Soil Carbon and Nitrogen Mineralization with Flexible Soil and Microbial C:N Ratios

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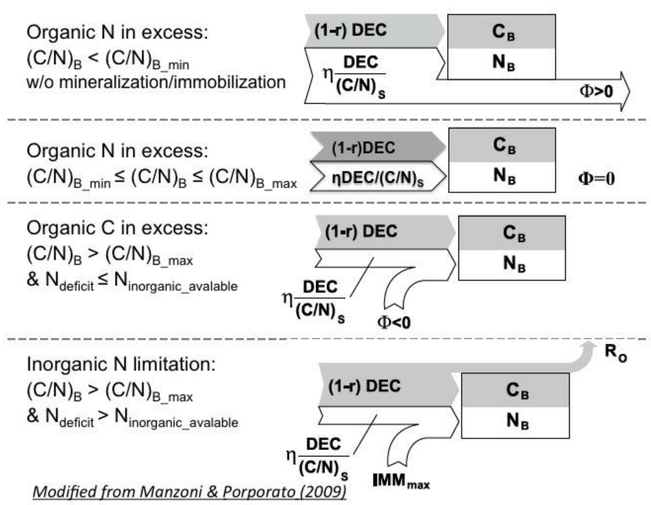
ABSTRACT

Microbial assimilation of carbon and nitrogen (C-N) and the physicochemical protection of soil organic matter (SOM) play fundamental roles in regulating land-atmosphere interactions. However, these microbial and physicochemical processes are not explicitly represented in current region/global terrestrial ecosystem models, e.g., the Community Land Model (CLM). The lack of explicit representation of microbial pools and functions results in unrealistic fixed C/N ratios in SOM pools currently in CLM. Thus current soil C-N model configuration is inadequate to model the effects of litter inputs or fertilization on soil carbon and nitrogen mineralization and linkages between plant litter C/N ratios and soil or microbial C/N ratios. We propose a coupled C-N model that allows for flexible C/N ratios in microbial and SOM pools and thus the ability to represent the decomposition response to fertilization and/or litter inputs with various C/N ratios. Our preliminary analysis has shown that the C/N ratios in SOM, dissolved organic matter (DOM), and microbial pools can be well constrained by the new C-N model and microbes regulate the C:N ratios in SOM and DOM pools. We will integrate this new microbial-enabled decomposition module into the land component of ACME model.

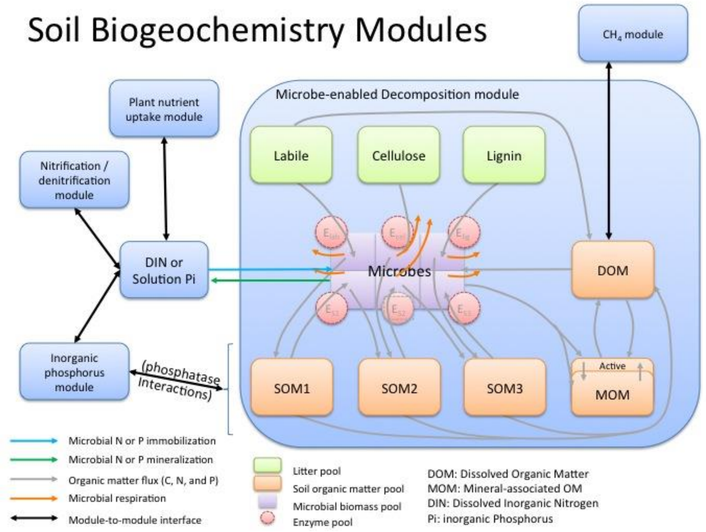
METHODS: N MINERALIZATION/IMMOBILIZATION

Assumptions:

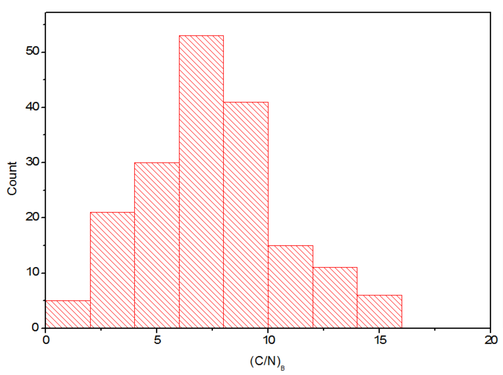
- A buffer may exist for microbial C/N ratio [$(C/N)_B$]. No nitrogen (N) mineralization/immobilization occurs (i.e., $\Phi = 0$) when the resulting $(C/N)_B$ is within this buffer, i.e., $(C/N)_{B\_min} \le (C/N)_B \le (C/N)_{B\_max}$.
- Carbon (C) overflow is employed under the condition of organic C in excess and inorganic N limitation.



METHODS: MICROBIAL-ENABLED MODEL



- Explicitly represent microbial biomass (MB) pools in the CLM-CN model.
- Each MB functional group is responsible for the decomposition and assimilation of a specific litter/SOM pool, and the resultant product of MB turnover enters a specific downstream SOM pool.
- The most downstream SOM pool is defined as the mineral-associated organic matter (MOM) pool including an active fraction interacting with DOM pool via adsorption and desorption processes.
- The labile litter pool and the SOM pools (SOM1,2,3) contribute to DOM depending on their solubility and soil water contents.
- Microbes compete with each other to uptake DOM.
- The above diagram also indicates the interfaces for other soil biogeochemistry modules (CH_4 and inorganic nutrients).



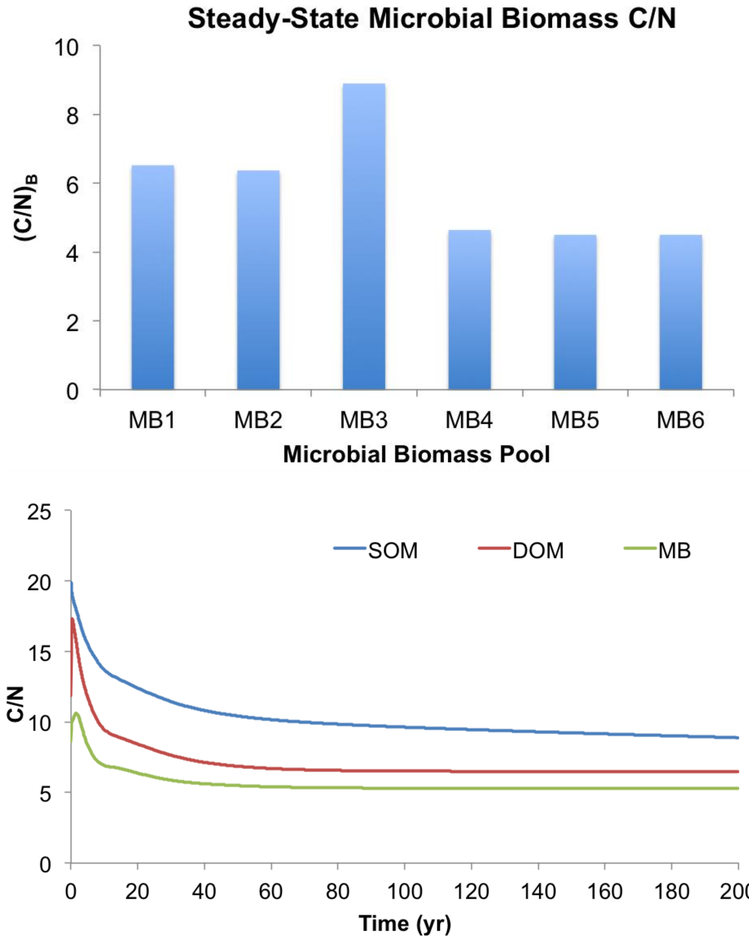
In model testing, we use

$(C/N)_{B\_min}$ = 4.5

$(C/N)_{B\_max}$ = 12.5

[*Wang et al. 2013; Xu et al. 2013*]

PRELIMINARY RESULTS



TAKE-HOME MESSAGE

- Observational data indicates that microbes can survive within a range of C/N, suggesting that flexible $(C/N)_B$ should be considered.
- The turnover of microbial biomass regulates the C/N ratios in SOM, which implies that fixed C/N for SOM is also unnecessary.
- Preliminary results show different steady-state C/N ratios in different microbial pools, which has been observed for different functional groups (e.g., bacteria and fungi).
- The module is being incorporating into the CLM-PFLOTRAN coupled system.
- Further development and testing of the model will be conducted and model parameterization will be investigated.

ACKNOWLEDGEMENTS: The work is funded through the US DOE's Regional & Global Climate Modeling and Terrestrial Ecosystem Science Programs. ORNL is managed by the University of Tennessee-Battelle, LLC, under contract DE-AC05-00OR22725 with the US DOE.