Crops & Plants in CLM5

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CLM N Cycle & Crop Model Development Teams
N'Assumptions in CLM5.0''

1. Leaf nitrogen content is *dynamic* & *related* to stomatal conductance

2. Photosynthetic capacity *does* respond to the environment

3. Plants *pay* C to get N'
Simulations: CLM5 Historical (1850-2010)

atmosphere:

GSWP

3

1) CLM4.5’N’
   "2)+’FlexCN’&’LUNA’’’’’’3’)+’FUN!”
Leaf Area Index ($\Delta m^2 m^{-2}$)

FlexCN + LUNA Effect

(FlexCN&Luna - CLM4.5 N)
Leaf Area Index ($\triangle m^2 m^{-2}$)

FlexCN + LUNA Effect
(FlexCN&Luna - CLM4.5 N)

2005
2005

Leaf Area Index ($\Delta m^2 m^{-2}$)

**FlexCN + LUNA Effect**
(FlexCN&Luna - CLM4.5 N)

**FUN Effect**
(CLMA5 All N - FlexCN&Luna)
Leaf Area Index ($\Delta m^2 m^{-2}$)

### FlexCN + LUNA Effect
*(FlexCN&Luna - CLM4.5 N)*

### FUN Effect
*(CLM5 All N - FlexCN&Luna)*

### CLM5 N Effect
*(CLM5 All N - CLM4.5 N)*
Leaf C/N (Δ)

FlexCN + LUNA Effect
(FlexCN&Luna - CLM4.5 N)
Leaf C/N (Δ)

FlexCN + LUNA Effect
(FlexCN&Luna - CLM4.5 N)

FUN Effect
(CLМ5 All N - FlexCN&Luna)
Leaf C/N (Δ)

FlexCN + LUNA Effect
(FlexCN&Luna - CLM4.5 N)

FUN Effect
(CLMS All N - FlexCN&Luna)
Global GPP (kg m\(^{-2}\) yr\(^{-1}\))

- CLM5 N (LUNA, FlexCN, FUN)
- LUNA & FlexCN (no FUN)
- CLM4.5 N
Global GPP (kg m\(^{-2}\) yr\(^{-1}\))

- CLM5 N (LUNA, FlexCN, FUN)
- LUNA & FlexCN (no FUN)
- CLM4.5 N
Global GPP (kg m$^{-2}$ yr$^{-1}$)

- CLM5 N (LUNA, FlexCN, FUN)
- LUNA & FlexCN (no FUN)
- CLM4.5 N
Natural Vegetation

**FlexCN & LUNA:**
- Generally increase LAI
- Increases C/N
- Increases Broadleaf Evergreen GPP

**FUN:**
- Generally small changes in LAI (except C3 Crop)
- Decreases C/N
- Lower Broadleaf Deciduous GPP (compared to FlexCN & LUNA)

**CLM5 N:**
- Very small changes in C/N
- Increases LAI
- Increases GPP (except C3 Grasses and BL Temperate & Boreal Trees)
Natural Vegetation

Variability in GPP among PFT responses

C3 Crops have intriguingly strong responses (to both FUN, and FlexCN & Luna)
* Temperate and tropical varieties
# New in CLM5-Crop

<table>
<thead>
<tr>
<th>Nitrogen</th>
<th>FUN &amp; FlexCN (no LUNA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop Types</td>
<td>Added Tropical Crops</td>
</tr>
<tr>
<td></td>
<td>(corn, soy)</td>
</tr>
<tr>
<td>Grain Harvest</td>
<td>Harvested Grain is Removed</td>
</tr>
</tbody>
</table>
Crop Management in CLM5
Crop GPP in 2000

*Chen et al. 2014 Biogeosciences*
Crop GPP in 2000

Global GPP (Pg & C) & (Pg & C)

<table>
<thead>
<tr>
<th>Crop Type</th>
<th>CLM5 (no new N)</th>
<th>Satellite Obs*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperate Corn</td>
<td>1.75</td>
<td>1.60</td>
</tr>
<tr>
<td>Temperate Soy</td>
<td>0.75</td>
<td>0.65</td>
</tr>
<tr>
<td>Temperate Corn</td>
<td>1.75</td>
<td>1.60</td>
</tr>
<tr>
<td>Temperate Soy</td>
<td>0.75</td>
<td>0.65</td>
</tr>
<tr>
<td>Spring Wheat</td>
<td>2.00</td>
<td>1.85</td>
</tr>
<tr>
<td>Rice</td>
<td>1.50</td>
<td>1.40</td>
</tr>
<tr>
<td>Cotton</td>
<td>0.50</td>
<td>0.40</td>
</tr>
<tr>
<td>Sugarcane</td>
<td>0.25</td>
<td>0.20</td>
</tr>
</tbody>
</table>

*Chen et al. 2014 Biogeosciences
Simulations: CLM5 1850

atmosphere:

GSWP

3

1) CLM4.5'N'  2)+'FlexCN'&'LUNA'  3)+'FUN!'
FlexCN Effect
(FlexCN&Luna - CLM4.5 N)

Crop GPP ($\Delta$ g C m$^{-2}$ yr$^{-1}$)

1850 Simulation

Spring Wheat

Tropical Corn
Crop GPP ($\Delta \text{g C m}^{-2} \text{yr}^{-1}$)

FlexCN Effect
(FlexCN&Luna - CLM4.5 N)

FUN Effect
(CLMS All N - FlexCN&Luna)
1850 Simulation

FlexCN Effect
(FlexCN&Luna - CLM4.5 N)

FUN Effect
(CLIM5 All N - FlexCN&Luna)

CLM5 N Effect
(CLIM5 All N - CLM4.5 N)

Crop GPP ($\Delta$ g C m$^{-2}$ yr$^{-1}$)
FlexCN Effect
(FlexCN&Luna - CLM4.5 N)

Crop Yield ($\Delta \ g \ C \ m^{-2}$)

Spring Wheat

Tropical Corn

1850 Simulation
1850 Simulations

FlexCN Effect
(FlexCN&Luna - CLM4.5 N)

FUN Effect
(CLMS All N - FlexCN&Luna)

Crop Yield ($\Delta g C m^{-2}$)

Spring Wheat

Tropical Corn

-120 -60 0 60 120

-120 -60 0 60 120

CONSTANT FIELD - VALUE IS 0

120 60 0 -60 -120

120 60 0 -60 -120
Crop Yield \((\Delta g \text{ C m}^{-2})\)

**CLM5 N Effect**  
(CL5 All N - CLM4.5 N)

**FlexCN Effect**  
(FlexCN&Luna - CLM4.5 N)

**FUN Effect**  
(CL5 All N - FlexCN&Luna)

**CLM5 N Effect**  
(CL5 All N - CLM4.5 N)
CLM5-Crop

Over-predicts corn & wheat yields in 2000
- in part due to fertilizer application

Decreases GPP and Yields in 1850
- Primarily due to FlexCN
- FUN only on for temperate corn, soy, & wheat
CLM4.5-Crop: Grain is harvested, but not removed
CLM4.5: Leave grain on the ground to decompose as litter

CLM5: Remove grain, and C and N release to atmosphere over 1 year

* All simulations run using the CLM4.5 code base, changing only grain removal
Grain Harvest

- Decreases available nutrients
- Decreases productivity and yield
- Does not change biogeophysical processes
CLM5

Natural Vegetation is sensitive to new N, though effect varies by plant type. GPP and LAI generally increase.

Crops decrease due to FlexCN; FUN needs to be investigated.

Harvesting grain decreases yield due to N limitation.