

Crops & Plants in CLM5



Danica Lombardozzi
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



2005

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

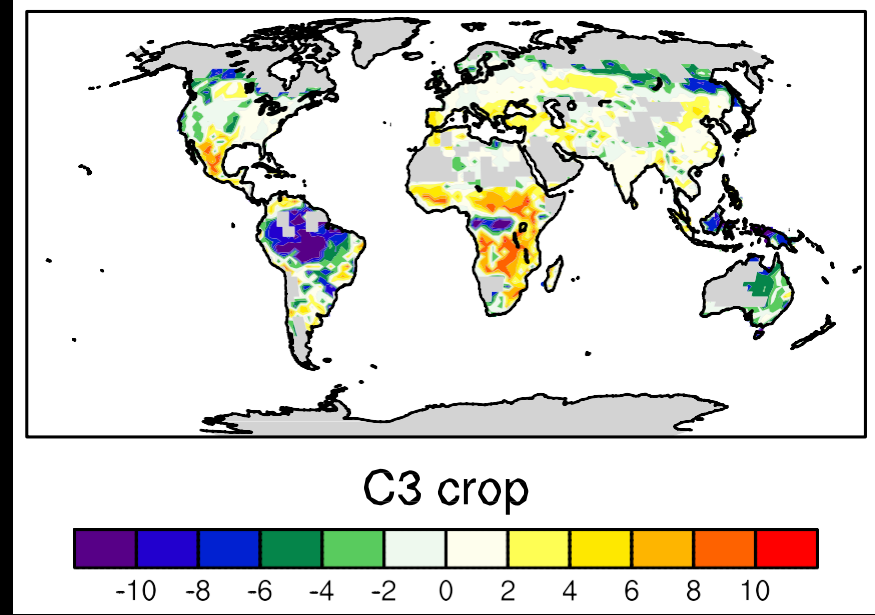
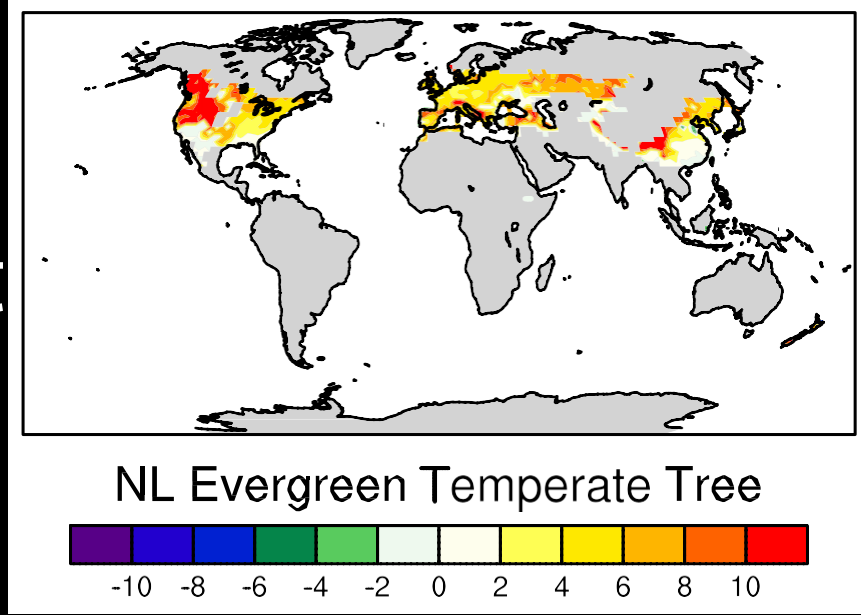
FlexCN + LUNA Effect

(FlexCN&Luna - CLM4.5 N)

2005

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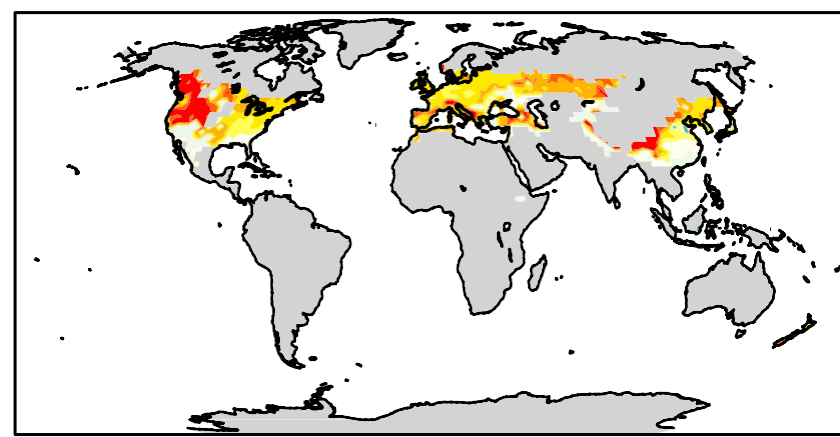


2005

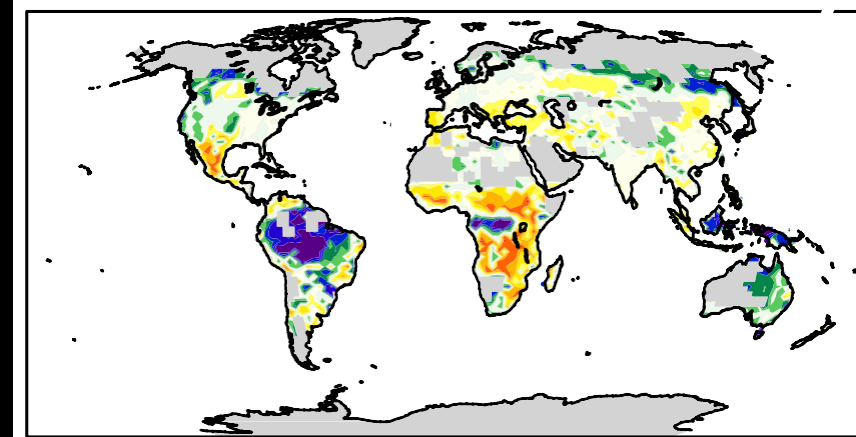
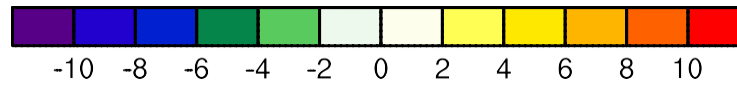
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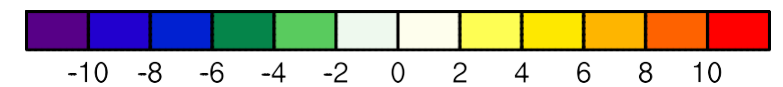
(FlexCN&Luna - CLM4.5 N)



NL Evergreen Temperate Tree

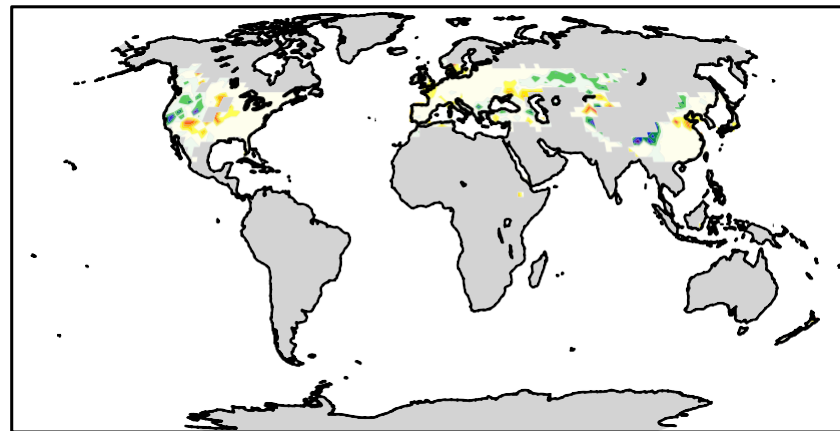


C3 crop

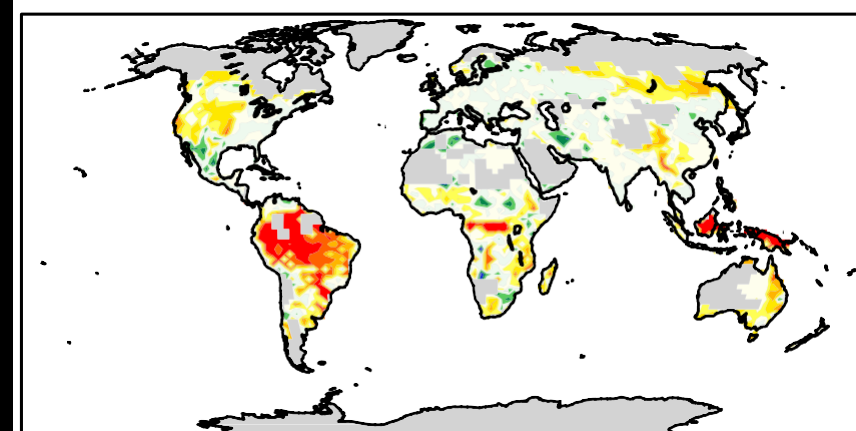
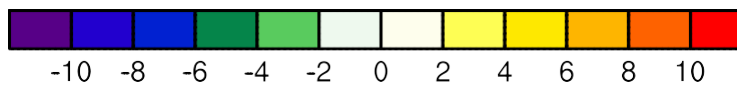


FUN Effect

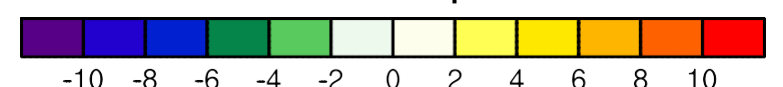
(CLM5 All N - FlexCN&Luna)



NL Evergreen Temperate Tree



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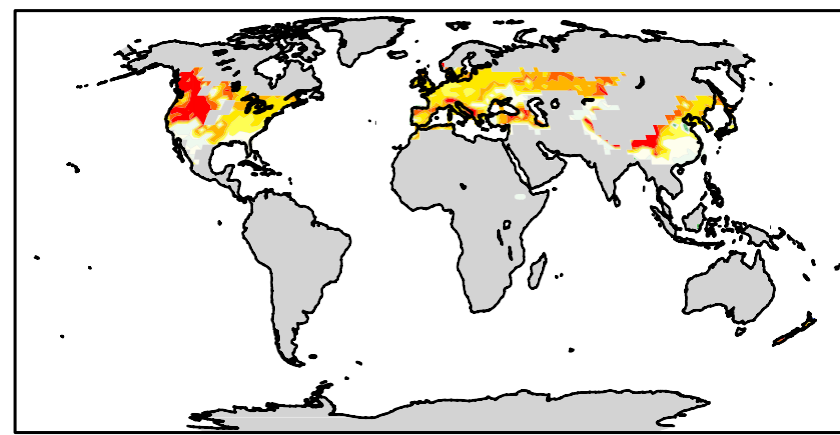


2005

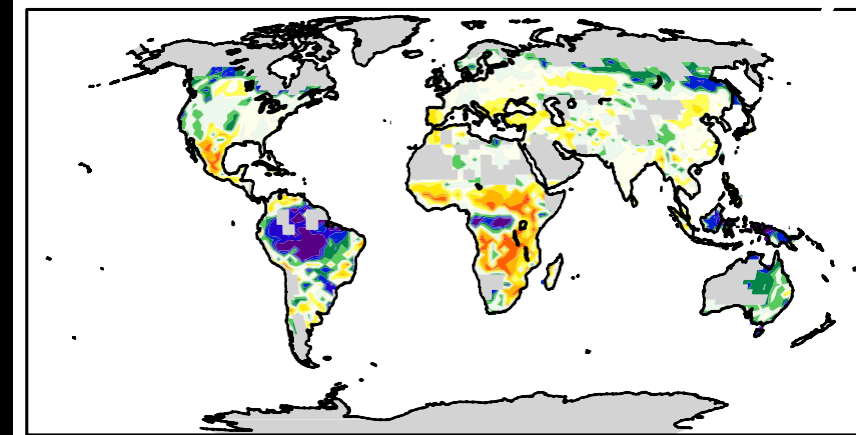
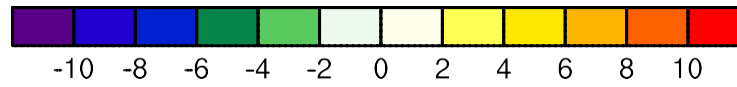
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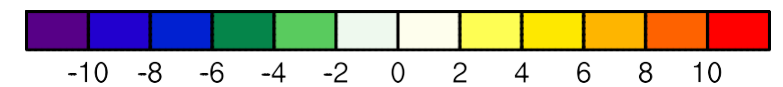
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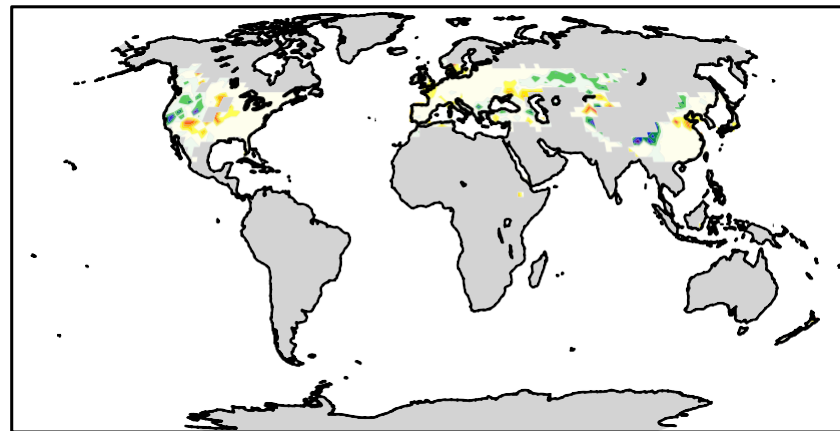


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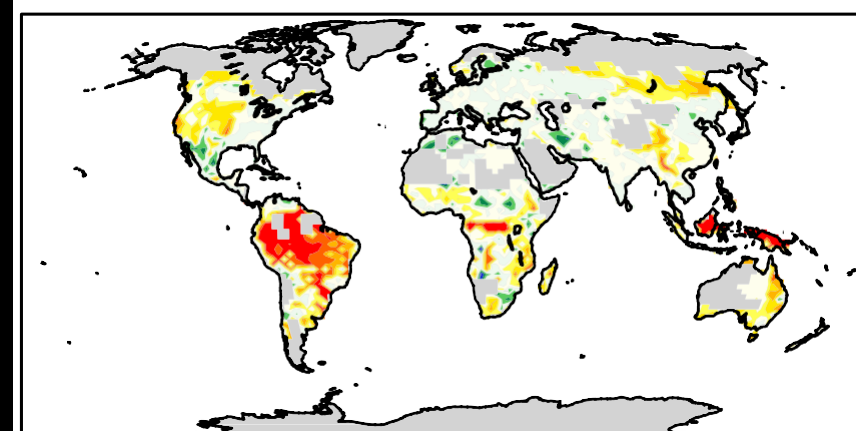
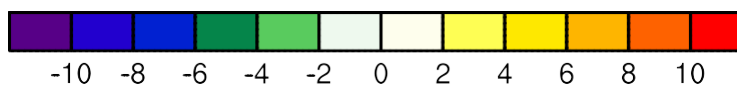


FUN Effect

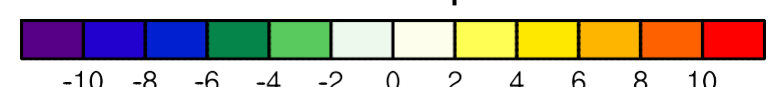
(CLM5 All N - FlexCN&Luna)



NL Evergreen Temperate Tree

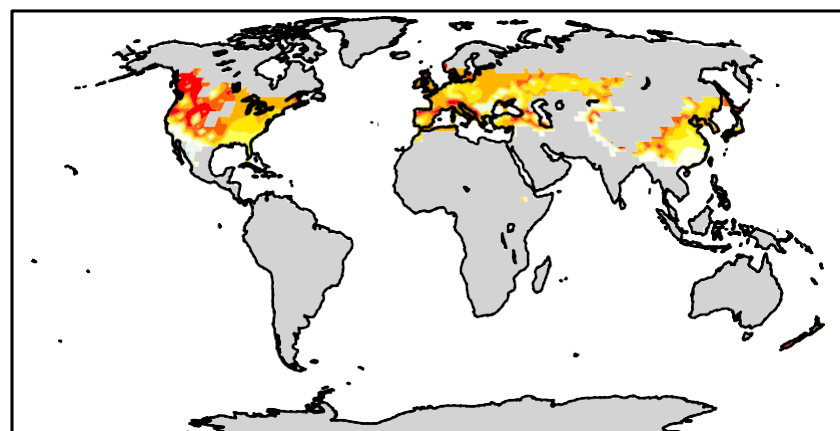


C3 crop

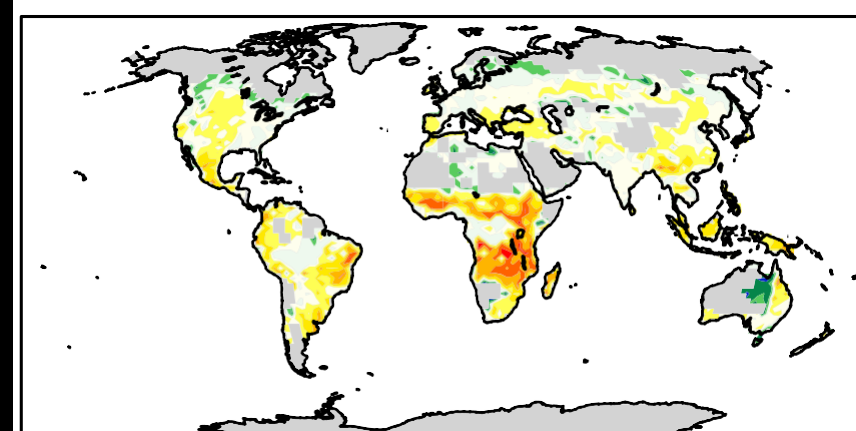
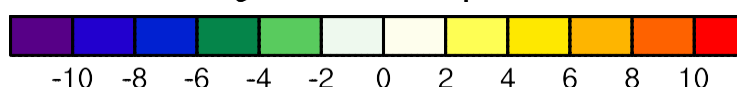


CLM5 N Effect

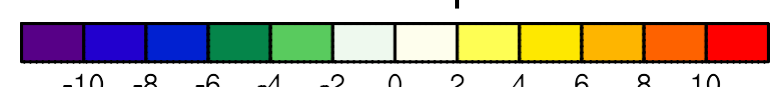
(CLM5 All N - CLM4.5 N)



NL Evergreen Temperate Tree



C3 crop

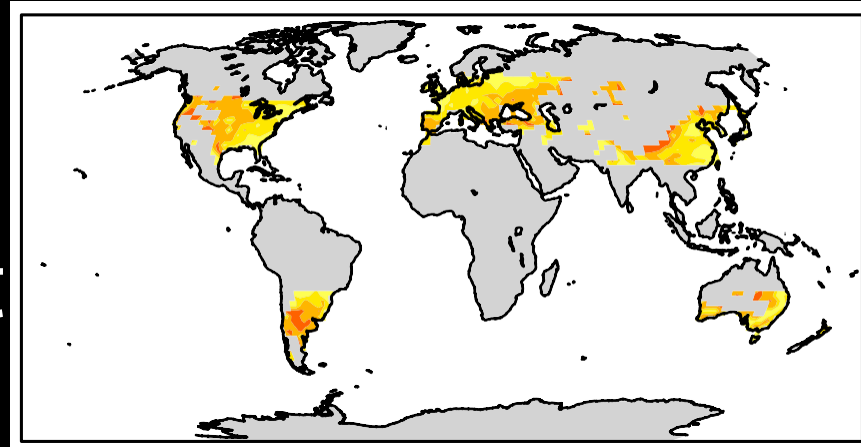


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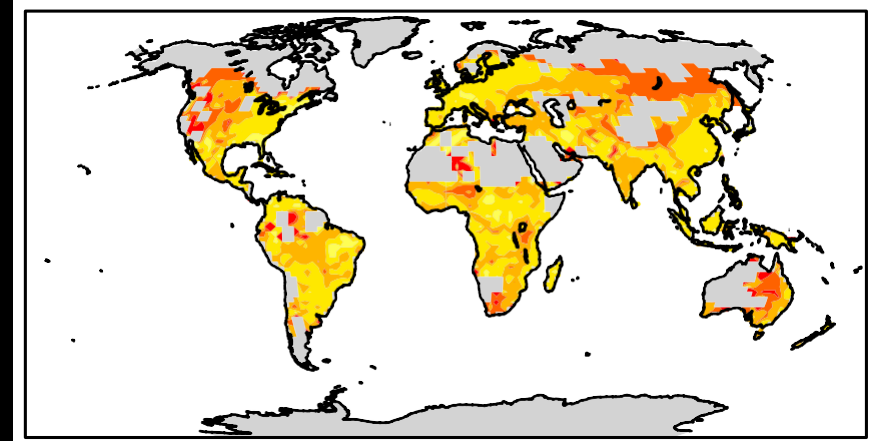
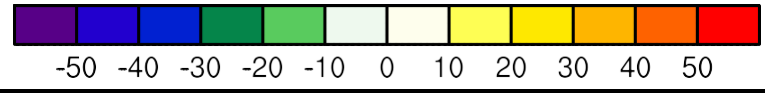
Leaf C/N (Δ)

FlexCN + LUNA Effect

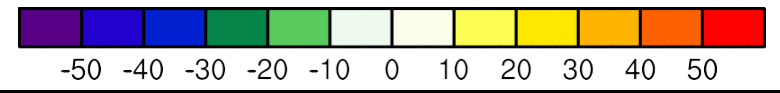
(FlexCN&Luna - CLM4.5 N)



BL Deciduous Temperate Tree



C3 crop

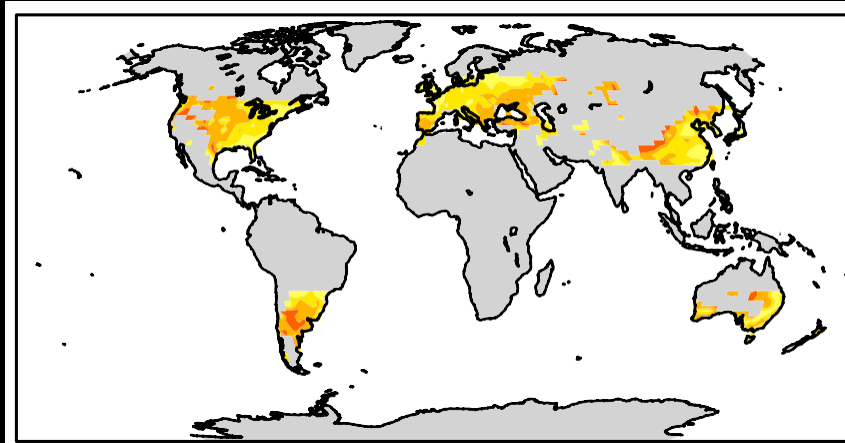


2005

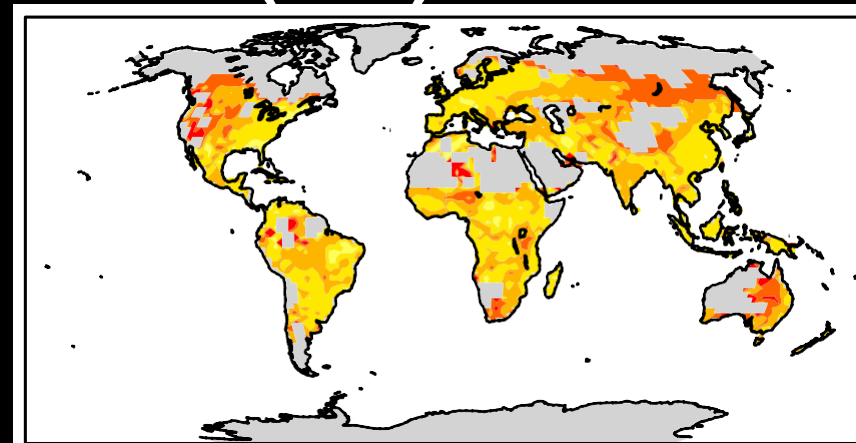
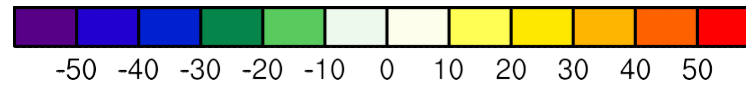
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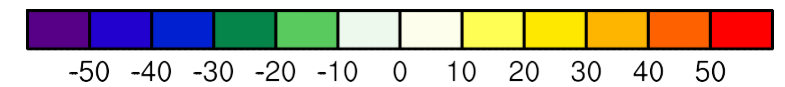
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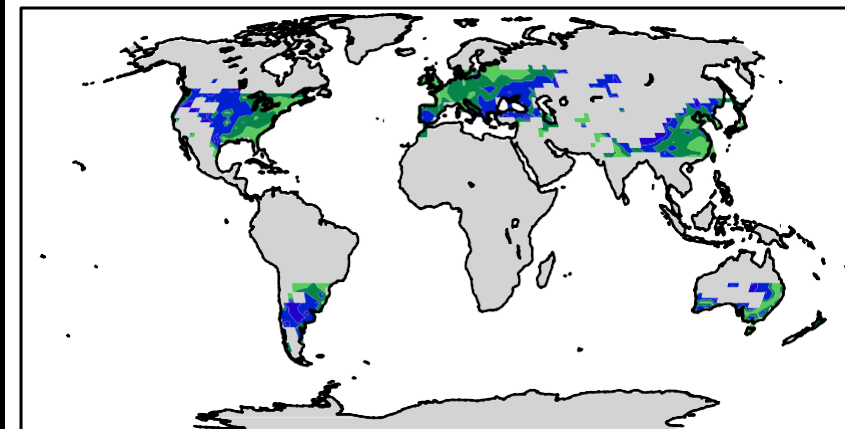


C3 crop

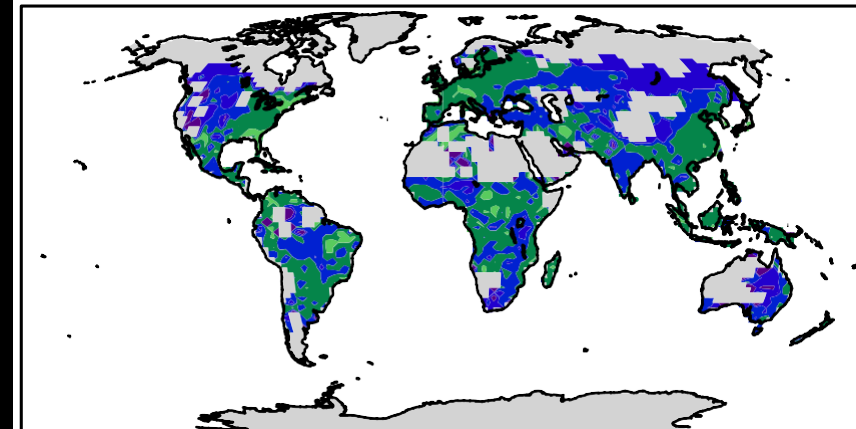
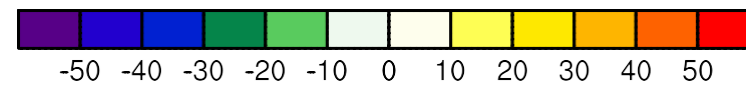


FUN Effect

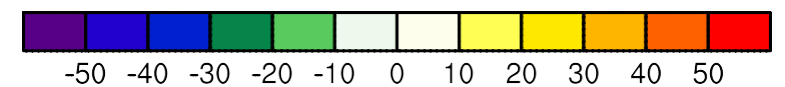
(CLM5 All N - FlexCN&Luna)



BL Deciduous Temperate Tree



C3 crop

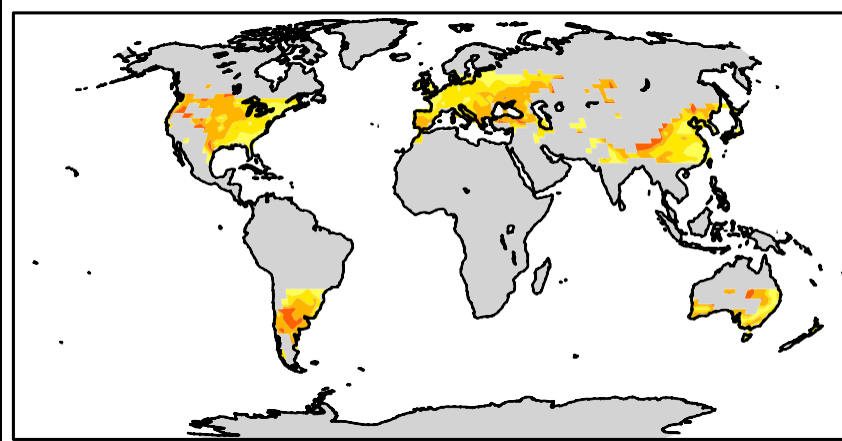


2005

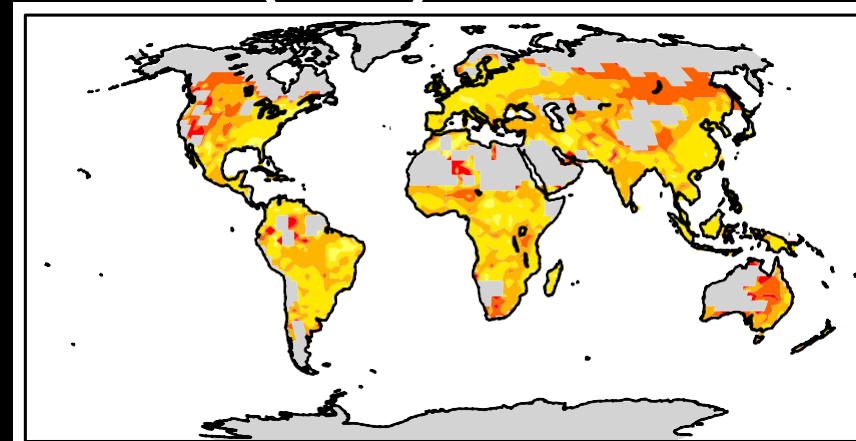
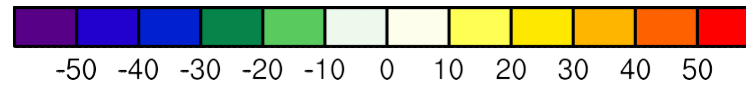
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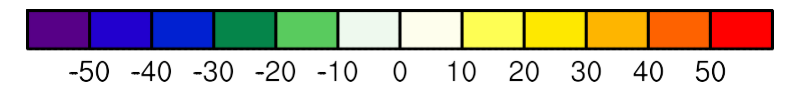
(FlexCN&Luna - CLM4.5 N)



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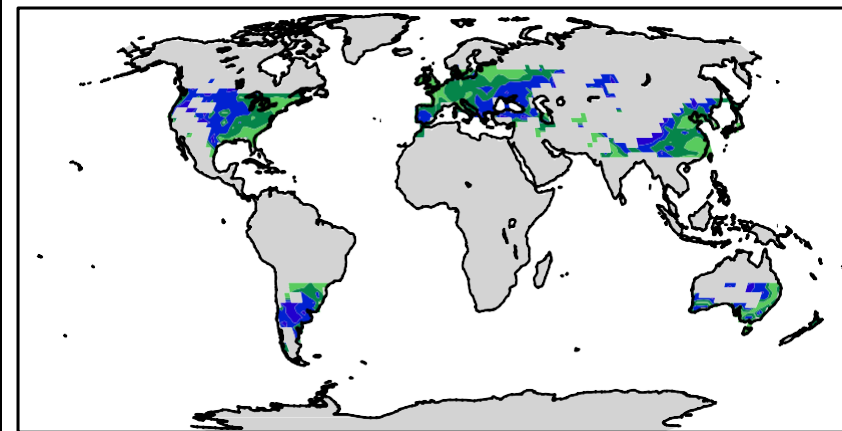


C3 crop

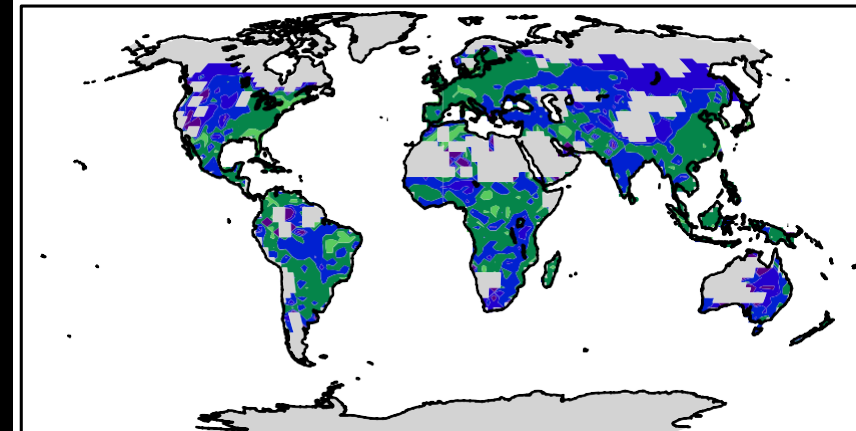
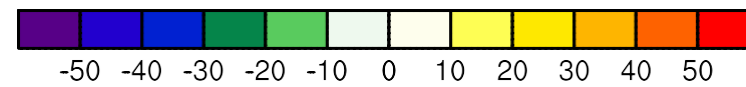


FUN Effect

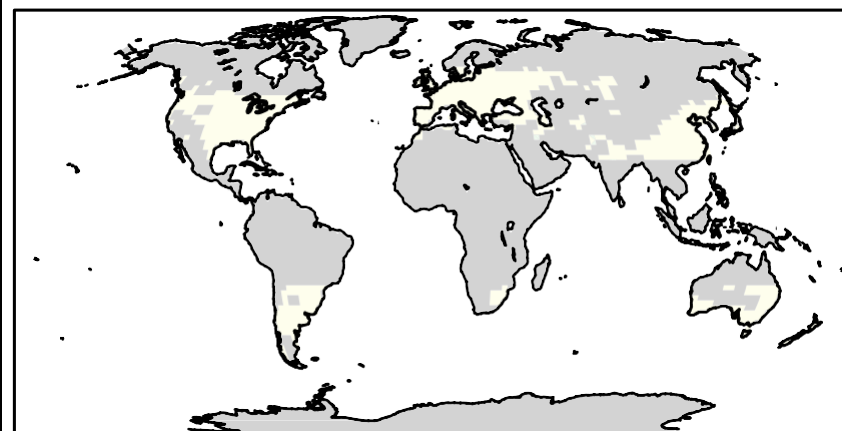
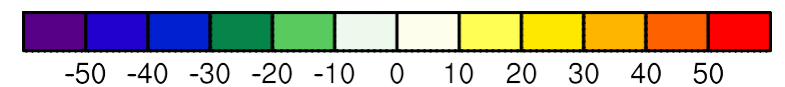
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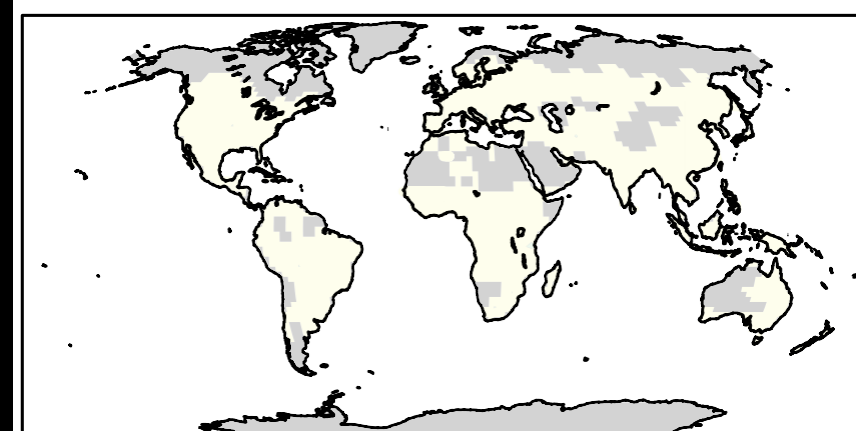
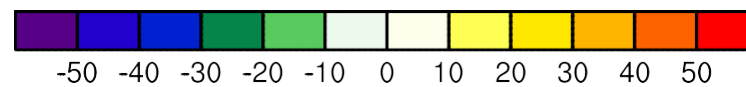
BL Deciduous Temperate Tree



C3 crop



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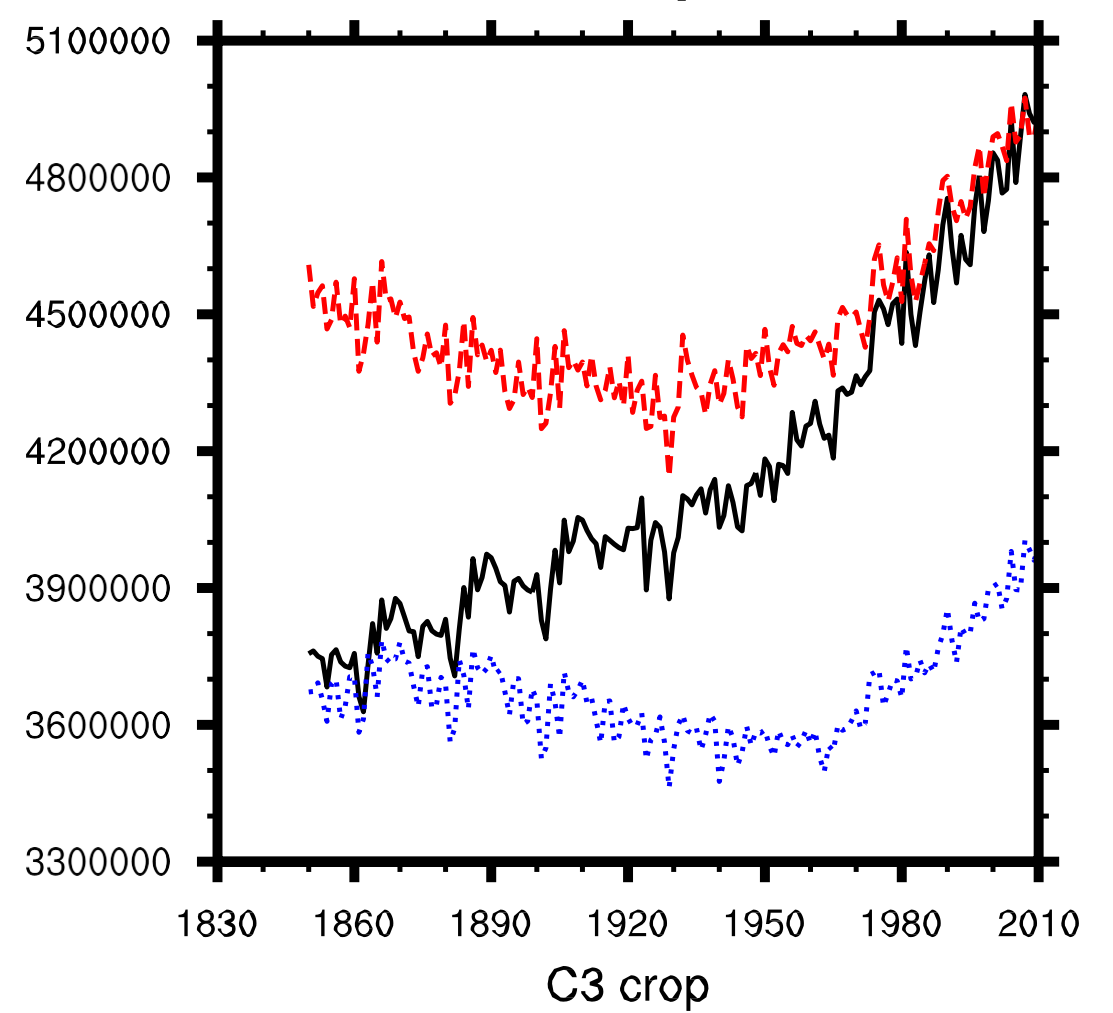


C3 crop



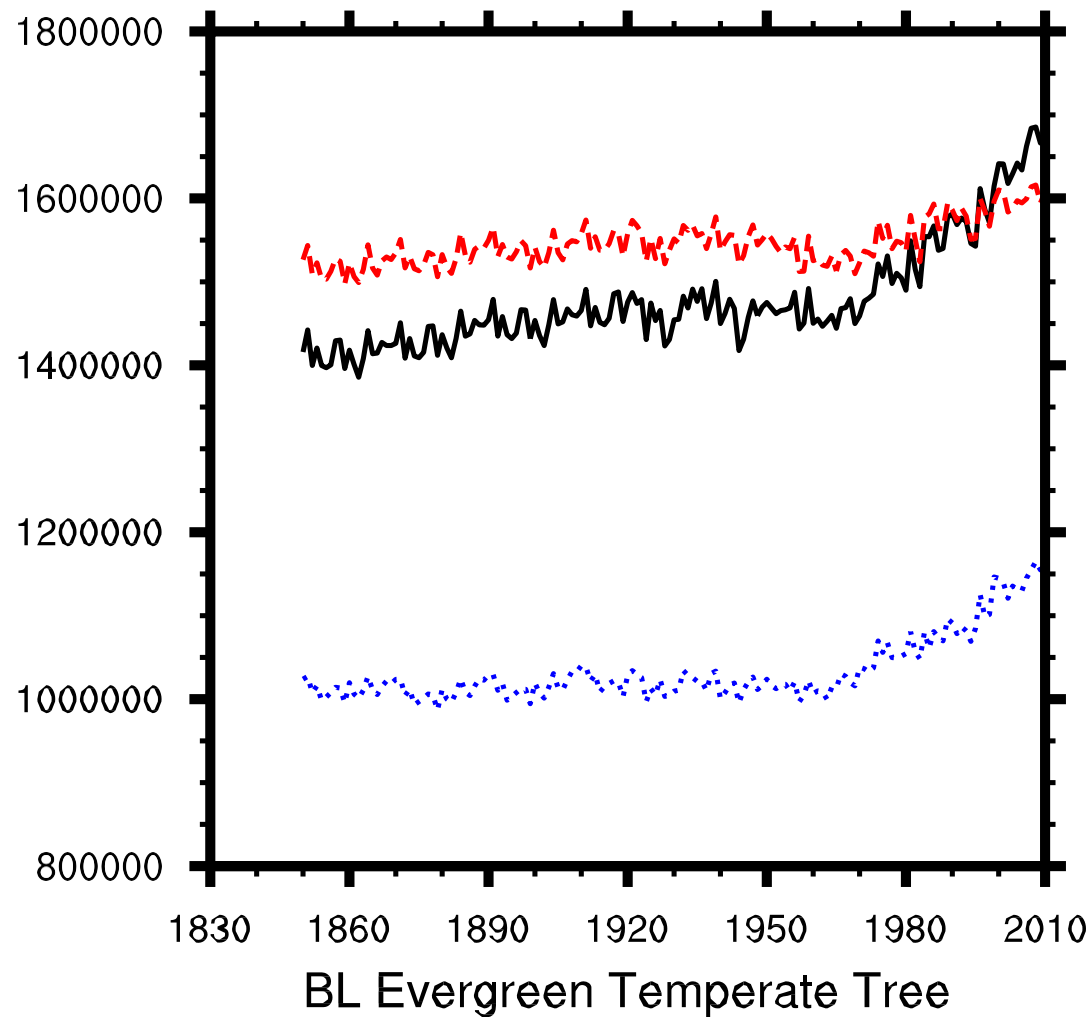
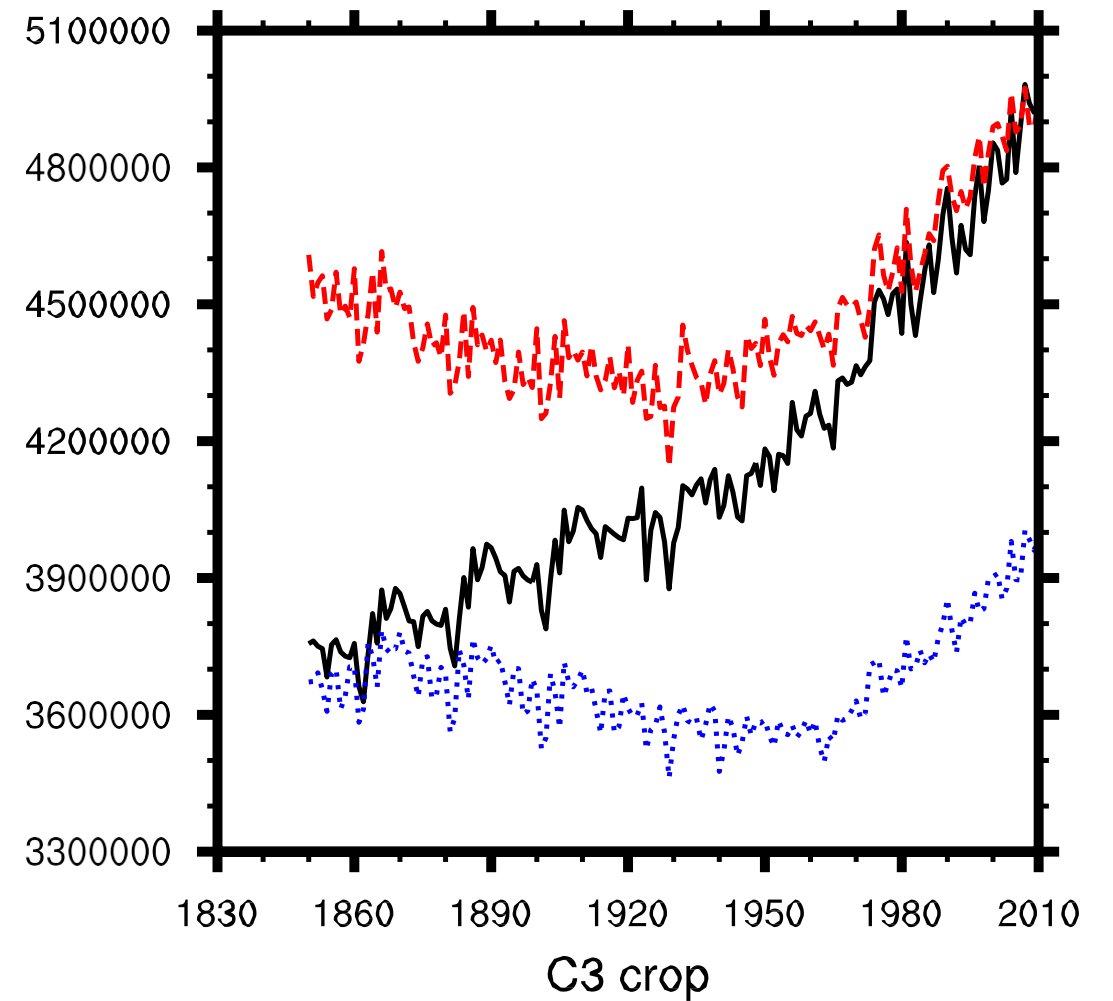
Global GPP (kg m⁻² yr⁻¹)

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



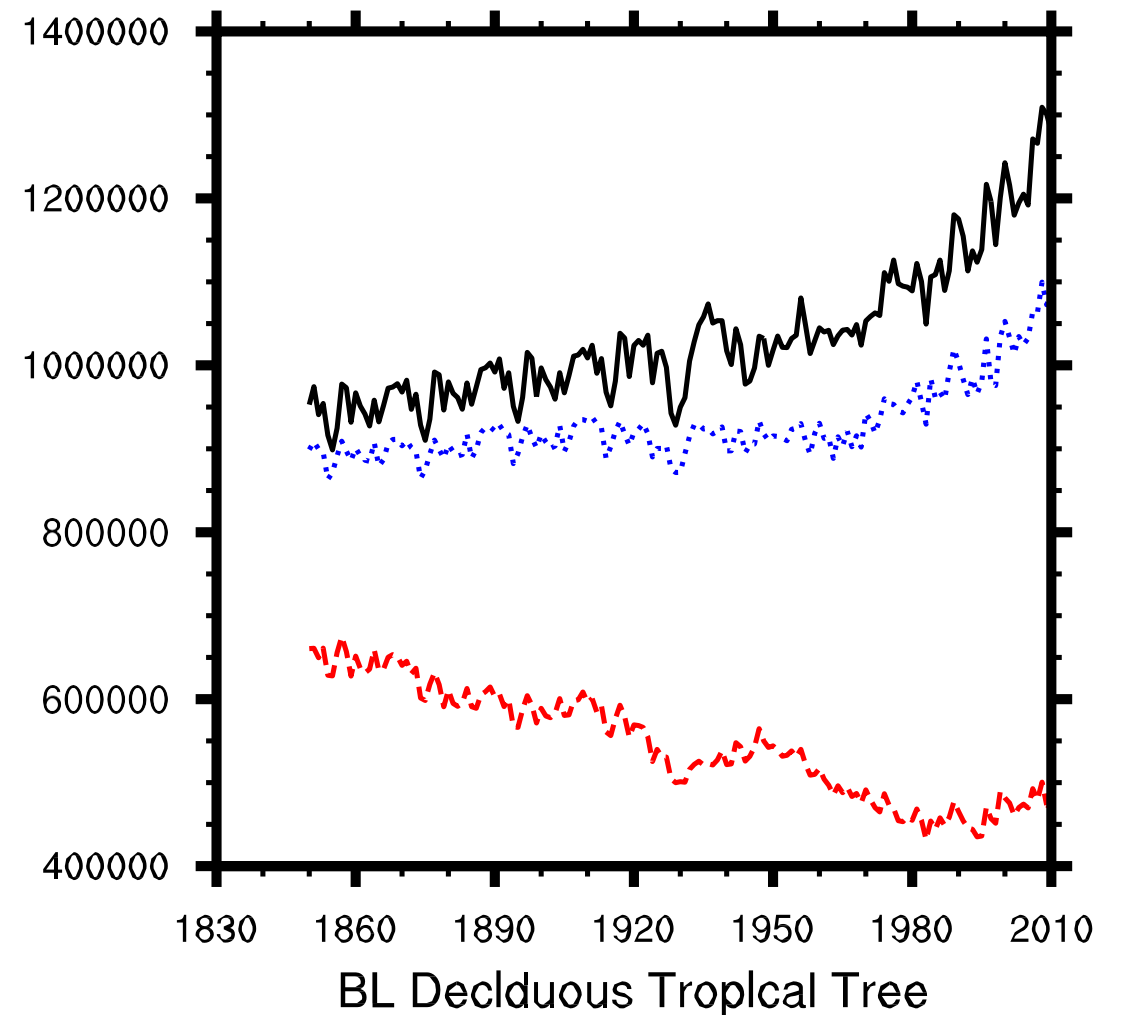
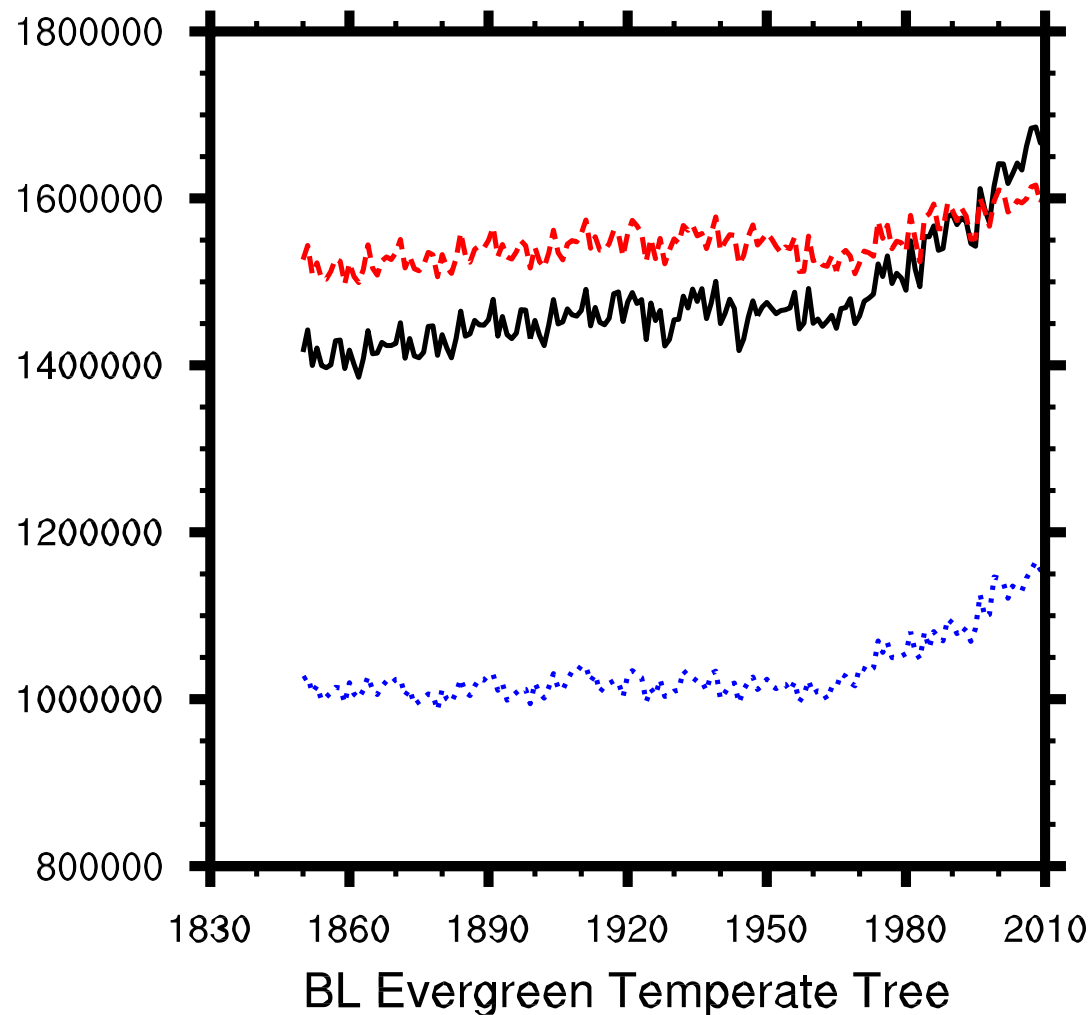
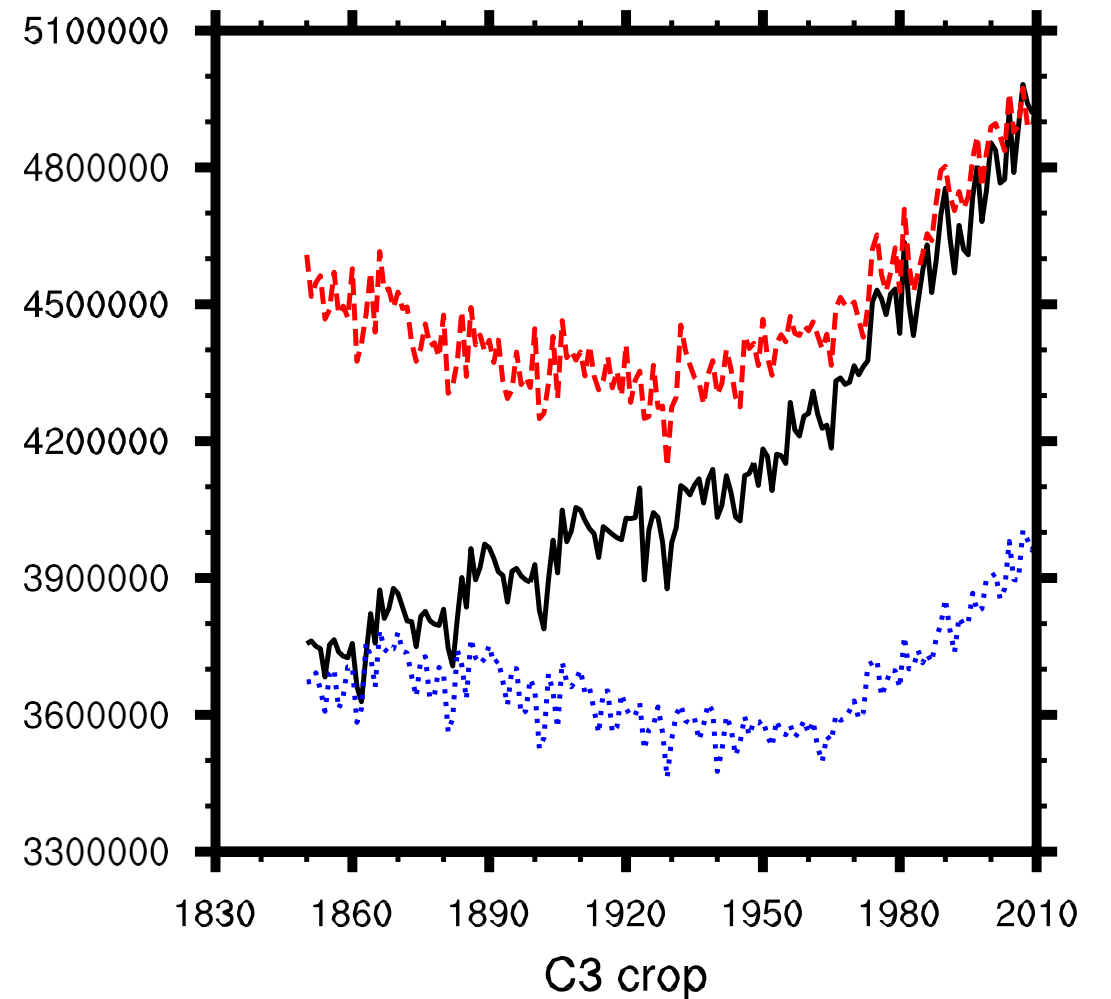
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Global GPP (kg m⁻² yr⁻¹)

- 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)



CLM5-Crop

Corn*



Whea



Sugarcane



Soy

*

Cotton

Rice

* *Temperate and tropical varieties*

New in CLM5-Crop

Nitrogen	FUN & FlexCN (no LUNA)
Crop Types	Added Tropical Crops (corn, soy)
Grain Harvest	Harvested Grain is Removed

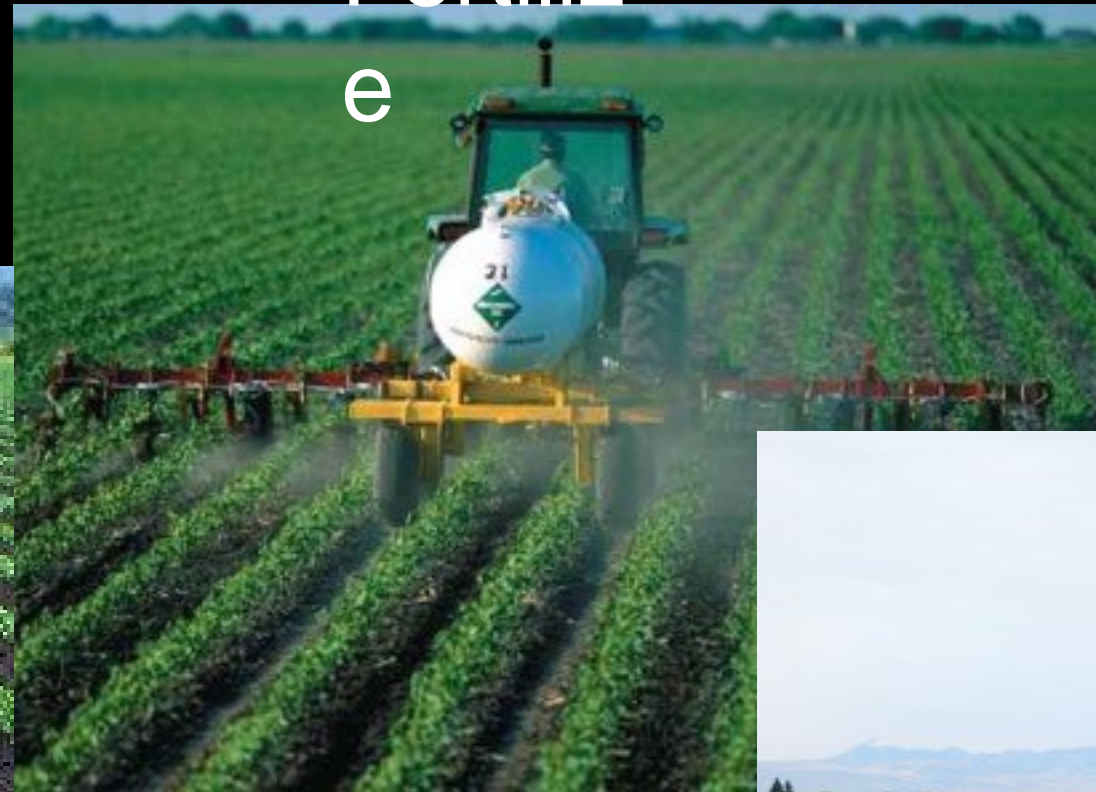
Crop Management in CLM5

Plan



Fertiliz

e

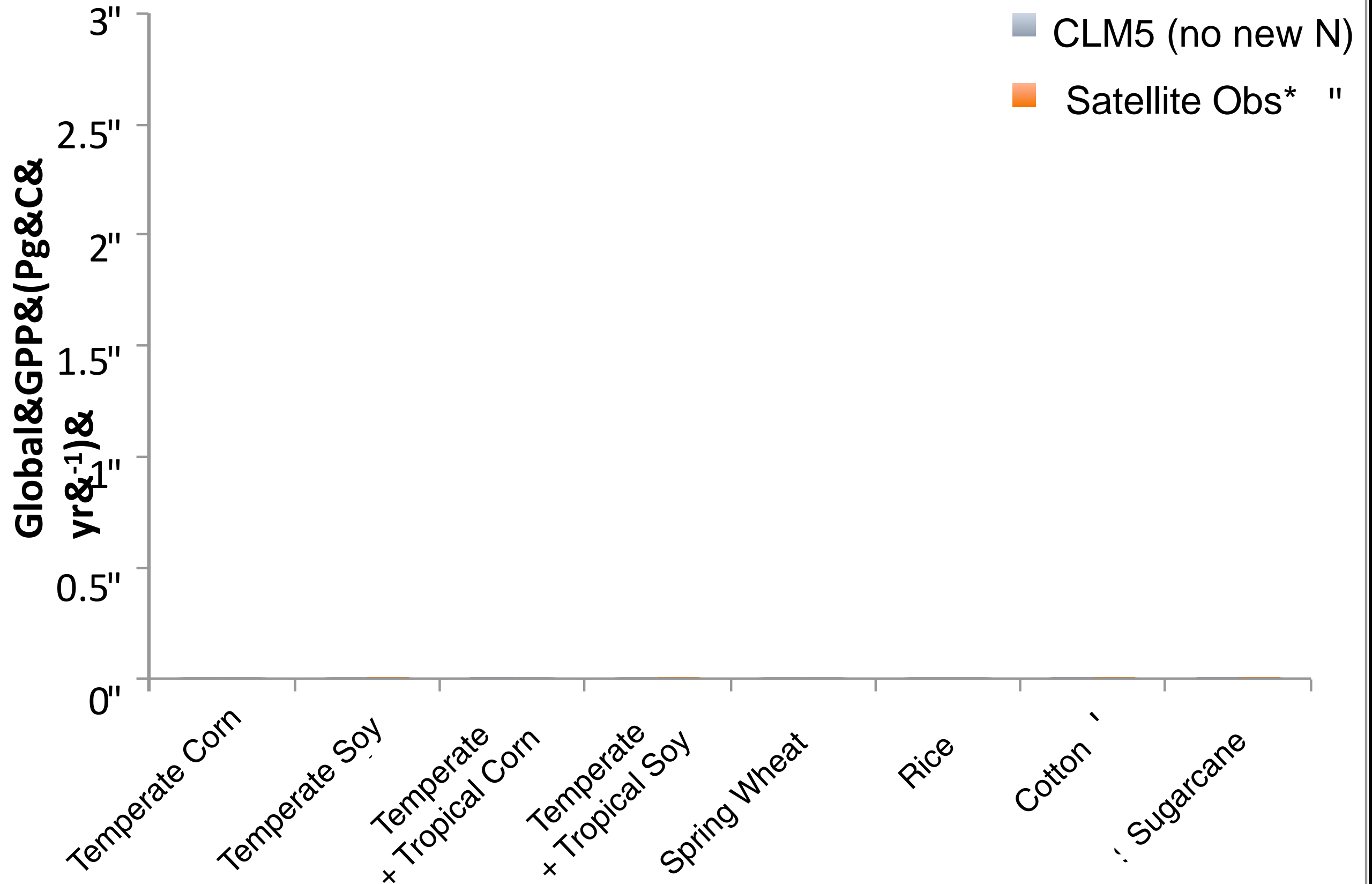


Harvest



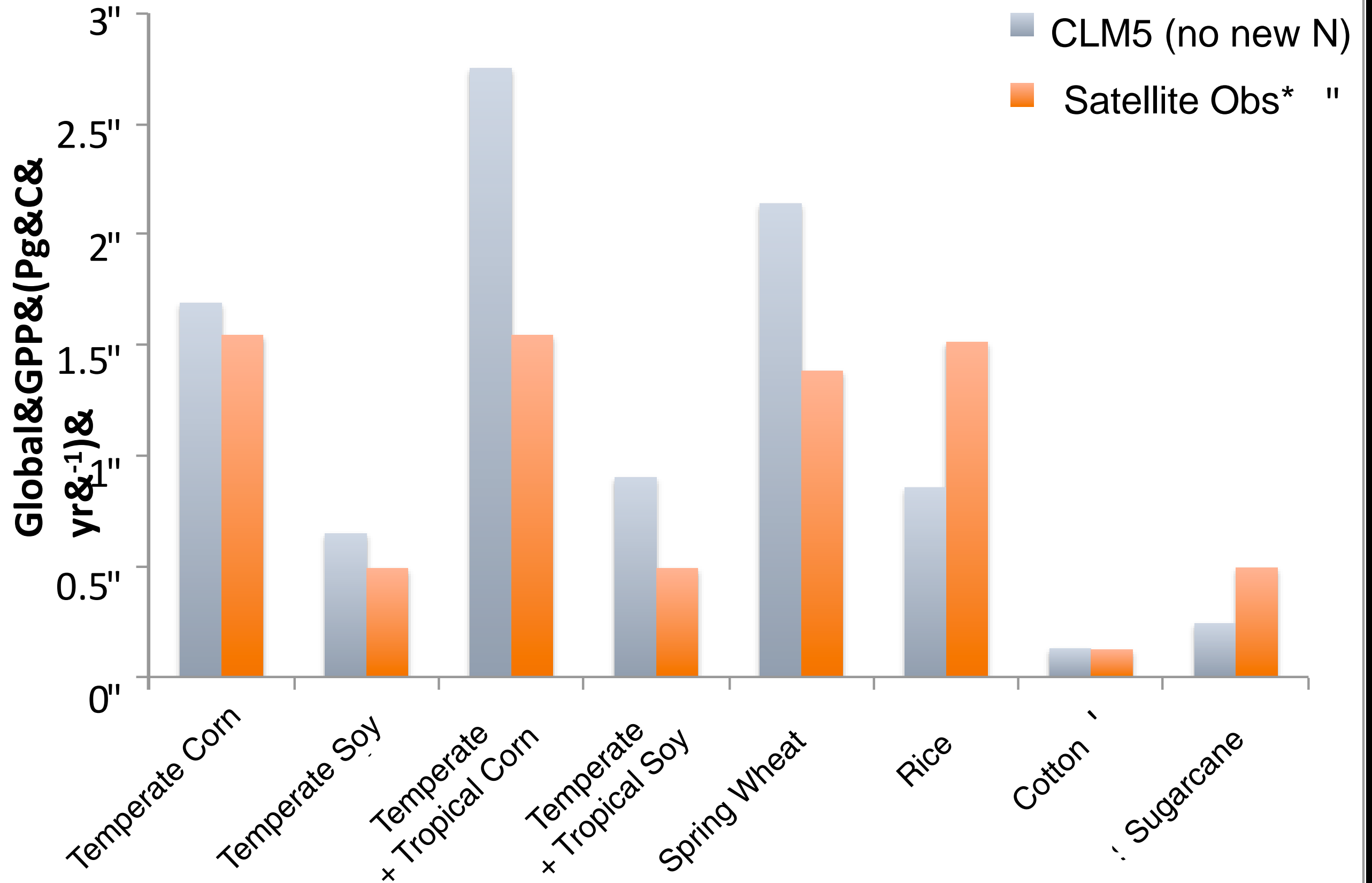
Irrigate

Crop GPP in 2000



*Chen et al. 2014 *Biogeosciences*

Crop GPP in 2000



*Chen et al. 2014 *Biogeosciences*

Simulations: CLM5 1850

atmosphere:

GSWP

3

1) CLM4.5'N ' '2)'+'FlexCN' & 'LUNA' ' ' '3)'+'FUN!



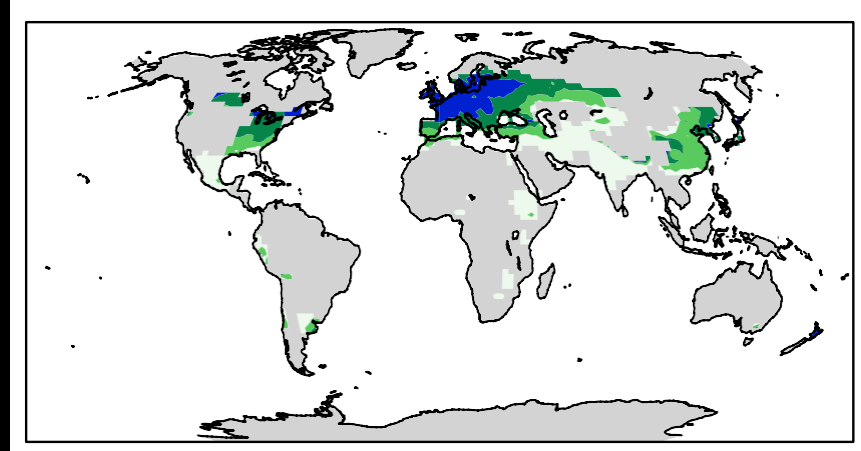
1850

Simulation

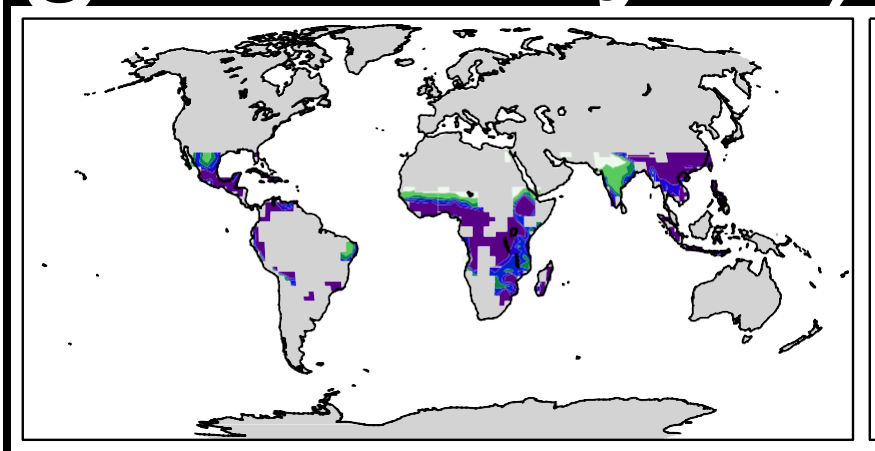
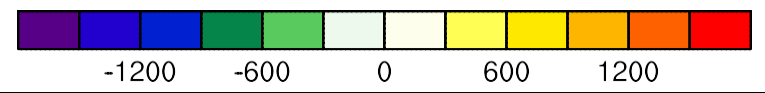
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FlexCN Effect
(FlexCN&Luna - CLM4.5 N)

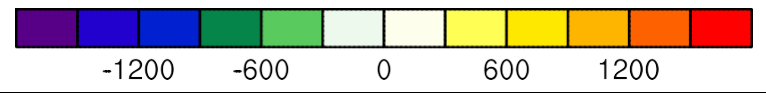
Crop GPP (Δ g C m⁻² yr⁻¹)



Spring Wheat



Tropical Corn



1850

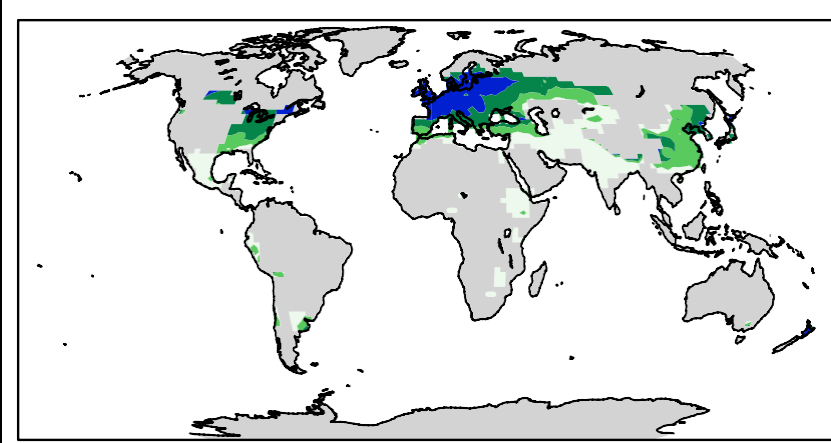
Simulation

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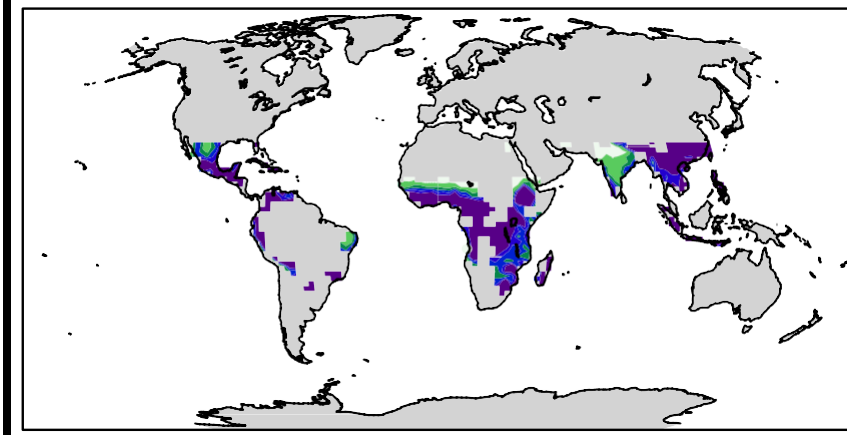
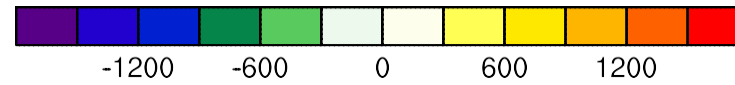
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FUN Effect
(CLM5 All N - FlexCN&Luna)

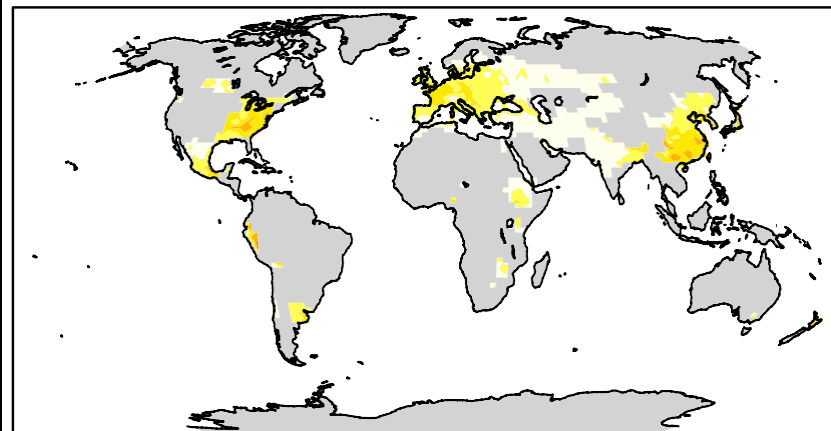
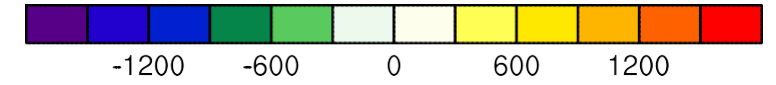
Crop GPP (Δ g C m⁻² yr⁻¹)



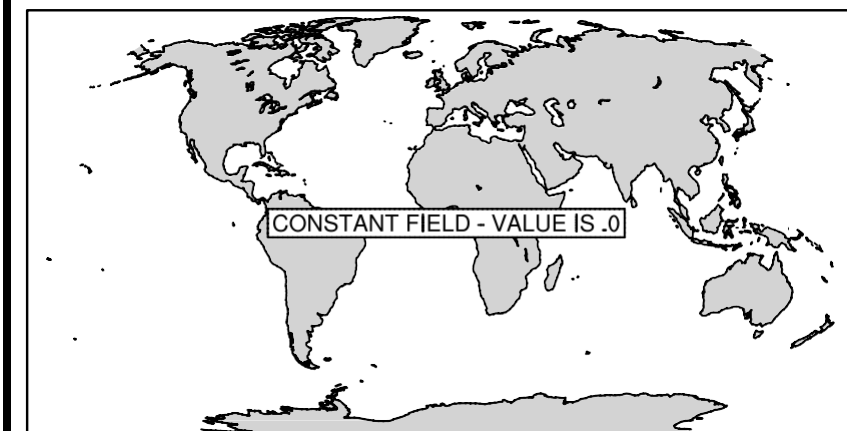
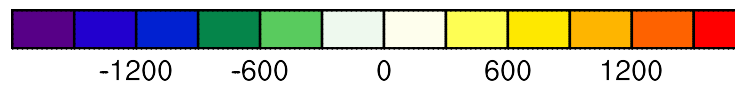
Spring Wheat



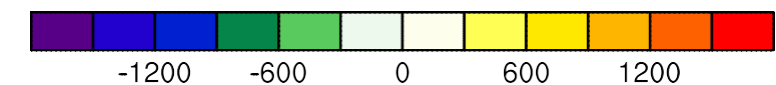
Tropical Corn



Spring Wheat



Tropical Corn



1850

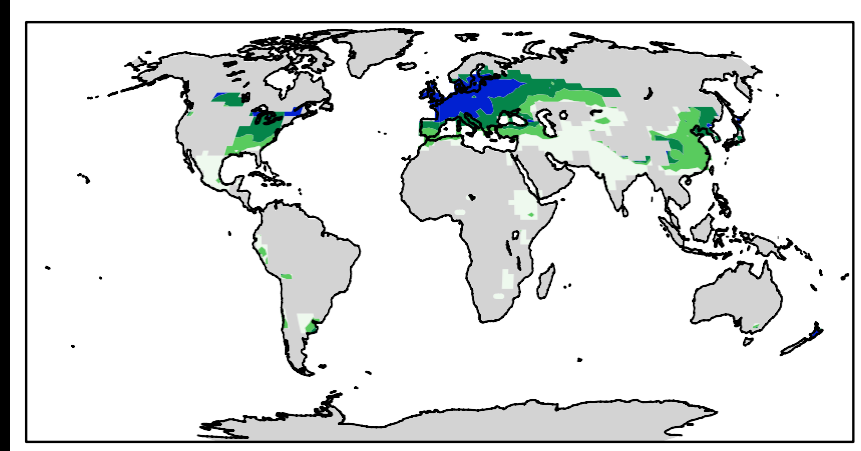
Simulation

n

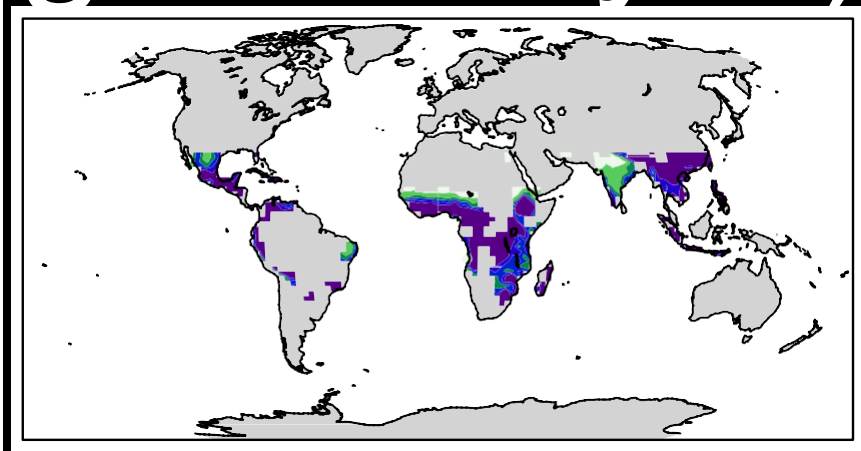
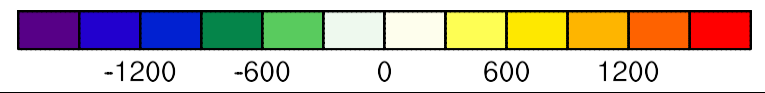
Crop GPP (Δ g C m⁻² yr⁻¹)

FlexCN Effect

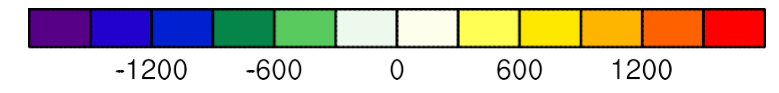
(FlexCN&Luna - CLM4.5 N)



Spring Wheat

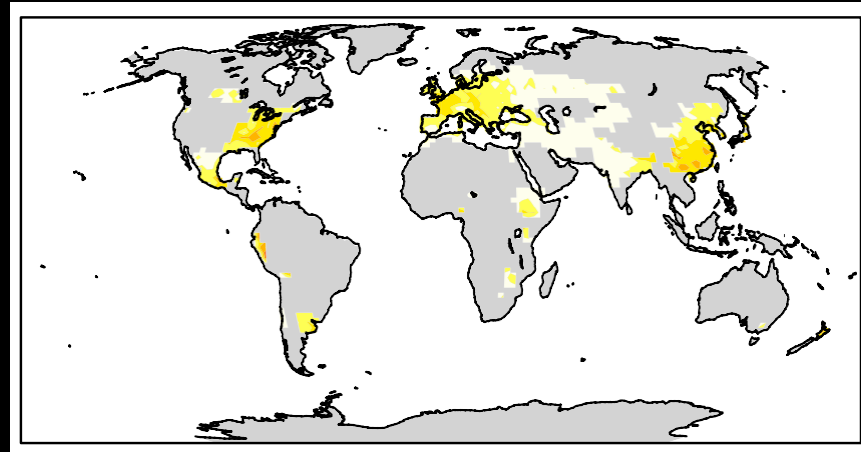


Tropical Corn

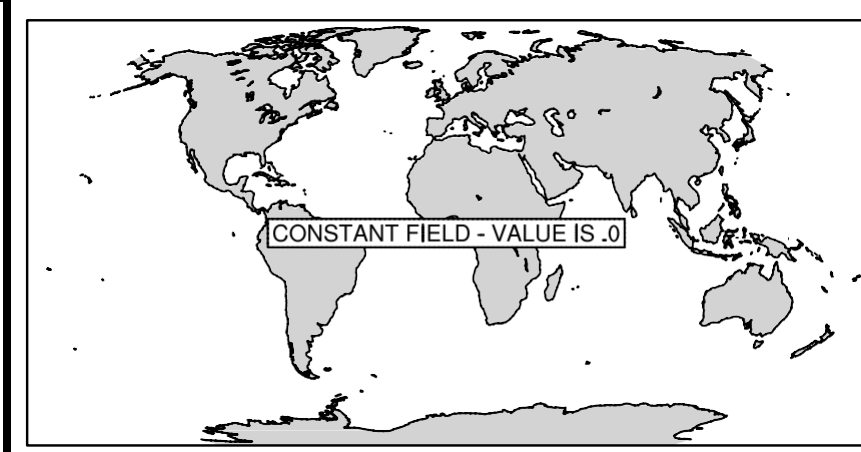
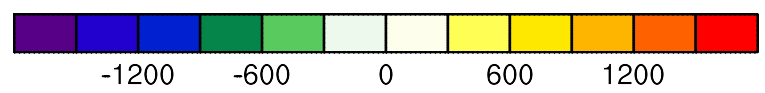


FUN Effect

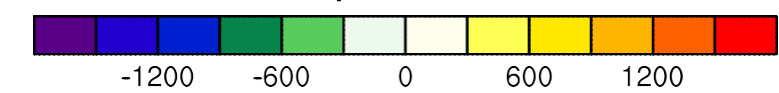
(CLM5 All N - FlexCN&Luna)



Spring Wheat

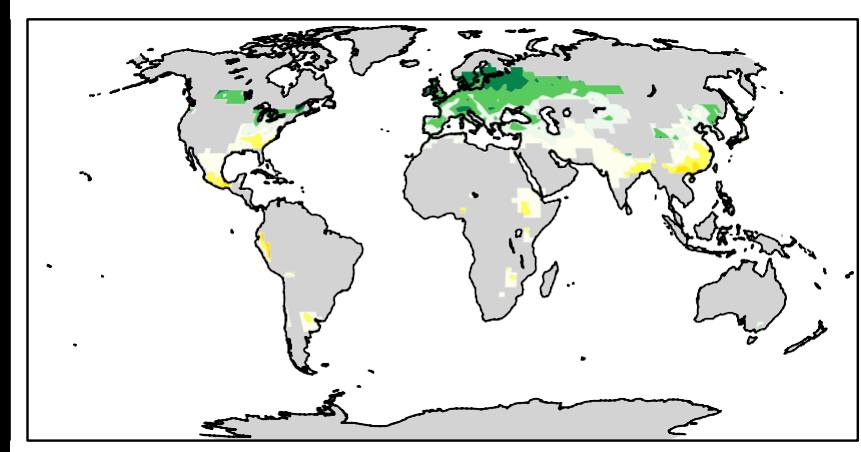


Tropical Corn

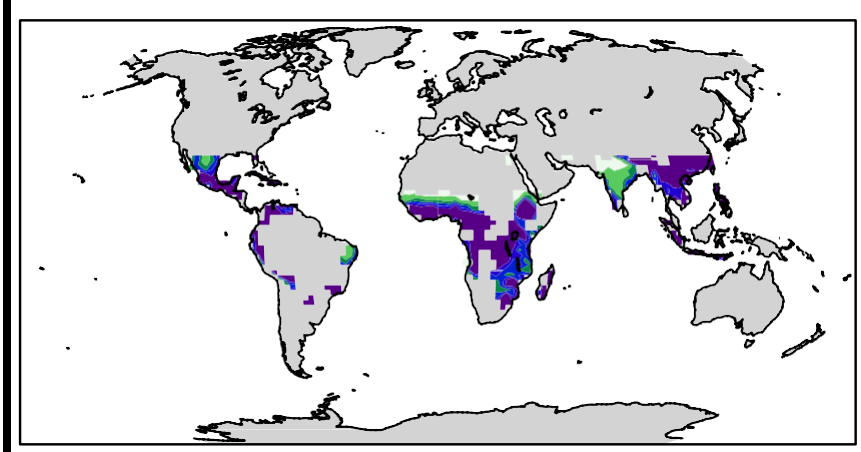
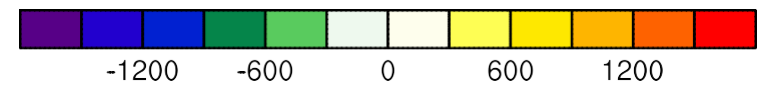


CLM5 N Effect

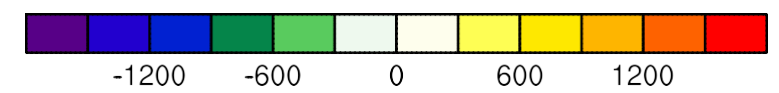
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Spring Wheat



Tropical Corn



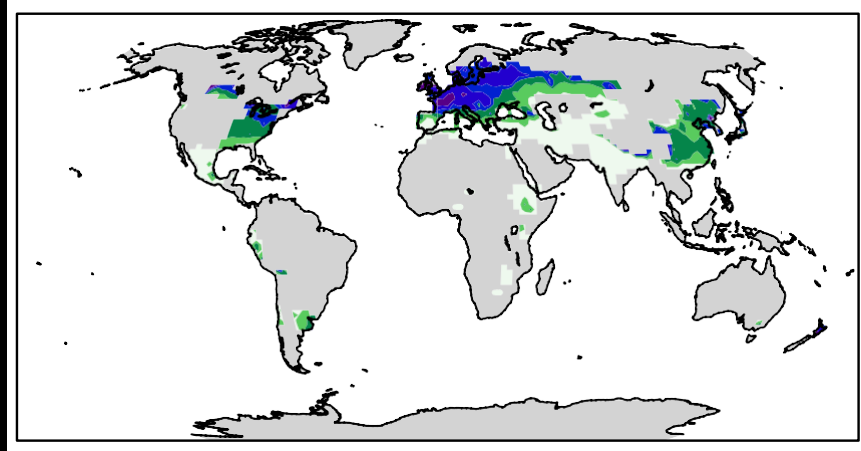
1850

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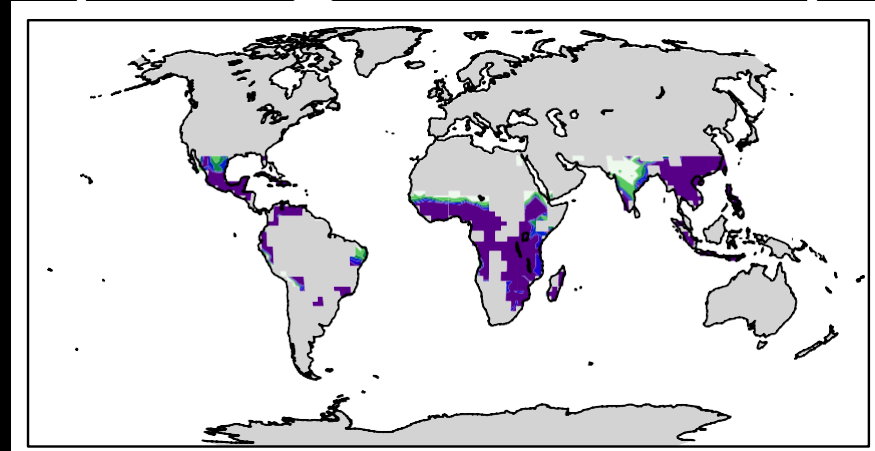
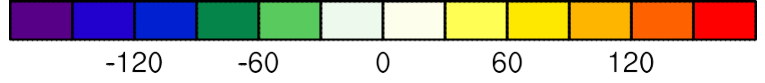
n

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

Crop Yield (Δ g C m⁻²)



Spring Wheat



Tropical Corn



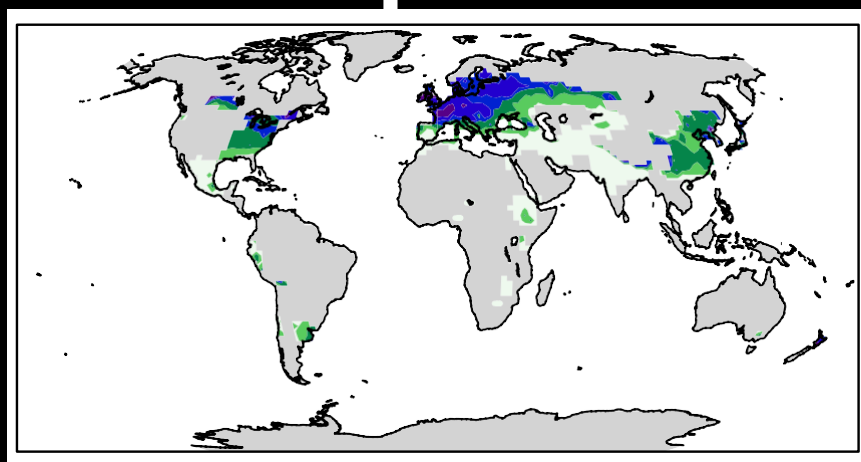
1850

Simulation

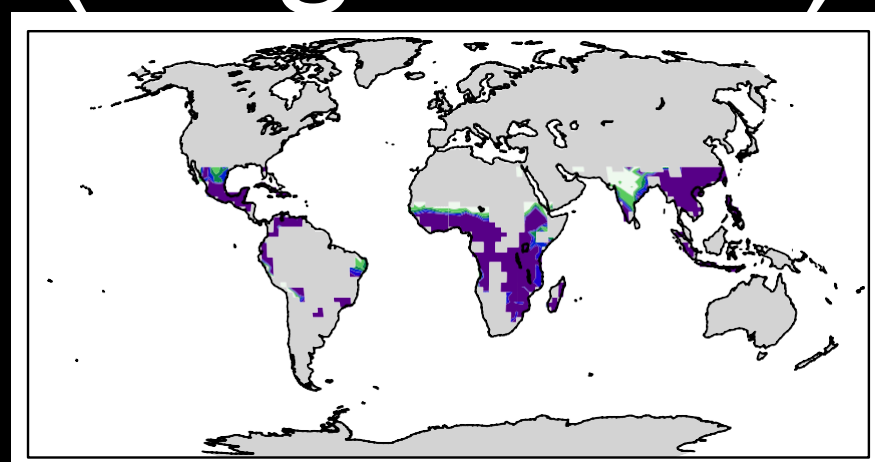
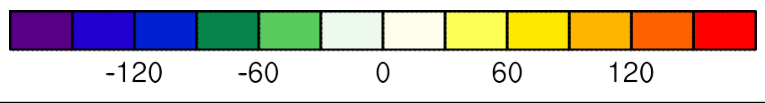
n

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

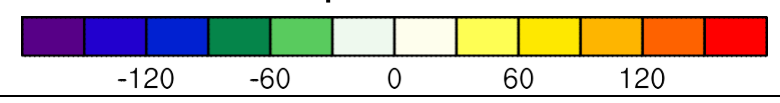
Crop Yield ($\Delta g C m^{-2}$)



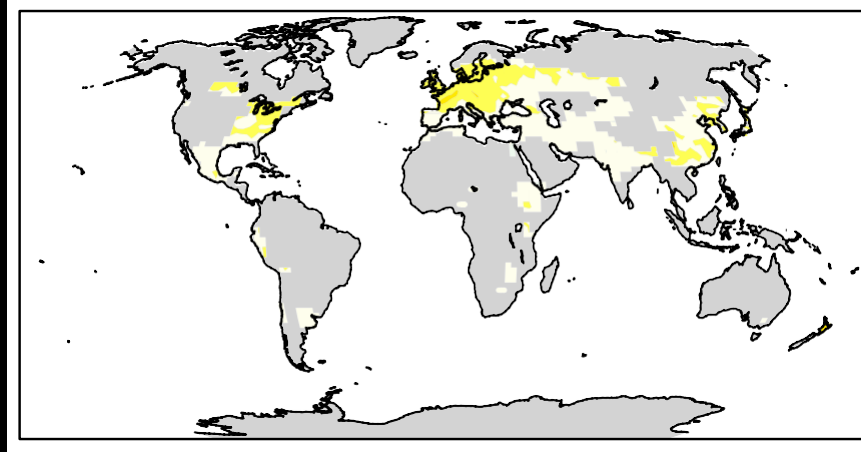
Spring Wheat



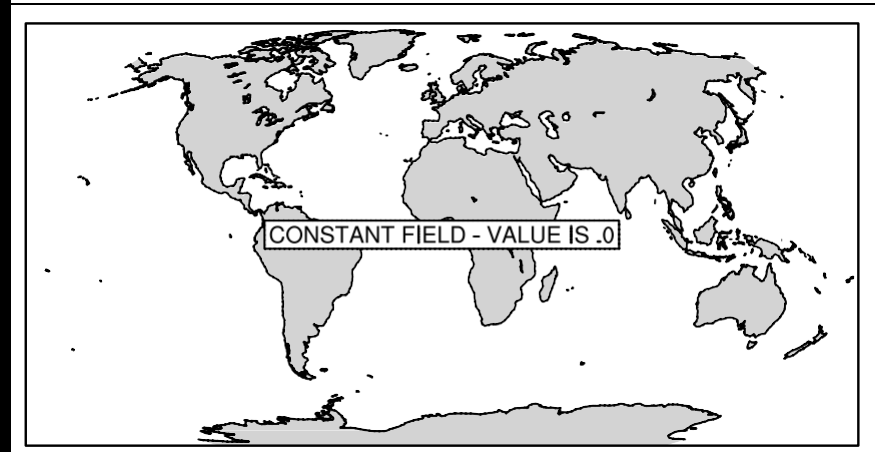
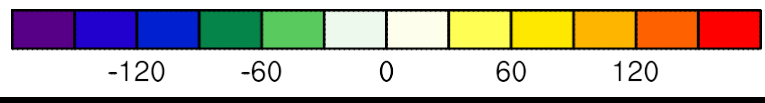
Tropical Corn



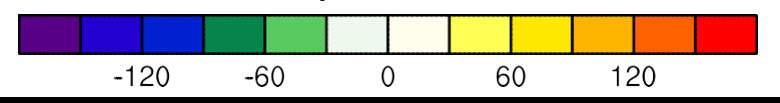
FUN Effect
(CLM5 All N - FlexCN&Luna)



Spring Wheat



Tropical Corn



1850

Simulation

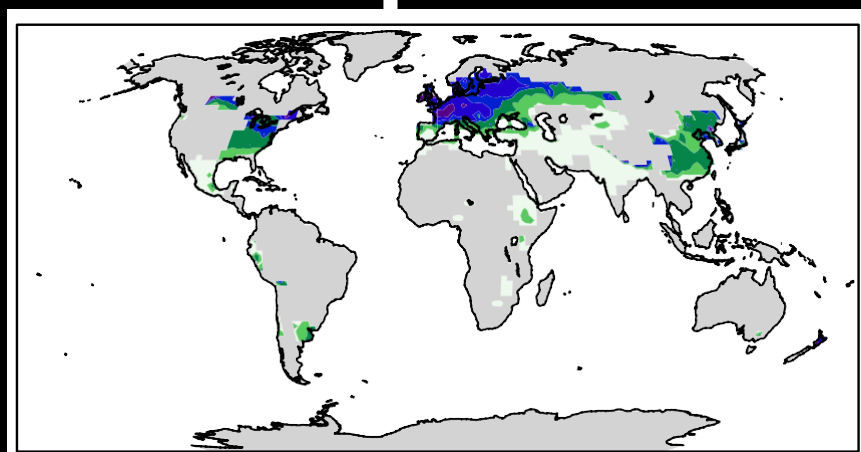
n

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

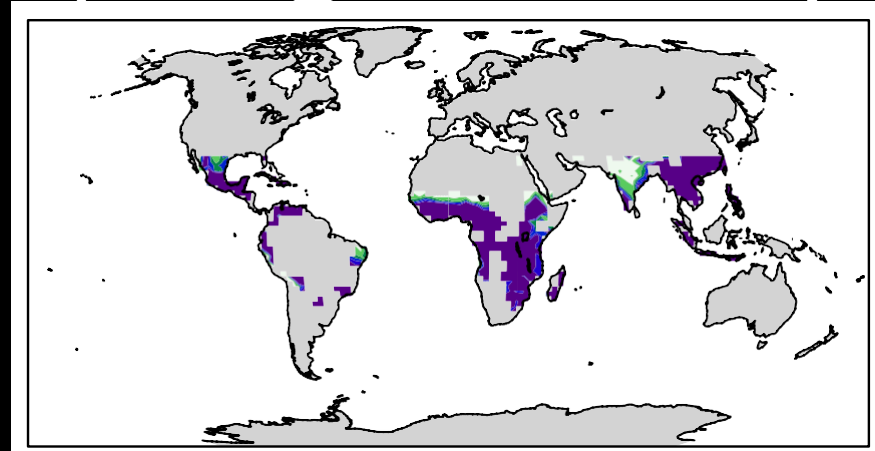
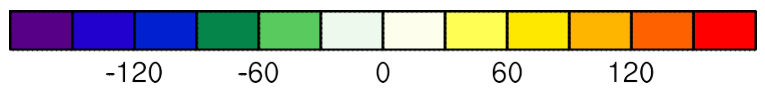
FUN Effect
(CLM5 All N - FlexCN&Luna)

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

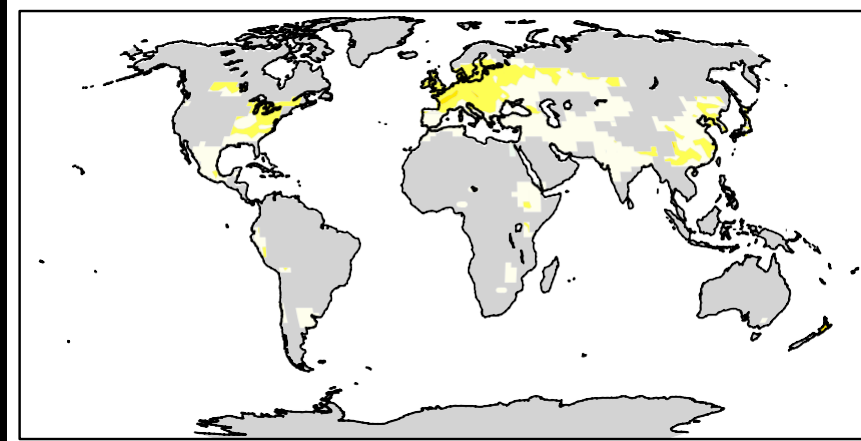
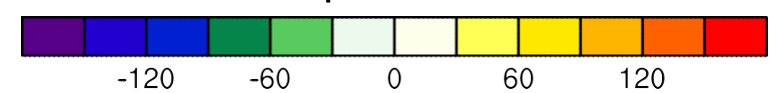
Crop Yield ($\Delta g C m^{-2}$)



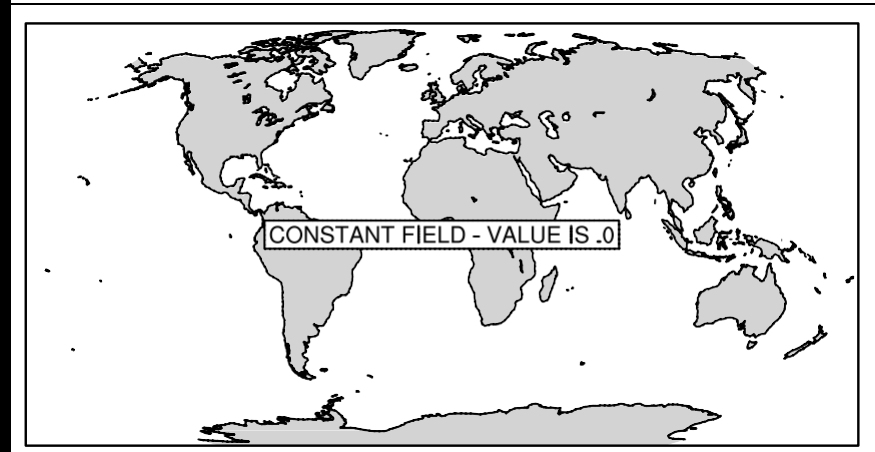
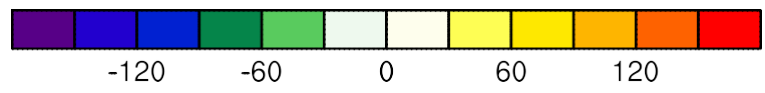
Spring Wheat



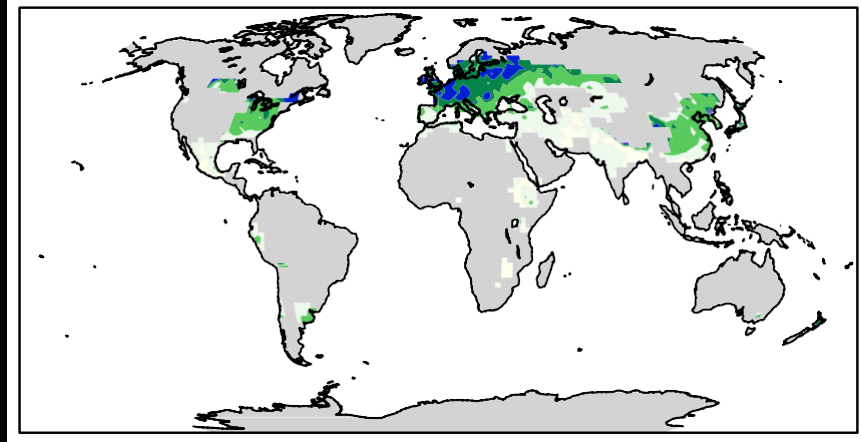
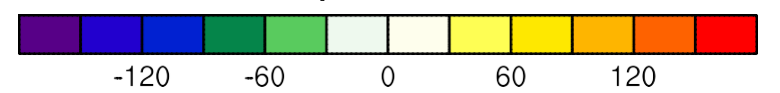
Tropical Corn



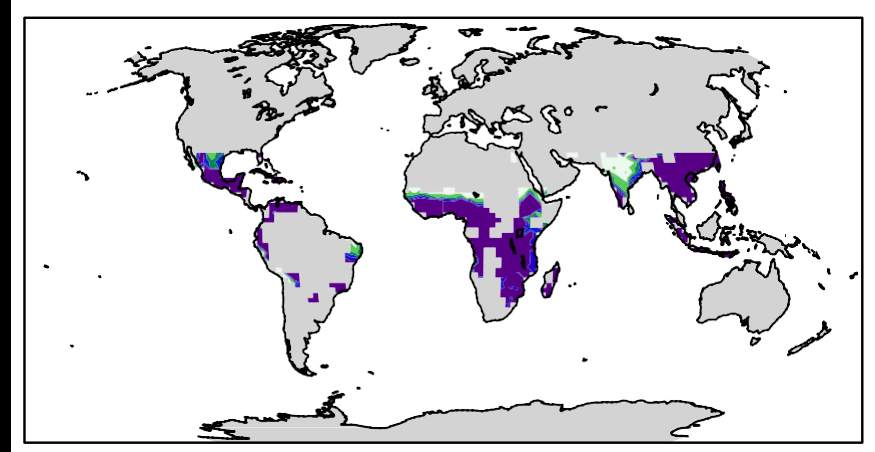
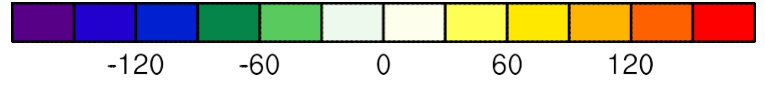
Spring Wheat



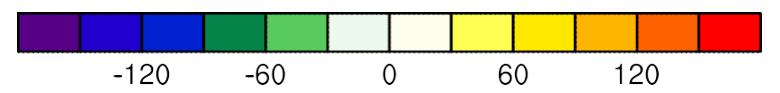
Tropical Corn



Spring Wheat



Tropical Corn



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





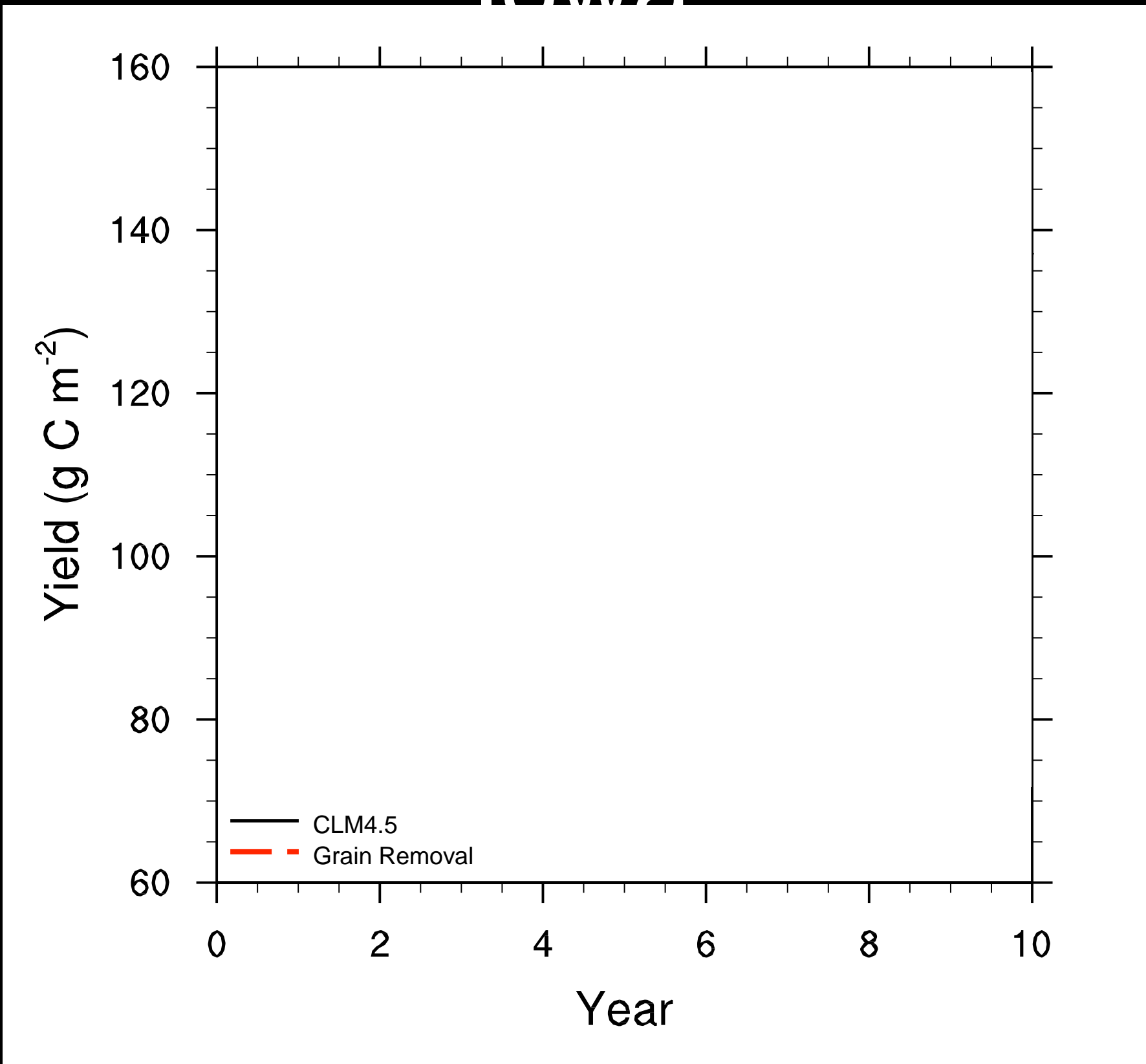
CLM4.5: Leave grain on the ground to decompose as litter



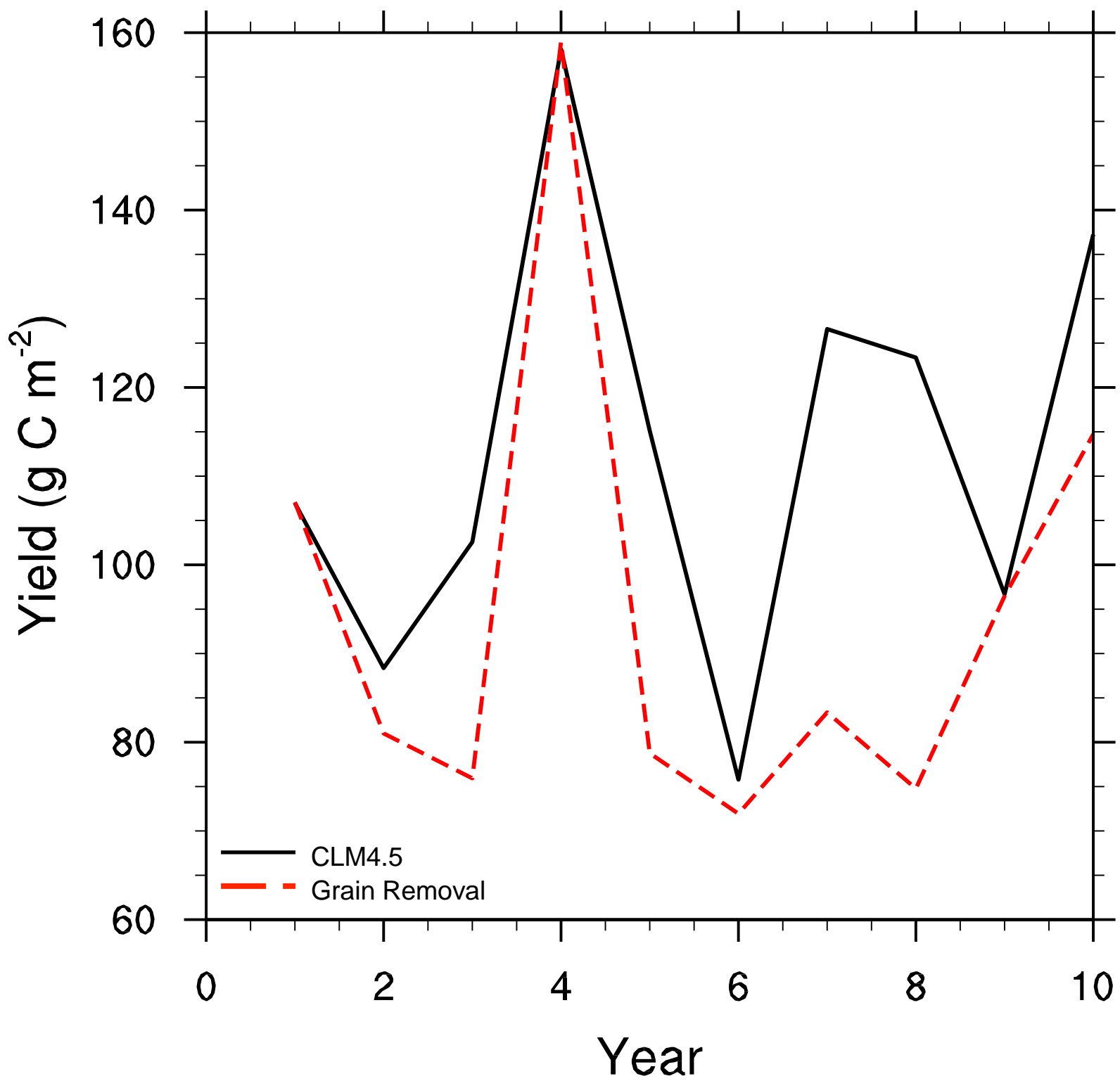
CLM5: Remove grain, and C and N release to atmosphere over 1 year

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

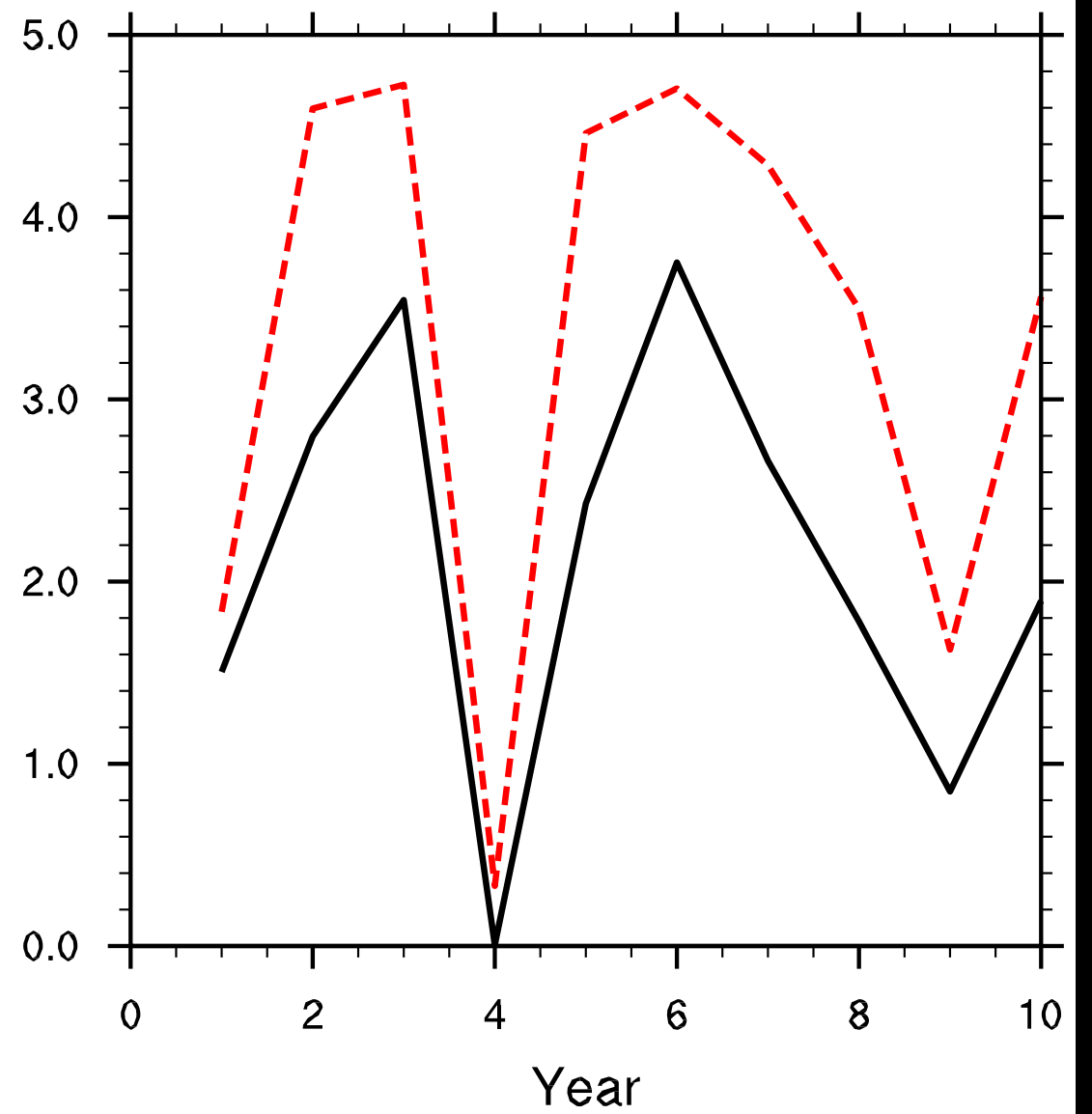
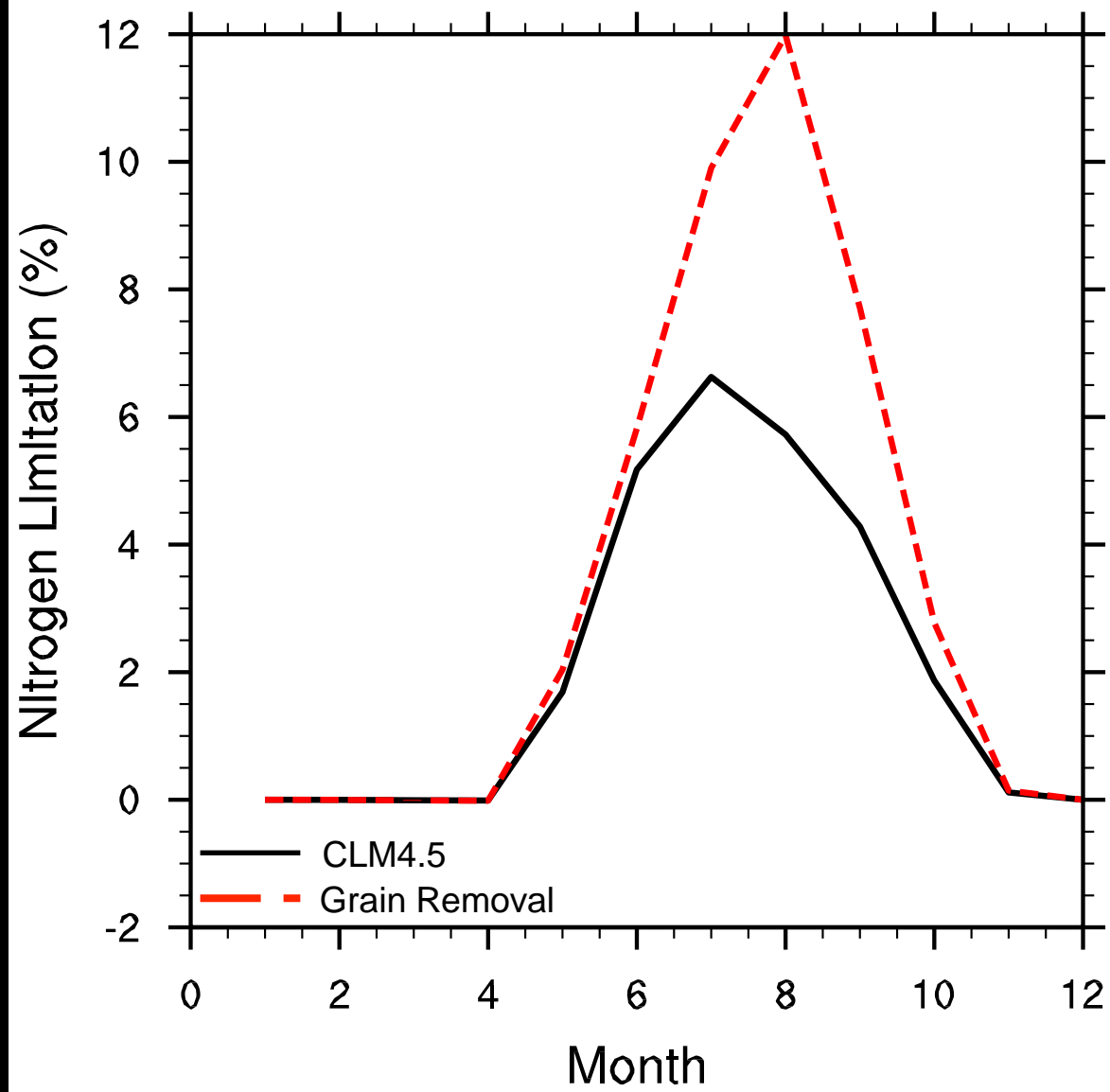
Iowa



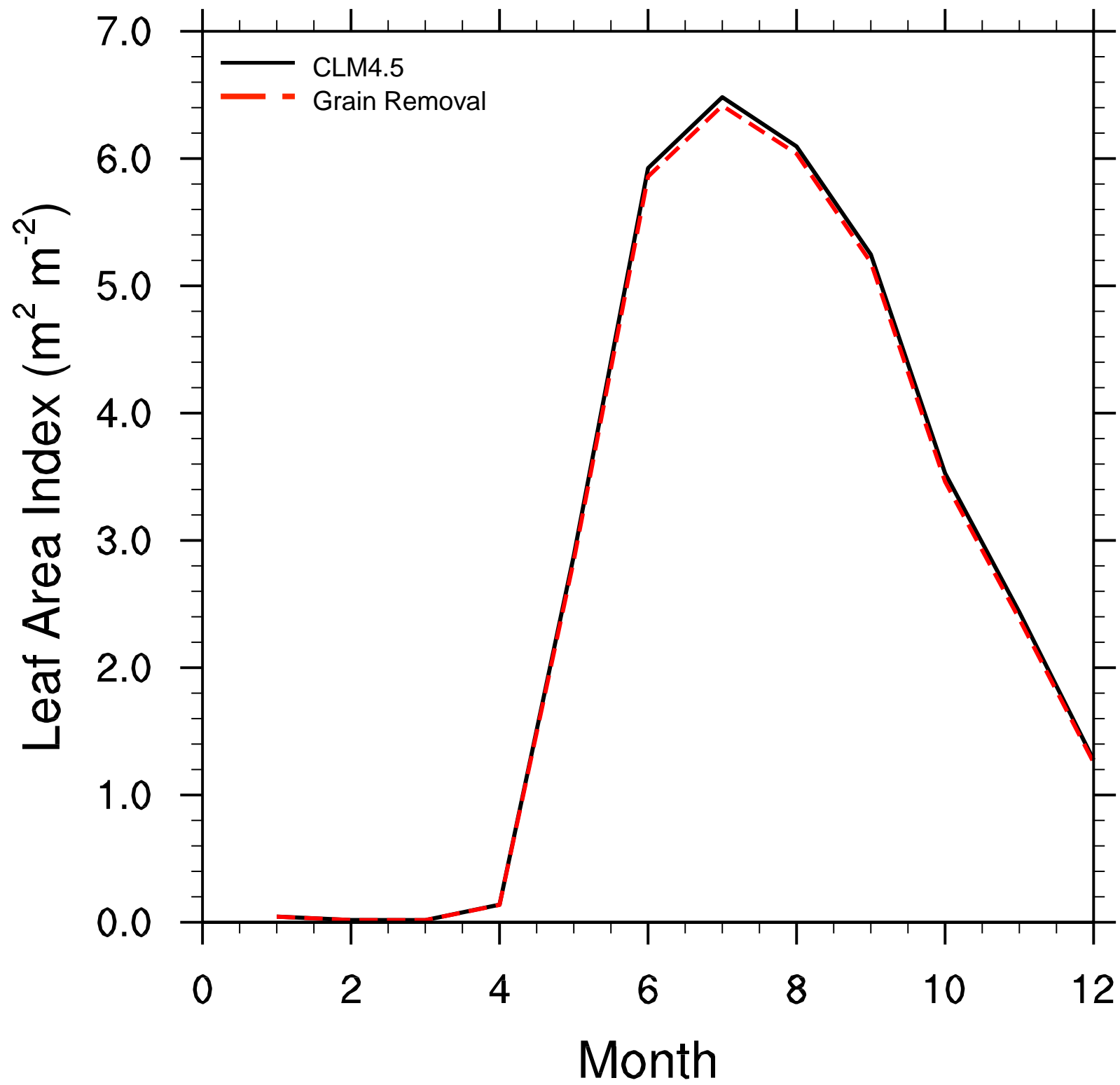
Iowa



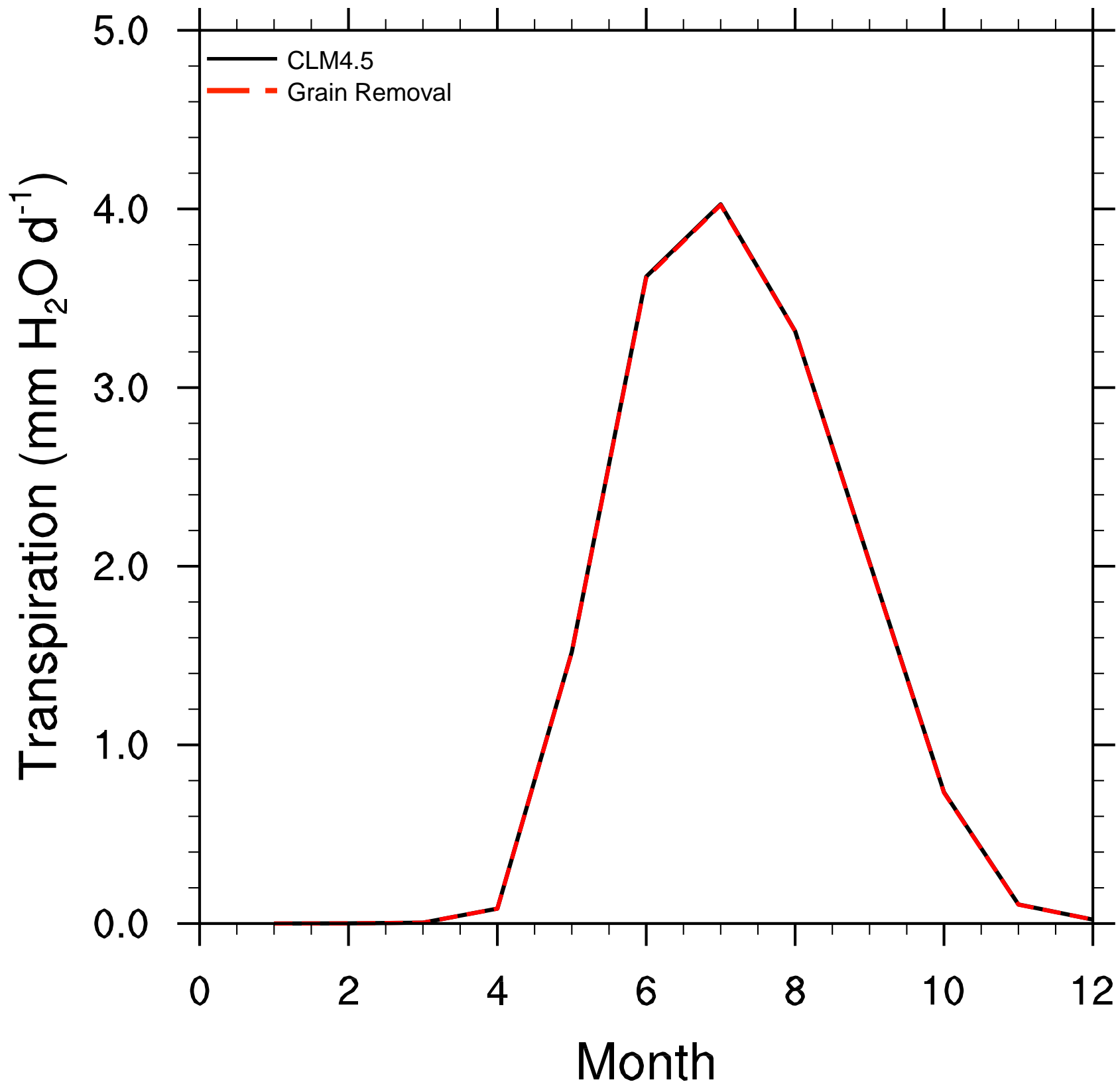
Iowa



Iowa

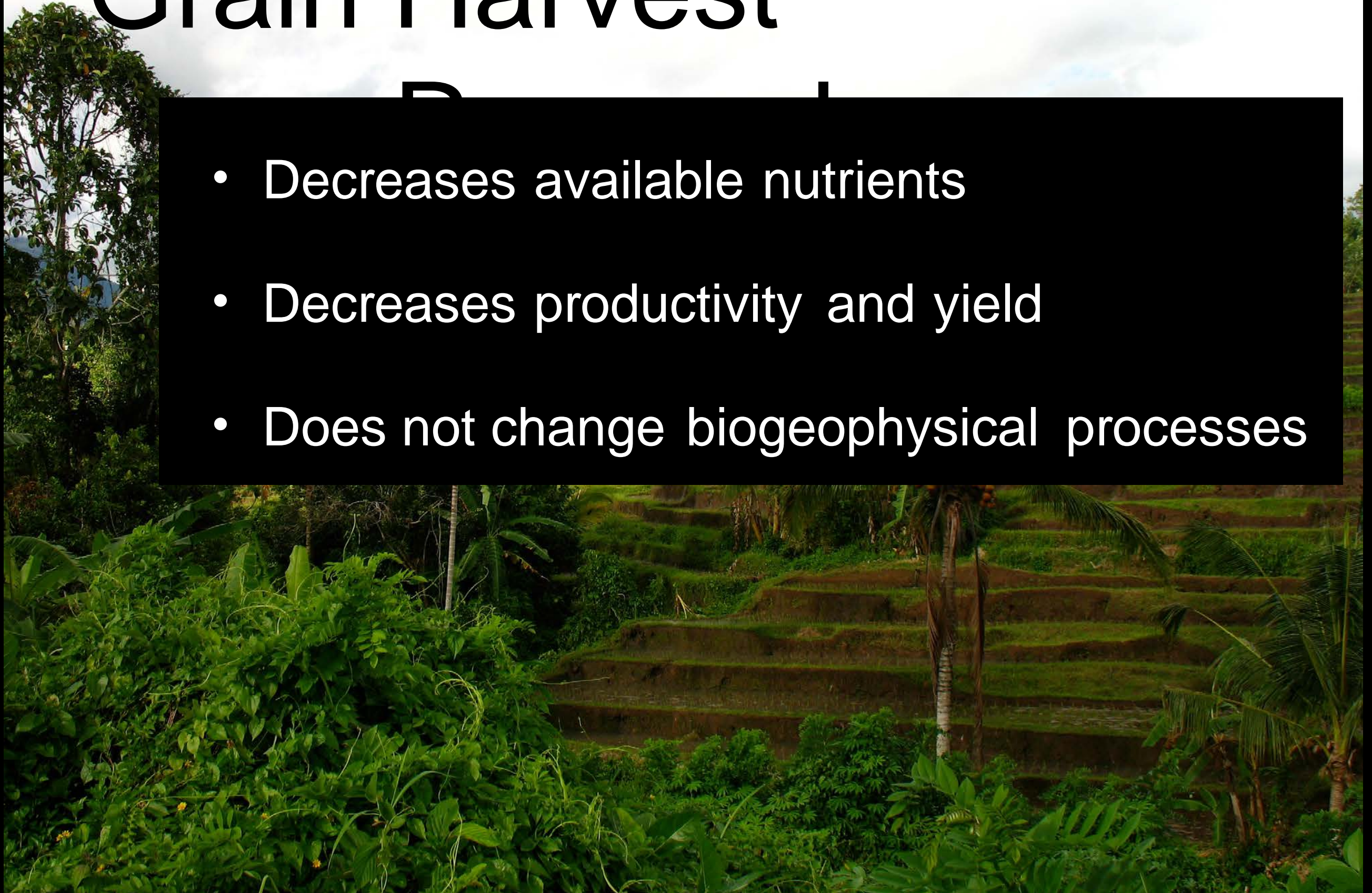


Iowa



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



CLM5: Global Average GPP (kg C m² y⁽¹⁾)

