Need to Represent Multi-Nutrient, Multi-Consumer Interactions

- Michaelis-Menten (1913), Monod (1949) kinetics derived using Law of Mass Action
- Enzyme-substrate interactions also theoretically derived from statistical and quantum mechanical approaches



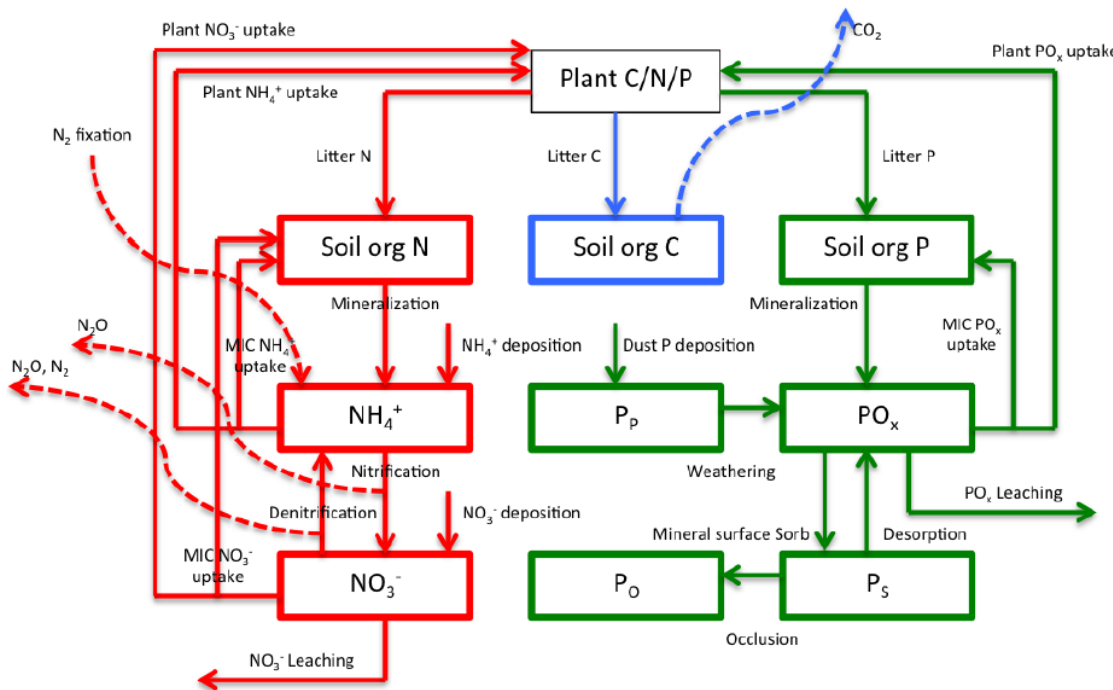
Next Generation LM's Will Need to Represent Multi-Nutrient, Multi-Consumer Interactions

- We extended the concepts to realistic, complex ecosystem processes and interactions (Tang and Riley 2013)



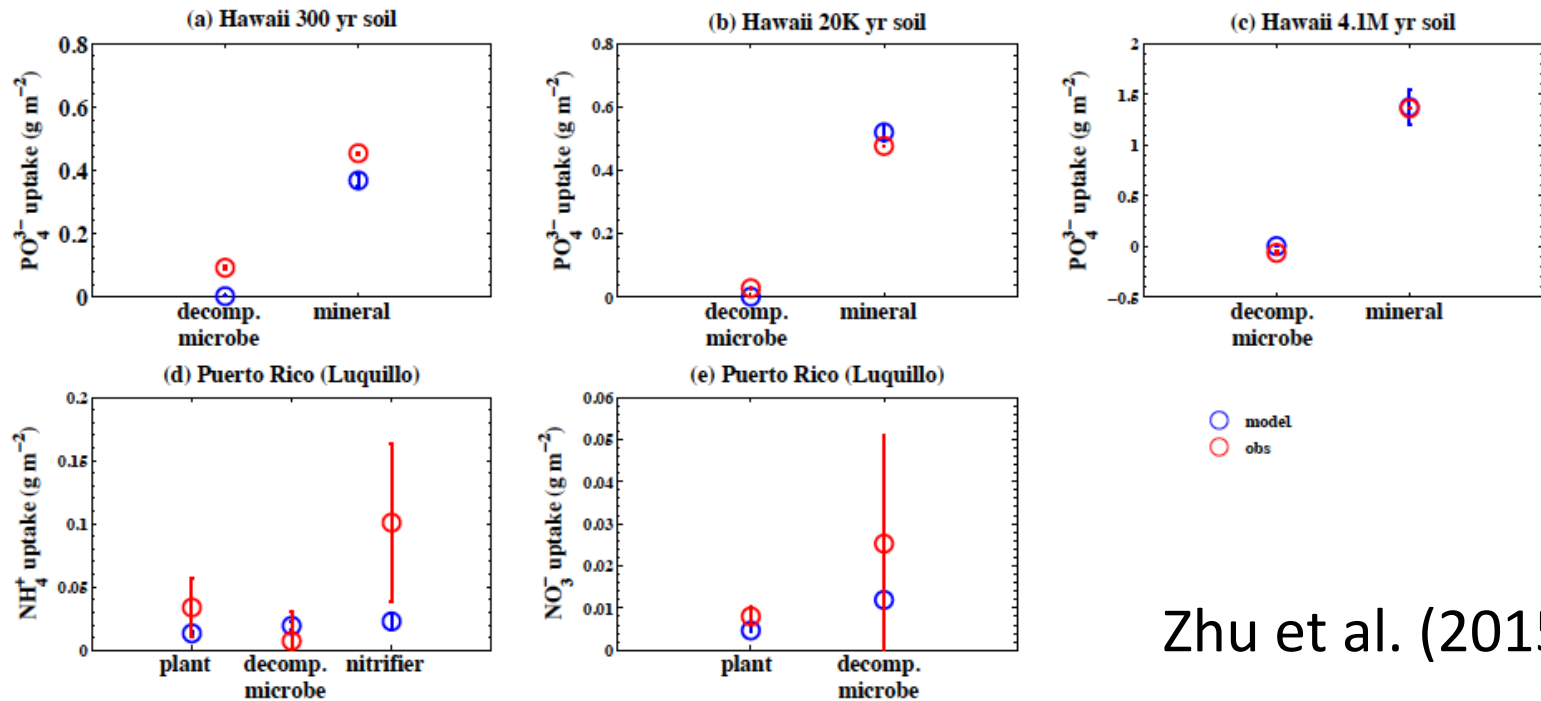
ECA Kinetics Multi-Nutrient, Multi-Consumer Competition

- Applications to N & P competition between heterotrophic decomposers, nitrifiers, denitrifiers, and plants (Zhu et al. 2015)



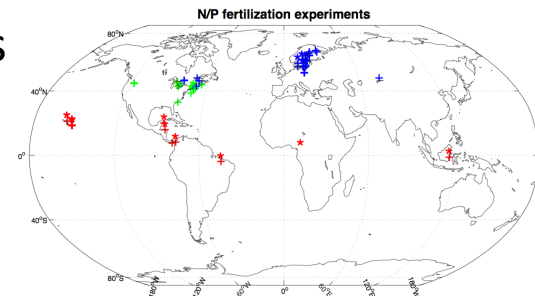
- **Unsettled science** for many components
- Serves as a foundation for initial development

ECA Kinetics and Multi-Nutrient Competition



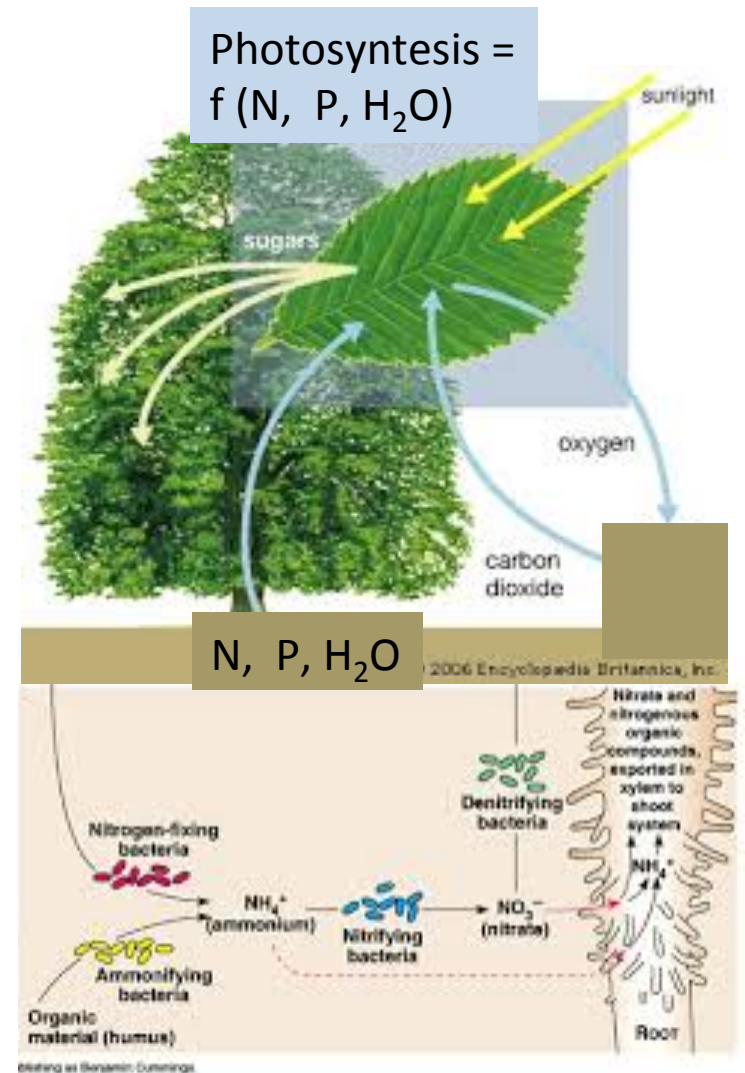
Zhu et al. (2015)

- ECA kinetics gave very accurate predictions of competition compared with tropical N & P manipulation experiments
- Comparison with >70 natural ecosystem fertilization experiments underway
 - Integration into ILAMB planned
- We have integrated these concepts into ALM for v1

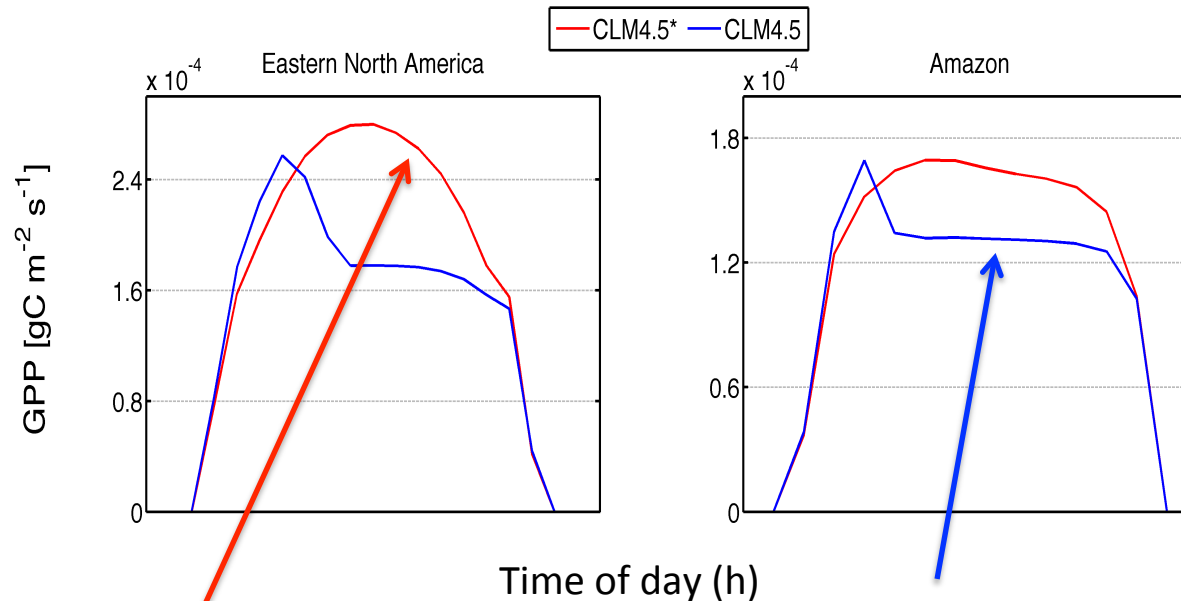


Integration in ALM of Leaf and Root Traits and Competition

- N uptake potential and affinity linked to root properties
- Competition with soil N consumers represented
- Leaf N dynamically predicted and affects photosynthesis



Impacts on Site-Level C Cycle



**Current unrealistic
nutrient controls on GPP**

ALM fixes to nutrient competition and leaf and root traits leads to conceptually realistic responses and better site to global predictions

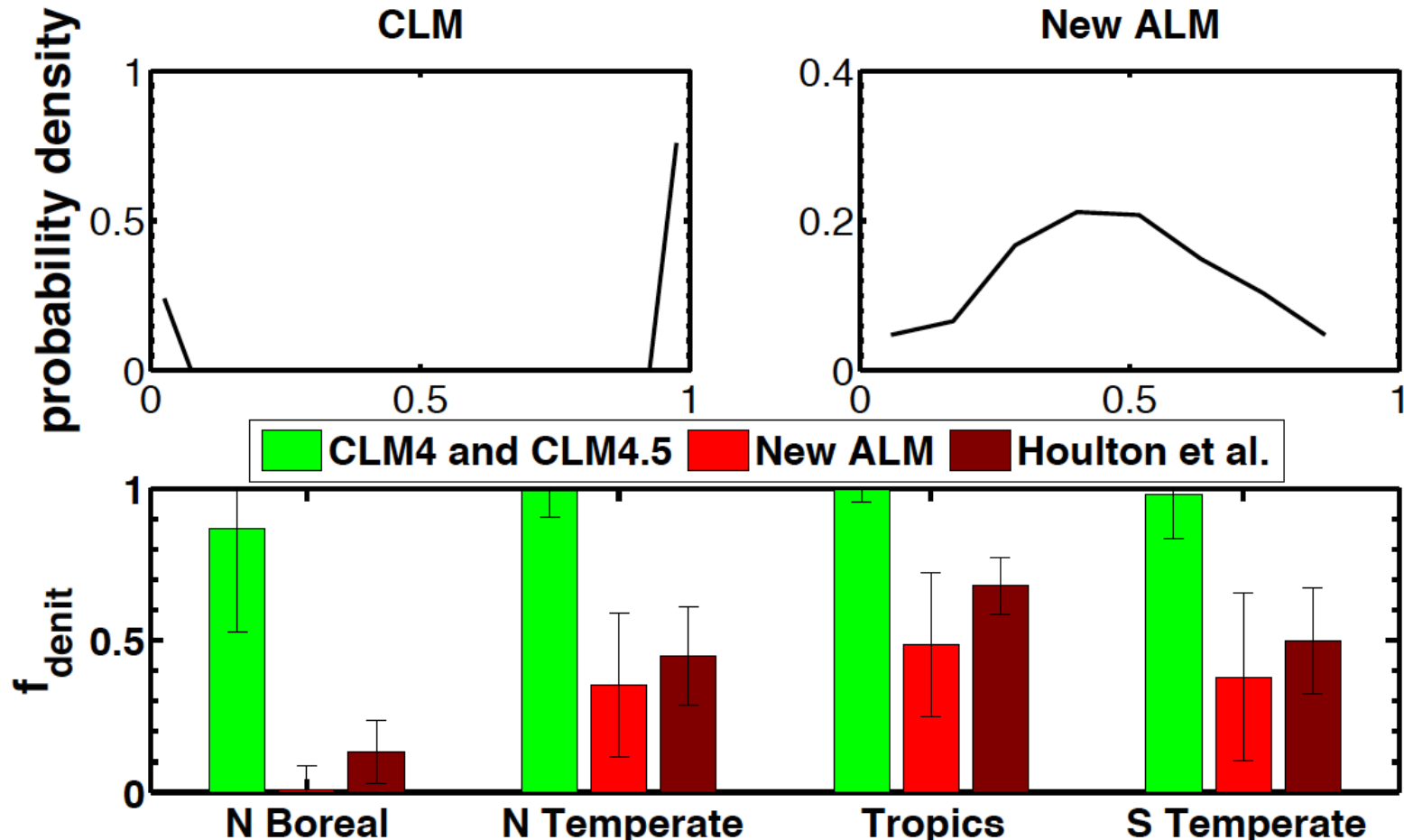
- 65% reduction in global GPP bias from CLM4.5
- Using ILAMB for broad investigation against observations

Representation of nitrogen in climate change forecasts

Benjamin Z. Houlton, Alison R. Marklein and Edith Bai

- Houlton et al. (2015; Nature Climate Change):
 - CLM4.0 and CLM4.5 (and therefore ALM) have very inaccurate estimates of Nitrogen losses
 - These errors affect
 - Terrestrial C cycle predictions
 - Nutrient competition relevant to ACME BGC Experiment

Global ALM Application of ECA Competition and Improved Transport



Conclusions

- ALM BGC Experiment will benefit from theoretically consistent and tested representations of nutrient controls on C dynamics
- ECA competition, root and leaf traits, and advection losses dramatically improve site and global predictions
 - Links with River BGC ongoing work at PNNL
- Code integration, testing, and analysis ongoing