Long Residence Times of Deep and Rapidly Decomposable SOM

Carbon Cycle Feedback Uncertainties

W.J. Riley[1], F.M. Maggi[2], M. Kleber[3], M.S. Torn[1], J.Y. Tang[1], D. Dwivedi[1], N. Guerry[2]

[1]Berkeley National Laboratory; [2]University of Sydney, [3]Oregon State University

MOTIVATION

- **Vertical structure and dynamics** of soil organic matter (SOM) decomposition in ESMs is critical for climate prediction
- **Large uncertainties exist** regarding how, and to what extent, relevant mechanisms should be included
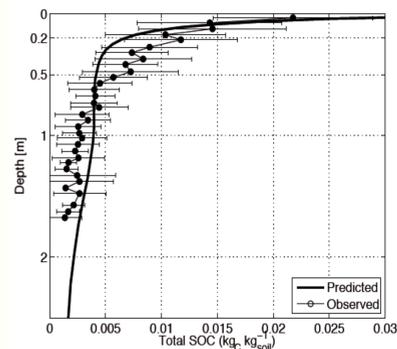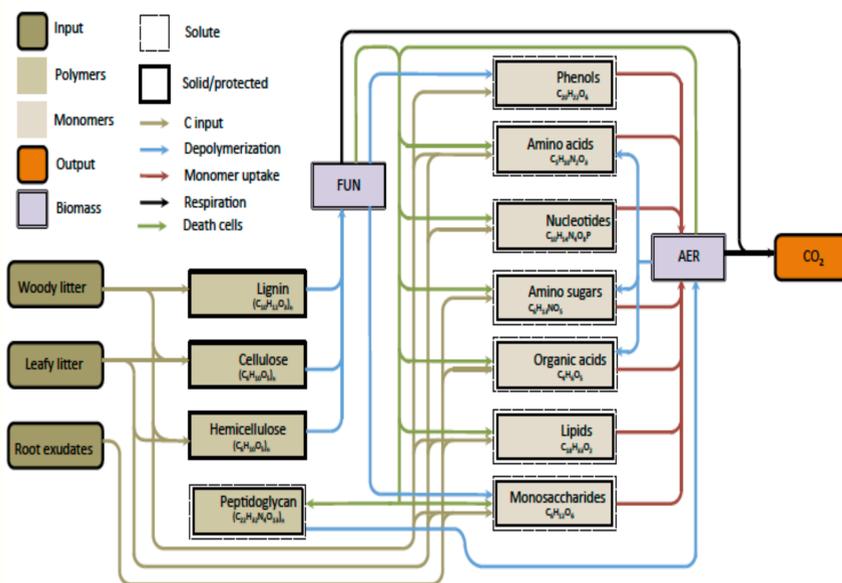

Predicted and observed total SOC profile for grasslands in the U.S. Midwest.

METHODS

Critical processes needed to model vertial SOM dynamics, and included in model:

- **Bacterial and fungal activity**
- **Polymeric and monomeric carbon substrates**
- **Aqueous chemistry**
- **Aqueous and gaseous transport**
- **Sorption**

- We used TOUGHREACT (Xu et al. (2008)) to solve the 1-Dimensional reactive transport problem with Michaelis-Menten kinetics:

$$\frac{\partial C_i}{\partial t} = -\frac{\partial}{\partial t}\left[D\frac{\partial C_i}{\partial z} + vC_i\right] + \sum_m S_m$$

$$\frac{dC_i}{dt} = -\mu_i \frac{C_i}{K_i + C_i} \frac{O_2}{K_{O_2} + O_2} \frac{B}{Y_i} f(\theta, pH, T)$$

RESULTS

- As with many SOM models, **the total SOM profile can be fit to observations**
- However, **our model also reproduces other observed metrics**, e.g., profiles of ^{14}C, fungi to bacteria ratio, lignin to cellulose ratio, and microbial necromass
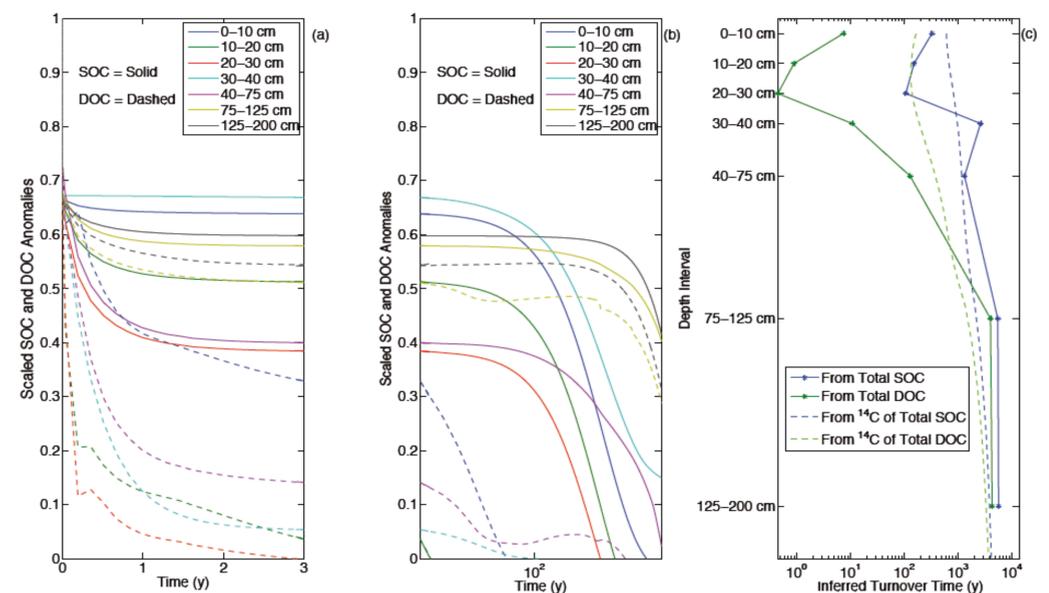
(a, b) Predicted time histories of total SOC and DOC anomalies resulting from a doubling of all compounds in the specified depth intervals. (c) Inferred first-order turnover times and ^{14}C ages.

SCIENCE IMPACT

- **A consistent representation of multiple microbial groups, sorption, protection, and aqueous transport can represent total SOC profiles, and other observable metrics of SOC dynamics**
- [14]C is an important and under utilized constraint.
- **Microbial cell wall material is an important and stable SOC constituent at depth**
- Interpretation of turnover times is complex in a multi-substrate, multi-consumer network with abiotic mechanisms
- We are currently integrating this network into **CLM4.5**