

Outrageous LAI for Replacement Vegetation in the Tropics

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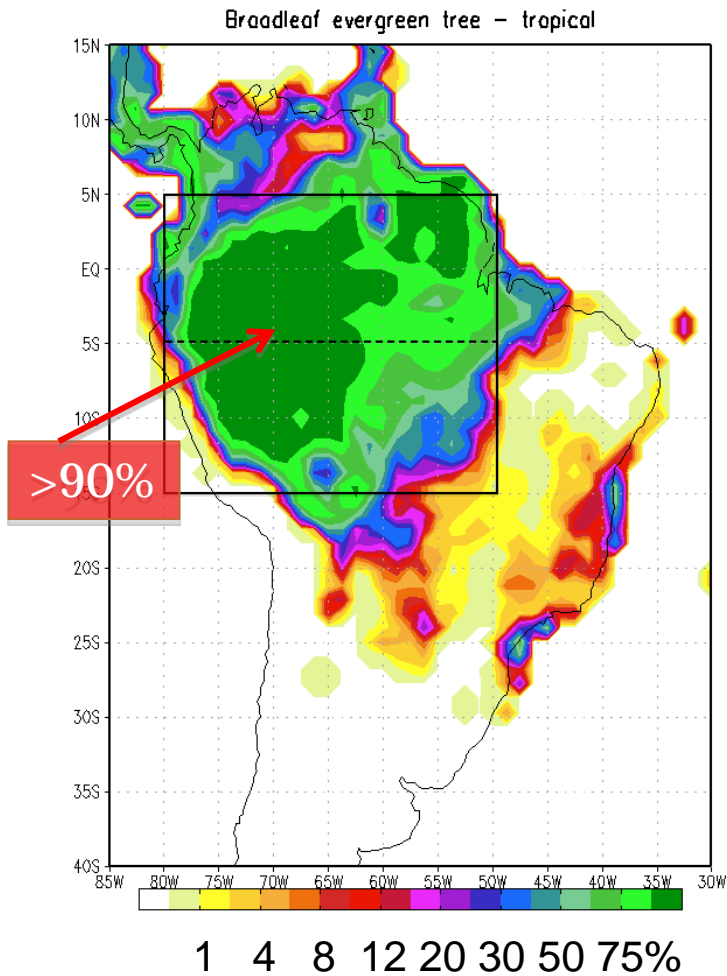
Motivation

- **PhD. Research project**
 - Land-use change modeling experiment – revisit Amazon deforestation
- **Better understanding of the response to large scale land-use change**
 - PBL interactions
 - Regional transports of energy and water
 - Circulation and climate changes

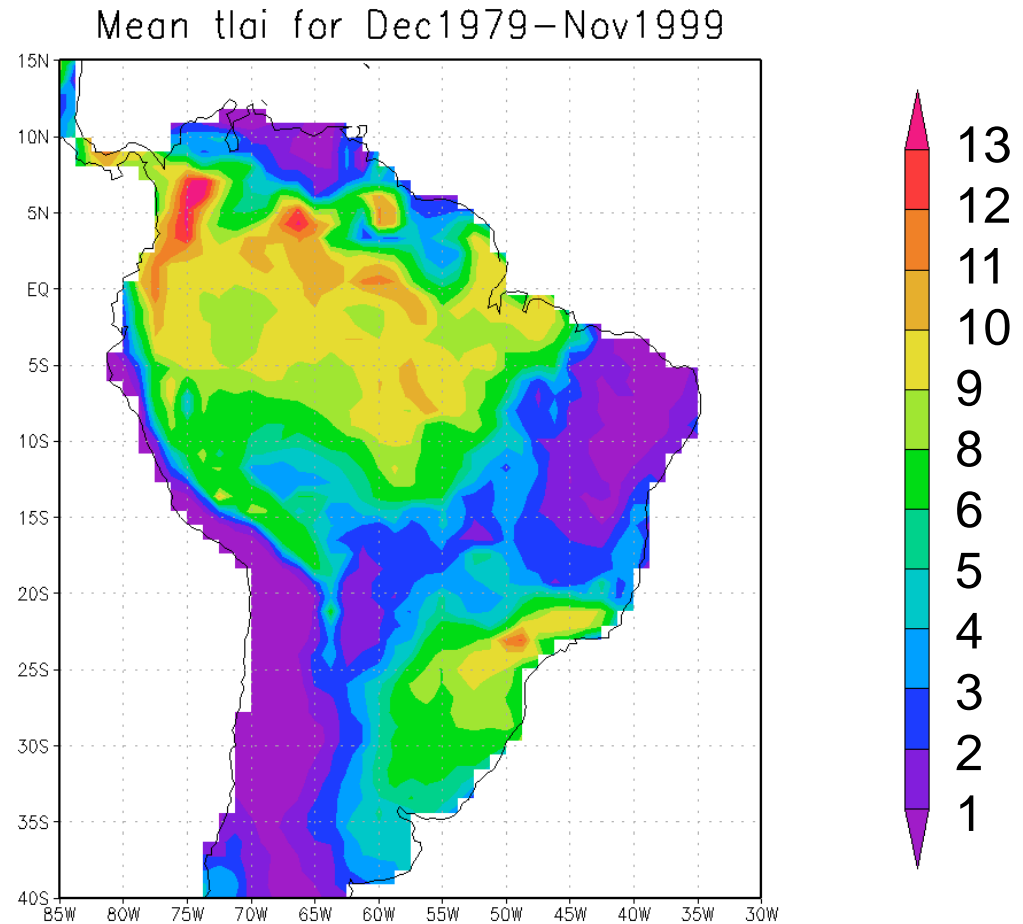
Methods

- **Phase 1: 40-year CLM4 offline simulation**
 - Qian et. al. atmosphere input data for 1948 to 2004
 - Simulated 1960-1999
 - CN (Carbon Nitrogen) biogeochemistry
 - CO₂ level and Aerosol deposition for 2000
- **Replaced tropical broadleaf evergreen (TBE) trees PFT in Amazon**
 - C3 Grass
 - Crops
 - C4 Grass

The Amazon Region



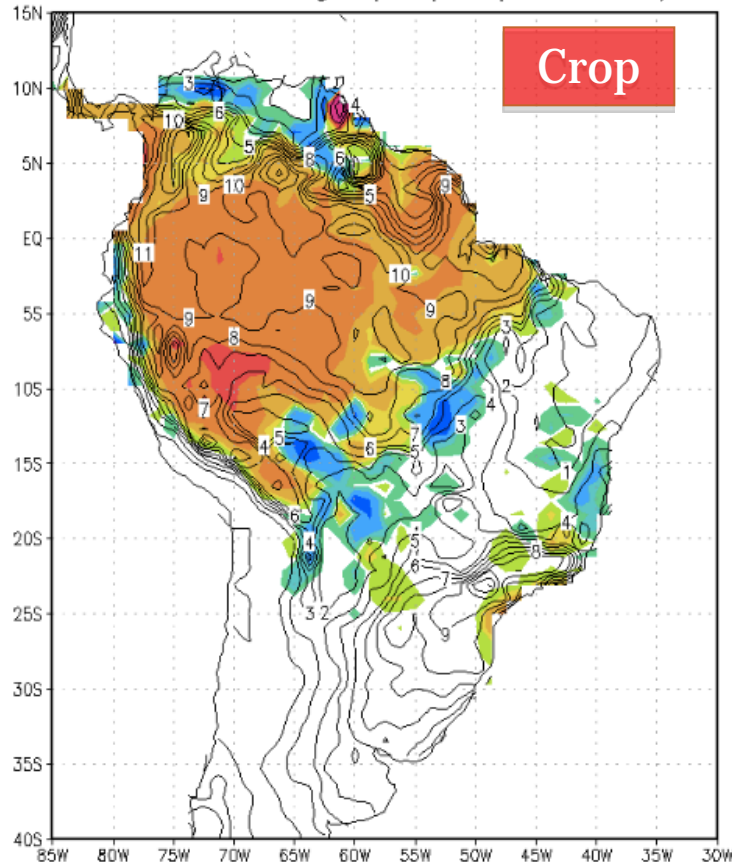
Initial coverage of TBE



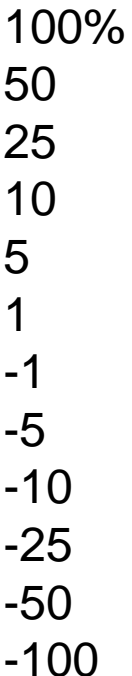
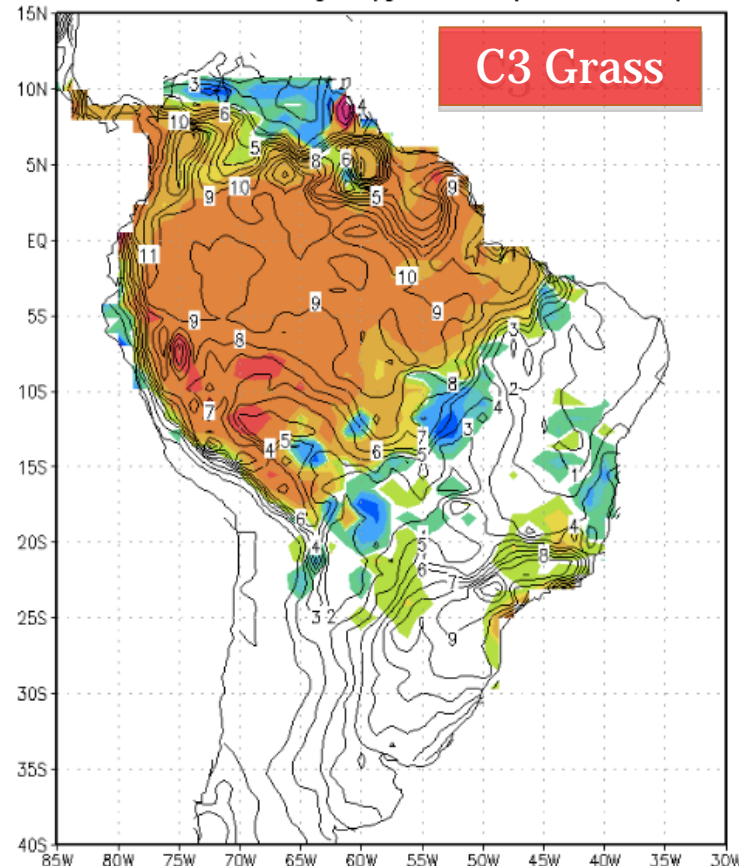
20-year mean of total leaf area index (TLAI) from control simulation

Annual Percent Change of TLAI

tlai, Annual DEC1979 – NOV1999
Percent Change (crop replacement)



tlai, Annual DEC1979 – NOV1999
Percent Change (grass replacement)

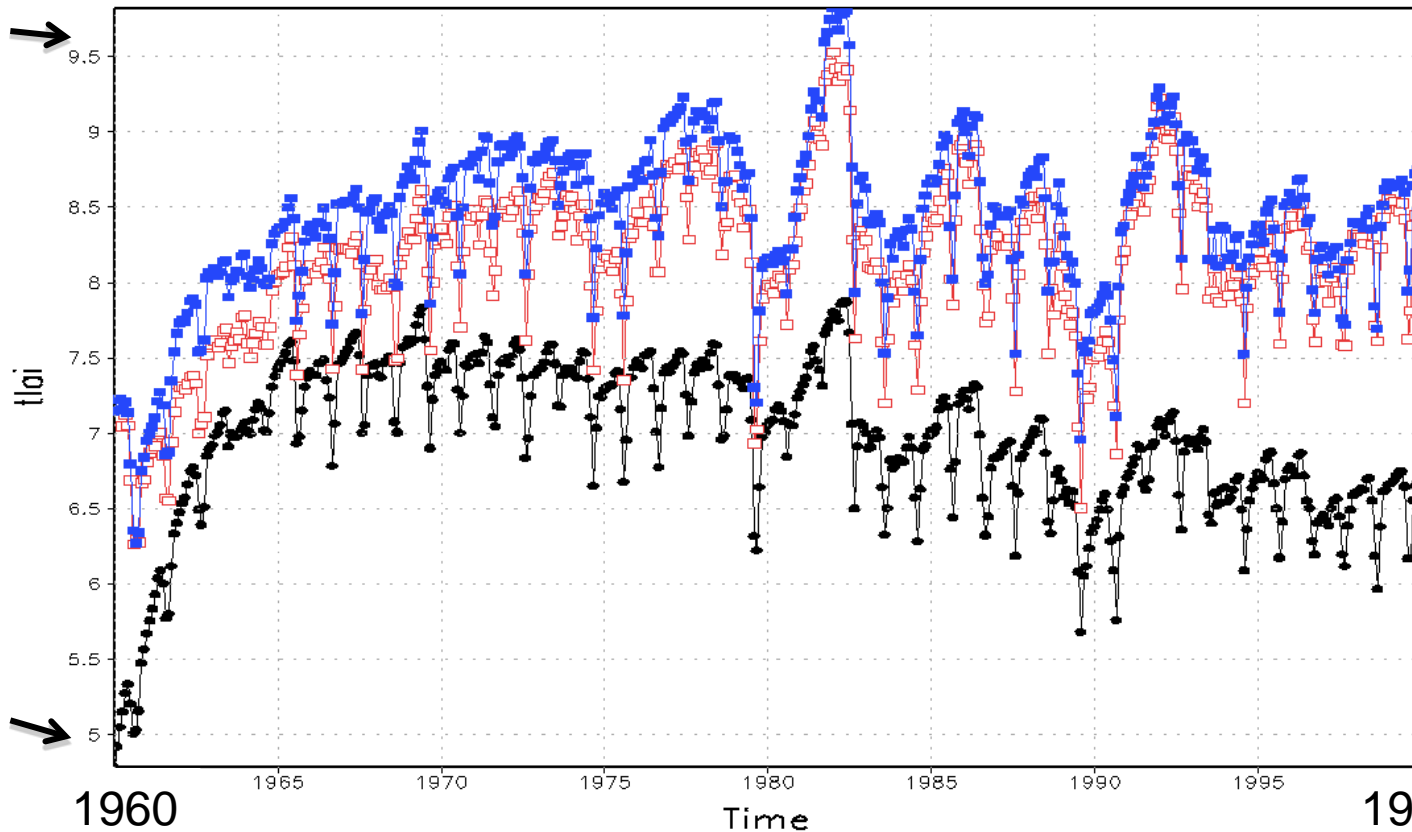


- Basin wide increases in TLAI for both crop and C3 grass

TLAI Area Average Timeline

Area Average of tlai for Deforested Region
control (Black), crop (red), grass (Blue)

9.5 →



TBE
changed to:

C3 Grass

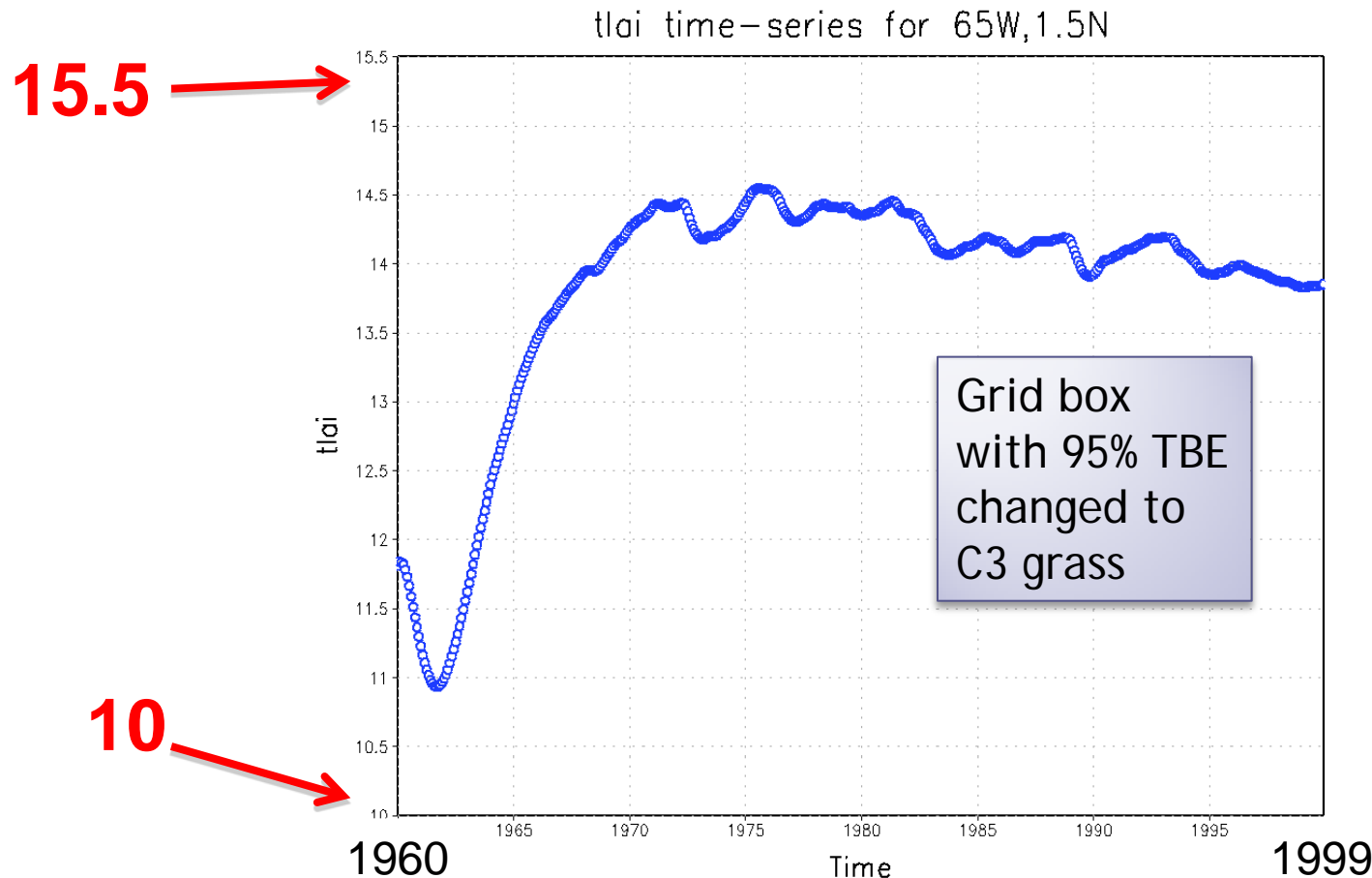
Crop

Control

5 →

- Area average of grid boxes that have a change in PFT
- Initial spin-up with both crop and C3 grass overshooting broadleaf evergreen trees

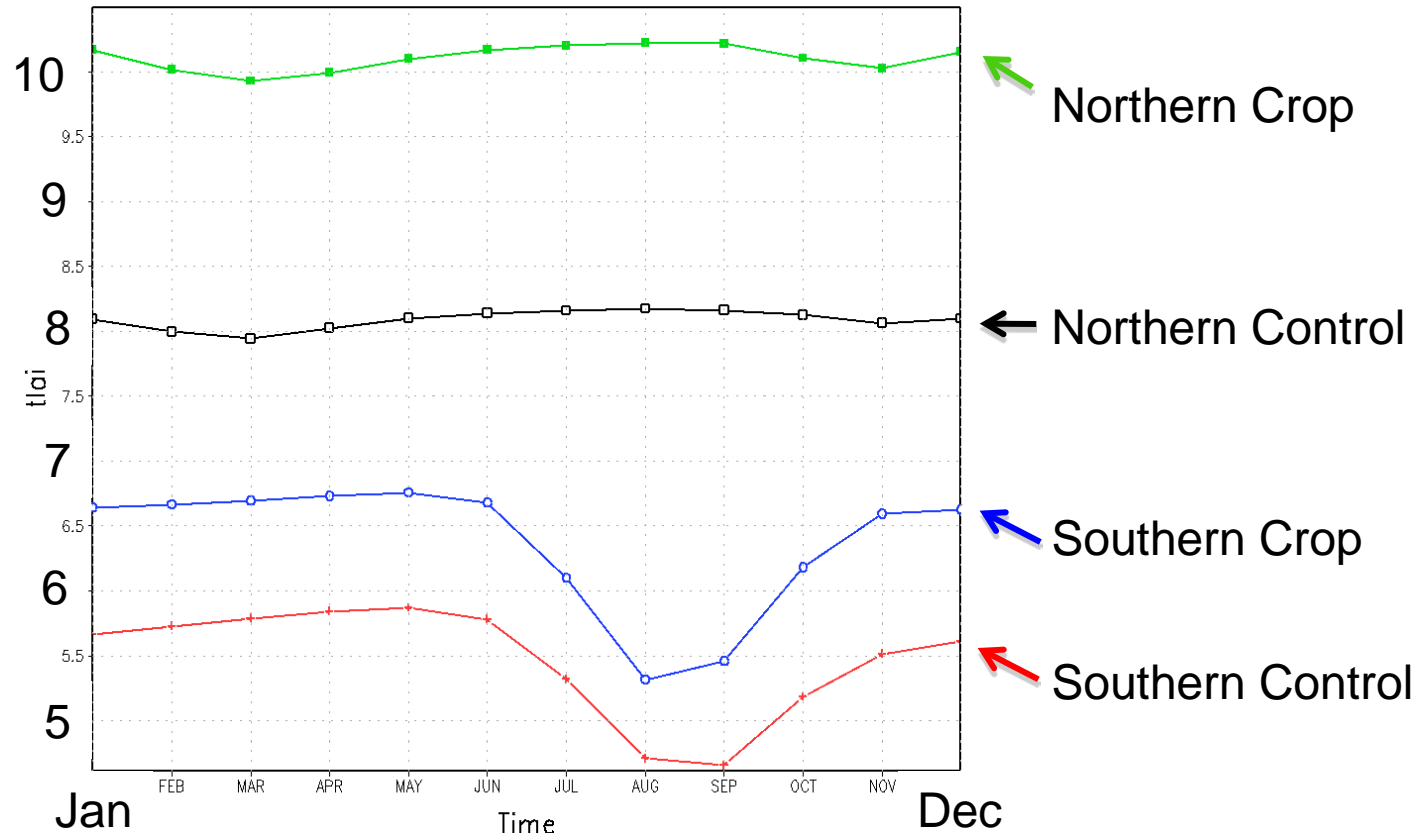
TLAI Timeline at One Location



- Area average is affected by different conditions north and south of equator
- LAI drift much worse in north than south...

Seasonal Cycle of TLAI for Crop

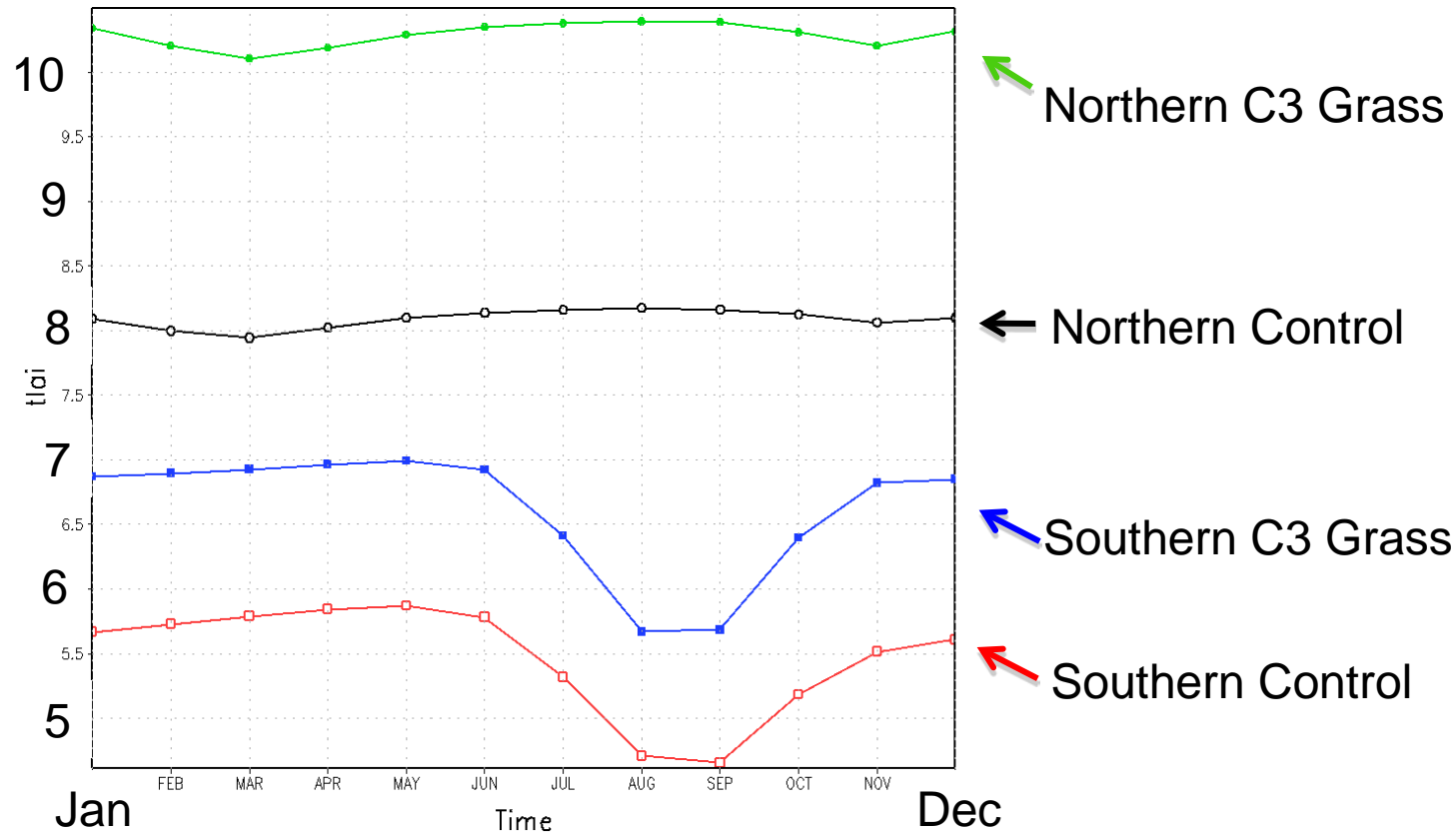
Area Average of tlai for Deforested Region
Crop Replacement



- Crop TLAI is consistently greater
- Recall area averages include all PFTs in grid boxes

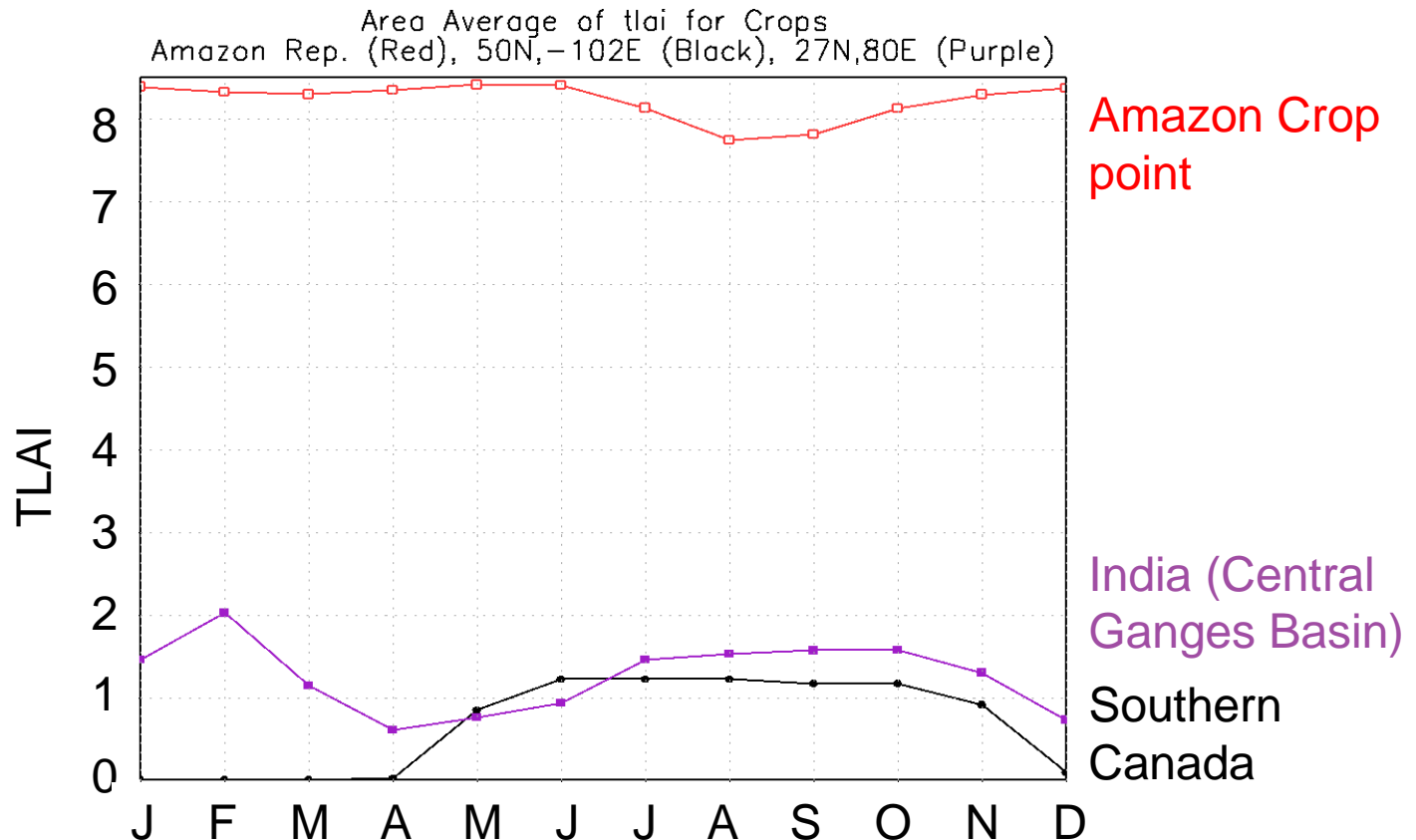
Seasonal Cycle of TLAI for C3 Grass

Area Average of tlai for Deforested Region
Grass Replacement



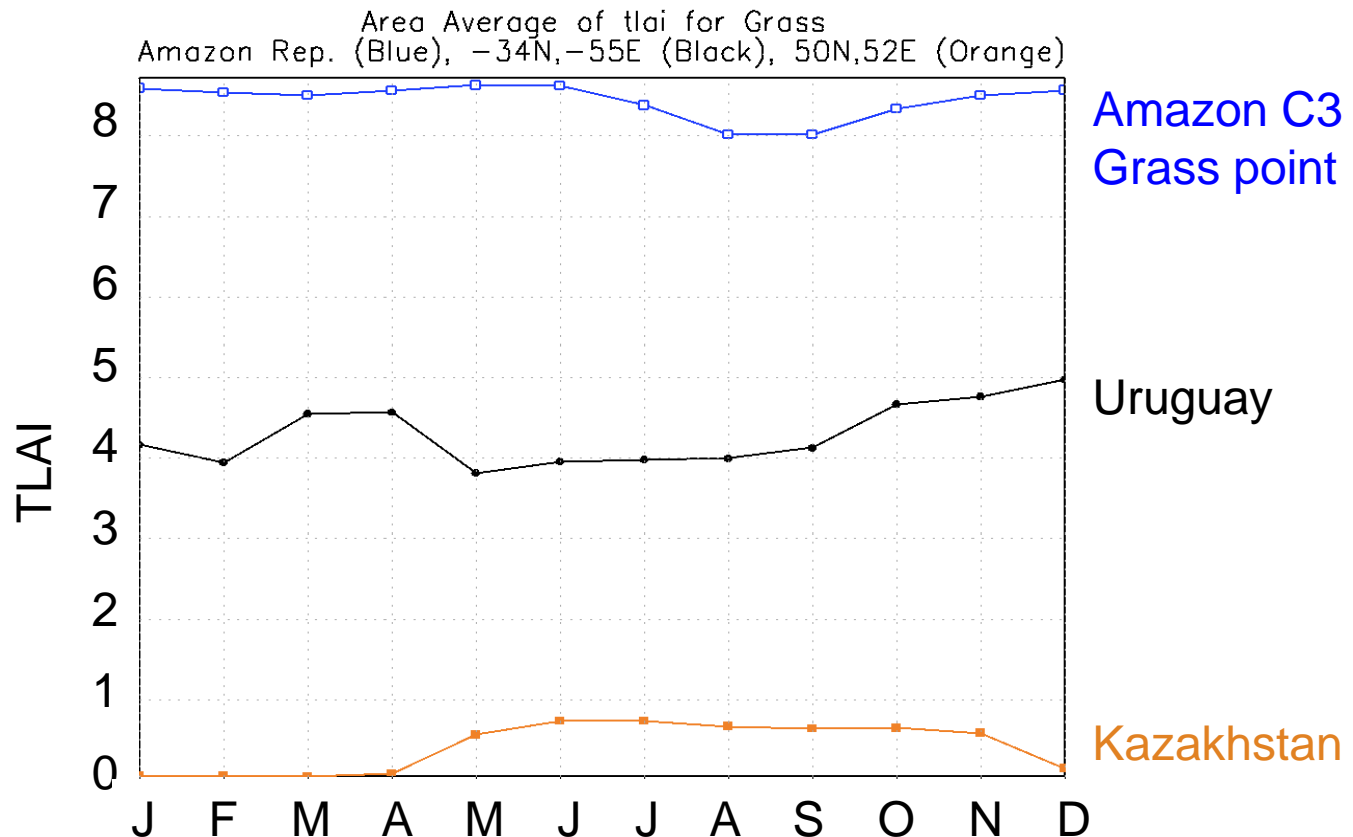
- C3 Grass TLAI is consistently greater
- Crop and C3 grass TLAI behave nearly identically

Seasonal Cycle of Crop PFT



- Amazon crop TLAJ is considerably higher than that of crops in natural locations
- 50° N, 102° W; Saskatchewan, Canada; 80% crop
- 27° N, 80° E; India; 87% crop

Seasonal Cycle of C3 Grass PFT



- Amazon C3 grass TLAI is consistently higher than that of C3 grass in natural locations
- 34° S, 55° W; Uruguay; 76% C3 grass
- 50° N, 52° E; Kazakhstan; 71% C3 grass

Why did this happen?

- C3 grass and crops are parameterized for the mid-latitudes
- The winter season temperature in the Amazon does not get cold enough to trigger senescence
 - Survival temperature for C3 grass: -17° C
 - Establishment temperature for C3 grass: 15.5° C
 - Planting temperature for managed crops: 7° - 13° C
- Greater moisture availability in the Amazon
 - Plants are not stressed by a lack of moisture availability

Why is this important?

- **LAI impacts numerous processes**
 - Radiation budget (albedo, longwave radiation)
 - Gross primary production (photosynthesis)
 - Evaporative Fraction (sensible heat from ground and vegetation)
 - Water cycle
 - Carbon cycle
- **Misrepresentation of LAI for replacement vegetation in the tropics will lead to errors in coupled global simulations of land-use change**

Summary

- LAI in replacement vegetation is unrealistically high
- Replacement vegetation was parameterized for mid latitudes
- Realistic crop replacement is essential to better model land-use change in the tropics
- **Although not shown, C4 grasses appear to have the same issues as C3 grass, perhaps worse**