Modeling nitrogen and phosphorus cycles and their impacts on the carbon cycle

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C only model

- Rate limiting steps
  - Photosynthesis
  - Plant respiration
  - Tissue longevity
  - SOM decomposition
CN only model

- Rate limiting steps
  - Photosynthesis (N)
  - Plant respiration (N)
  - Tissue longevity (N)
  - SOM decomposition (N)

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Manzoni 2010

McCormack 2015
CNP model

- Rate limiting steps
  - Photosynthesis (N,P)
  - Plant respiration (N,P)
  - SOM decomposition (N,P)

Manzoni 2010

Reich 2009

Wang 2015
How do we couple N and P cycles to C cycle in the model?
Coupling philosophy

- Stoichiometry coupling
  - Fixed CNP stoichiometry
  - Instantaneous down-regulation of photosynthesis
  - Demand based Nutrient uptake

<table>
<thead>
<tr>
<th></th>
<th>$^{15}$N turnover (mg N m$^{-2}$ day$^{-1}$)</th>
<th>$^{15}$N uptake (mg N m$^{-2}$ day$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Production</td>
<td>Consumption</td>
</tr>
<tr>
<td>November</td>
<td>954 ± 114</td>
<td>1,364 ± 166</td>
</tr>
<tr>
<td>April</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>July</td>
<td>37 ± 32</td>
<td>0 ± 0</td>
</tr>
</tbody>
</table>

Miller 2009

Ghimire 2014
Coupling philosophy

- Functional coupling
  - Flexible CNP stoichiometry
  - Functional down-regulation of photosynthesis
  - Competition based Nutrient uptake

Walker et al., 2014
Zhu et al., 2016
Zhu et al., in prep
ACME land model (ALMv1-ECA-CNP)

Overview

- C/N/P uptake
- Resources allocation
- Growth and turnover
Research question

How does the model perform at global scale?
Benchmark

Zhu et al., in prep
Benchmark

LAI (m² leaf m⁻² ground area)

**ALMv1–CNP–ECA**

**ALMv0 bias**

Crop

C4

Non-Arc C3 grass

Arc C3 grass

BDS

Tem BDS

Tem BES

BDT

Tem BDT

Bor BDT

Bor BET

Tem BET

Tro BET

Tem Tro

Bor NDT

Bor NET

Tem NET

Arc C3 grass

C4

Non-Arc C3 grass

Arc C3 grass

Crop

LAI (m² leaf m⁻² ground area)

**ALMv1–CNP–ECA**

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Non-Arc C3 grass

Arc C3 grass

BDS

Tem BDS

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BDT

Tem BDT

Bor BDT

Bor BET

Tem BET

Tro BET

Tem Tro

Bor NDT

Bor NET

Tem NET

Arc C3 grass

C4

Non-Arc C3 grass

Arc C3 grass

Crop
Benchmark

Soil Carbon top 1 m (Pg)
THANKS!

QUESTIONS?