Tropical forest drought tolerance and forest resilience

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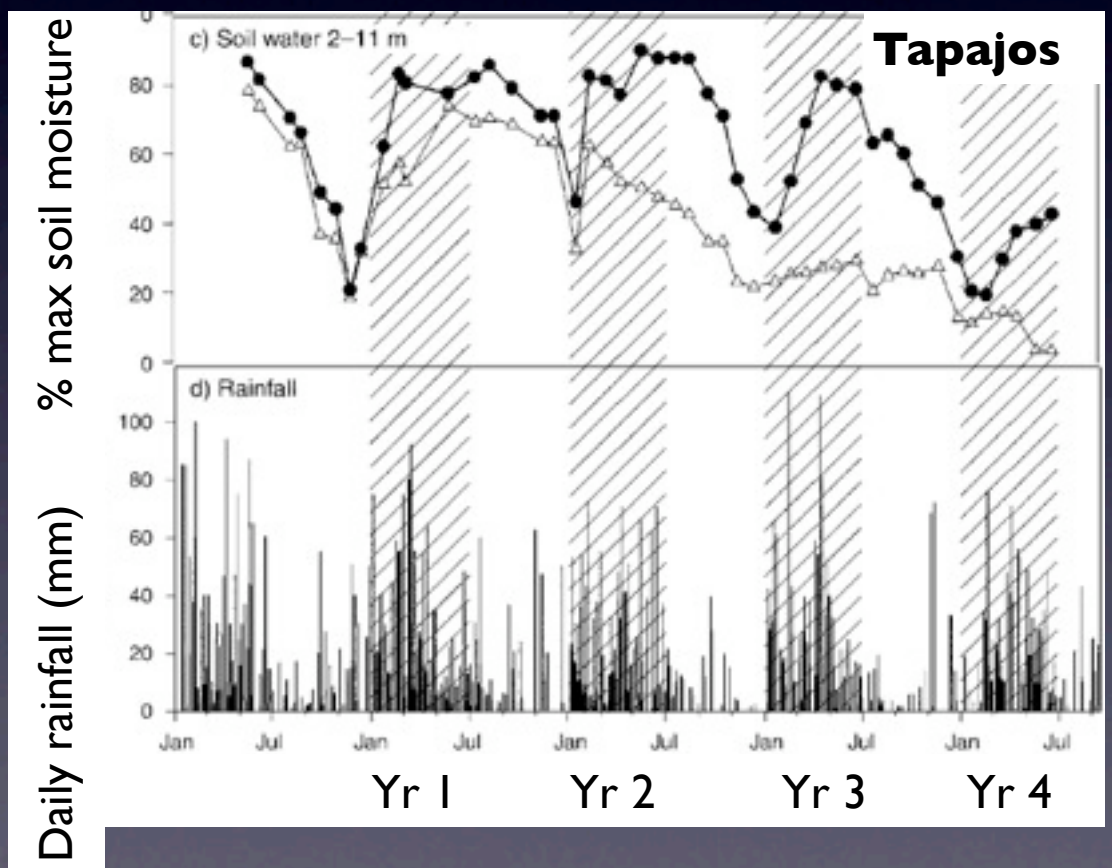
CMMAP team meeting: Multiscale land surface breakout

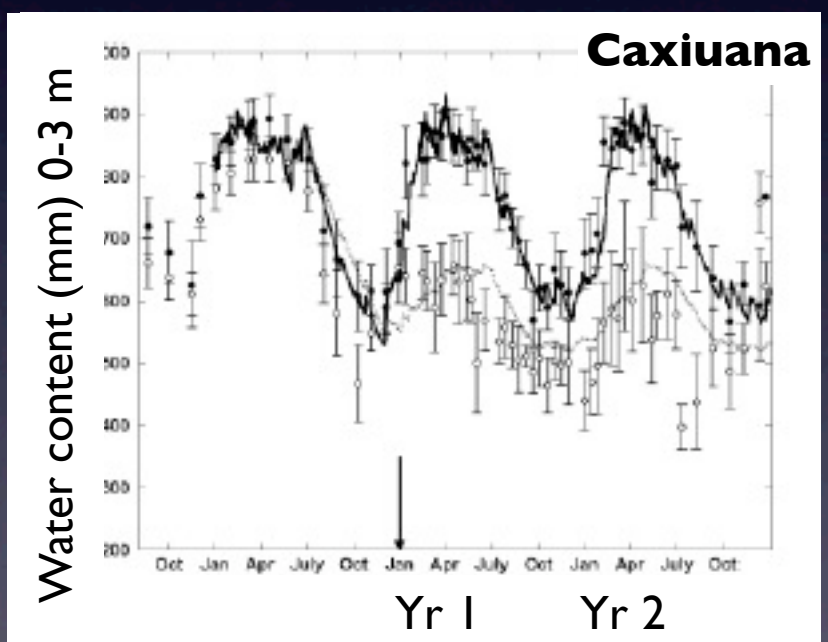
Aug. 12, 2011

What determines tropical forest drought response?

- Observational evidence suggests heterogeneous response
- Requires heterogeneous modeling approach
- Determining factors in forest adaptations
- Testing a new approach
- Implications for multiscale modeling

Effects of multiyear drought





Nepstad et al. 2007 (left)
Fisher et al. 2007 (right)

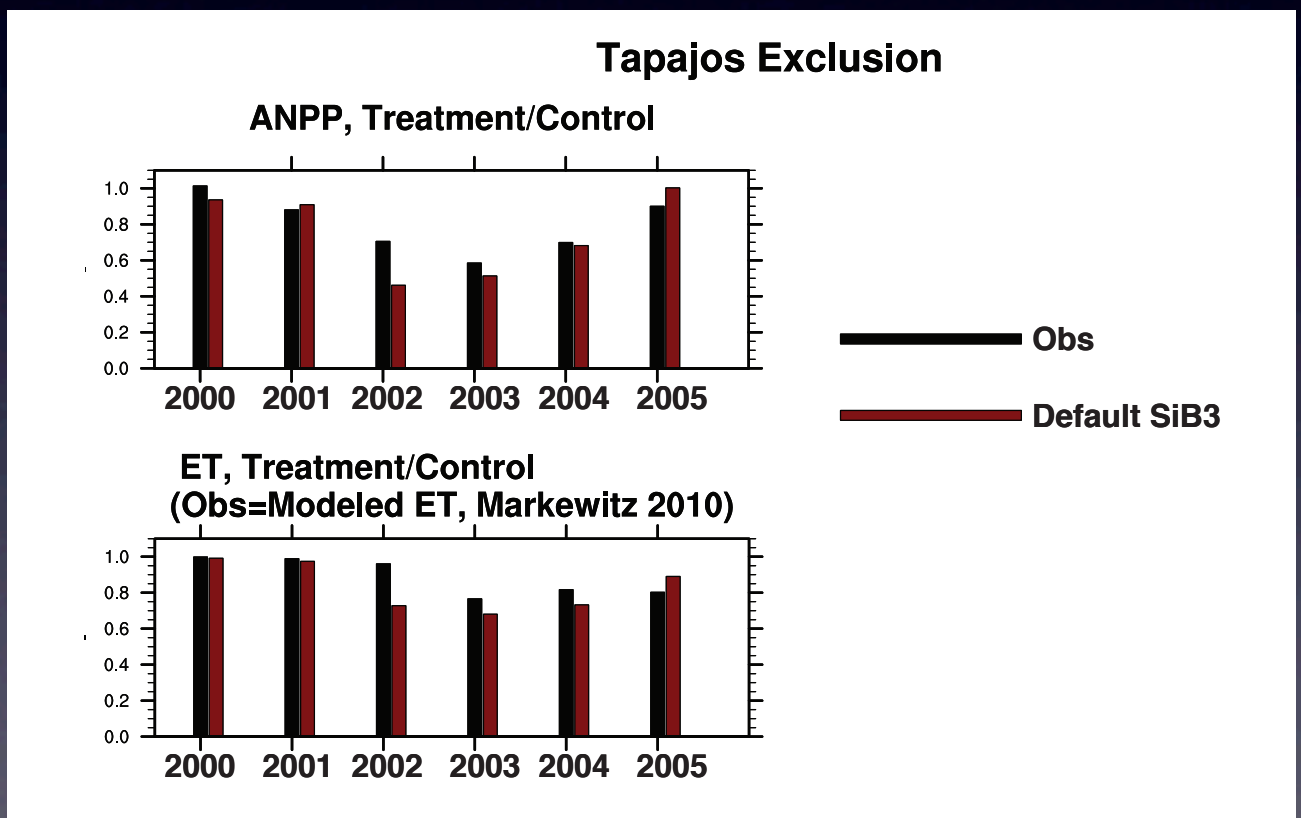
rainfall exclusion

	Tapajos	Caxiuana
rainfall exclusion	during wet season only	year-round
soil type	clay	sand, sandy loam
water table depth	100 m	as shallow as 10 m
annual precipitation	2042 mm	2736 mm
dry season	4-5 months	3 months
strong dry seasons	more long, dry dry seasons	

Caxiuana forest has evolved in a wetter climate

Tapajos exclusion: SiB3

- SiB3 w/ 10 m soil overestimates drought
- Larger soil moisture reservoir (deeper roots) best capture response
- Improvements with observed LAI



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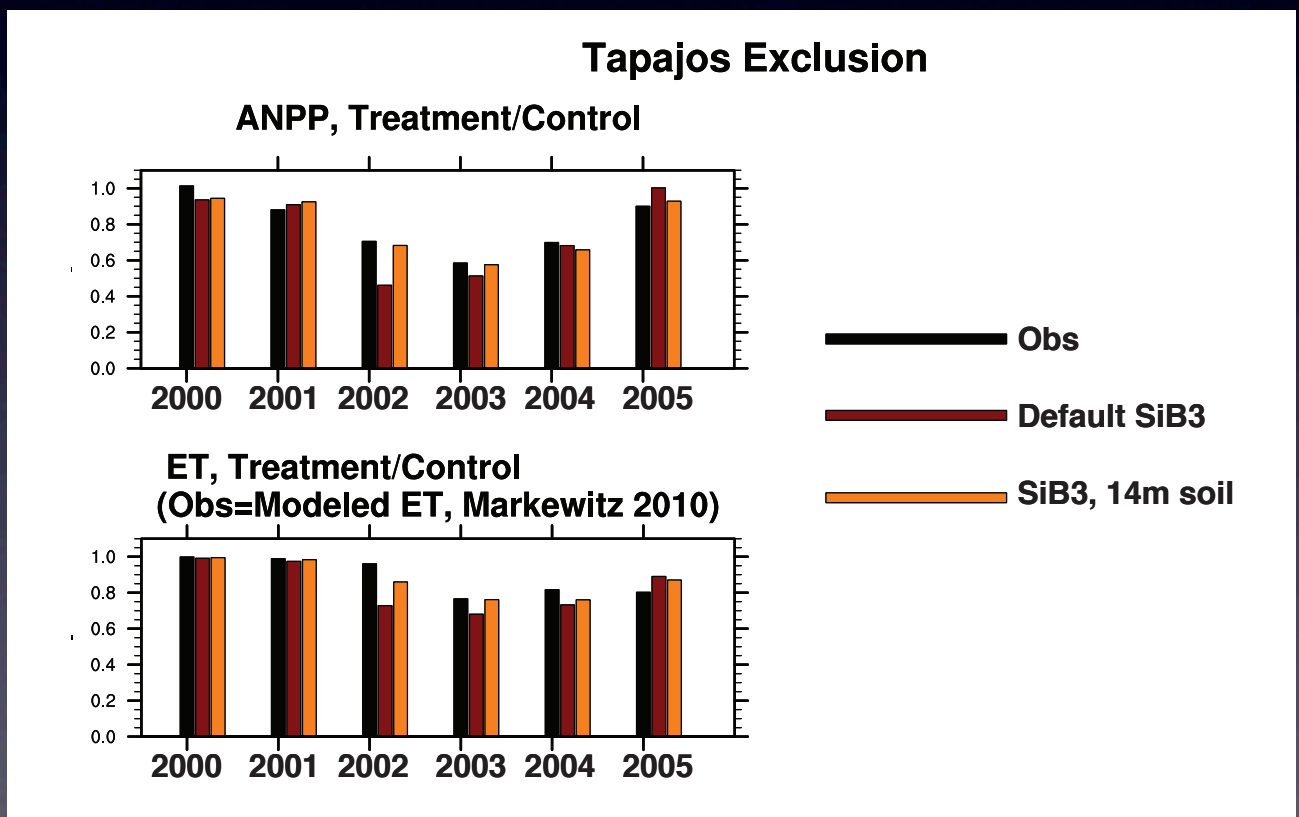

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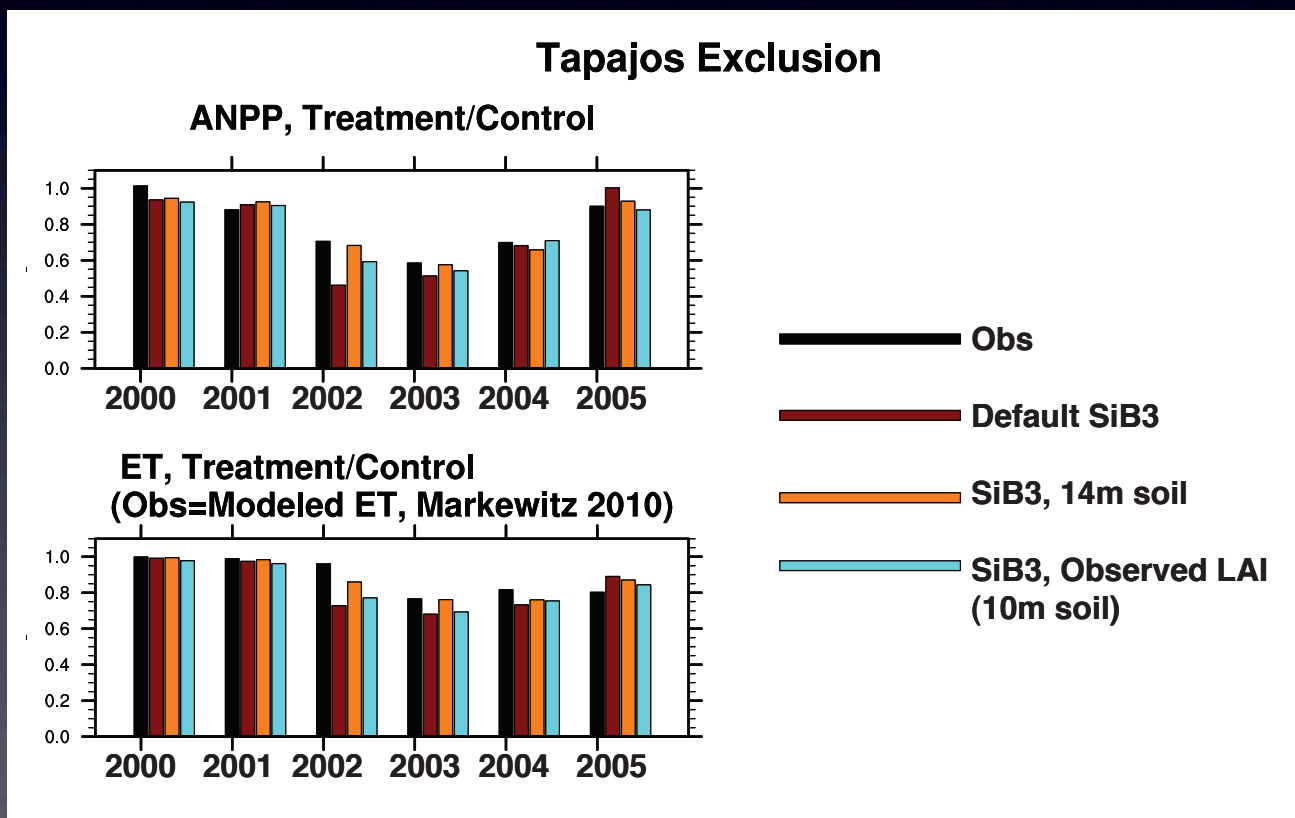

Caxiuana Exclusion: SiB3

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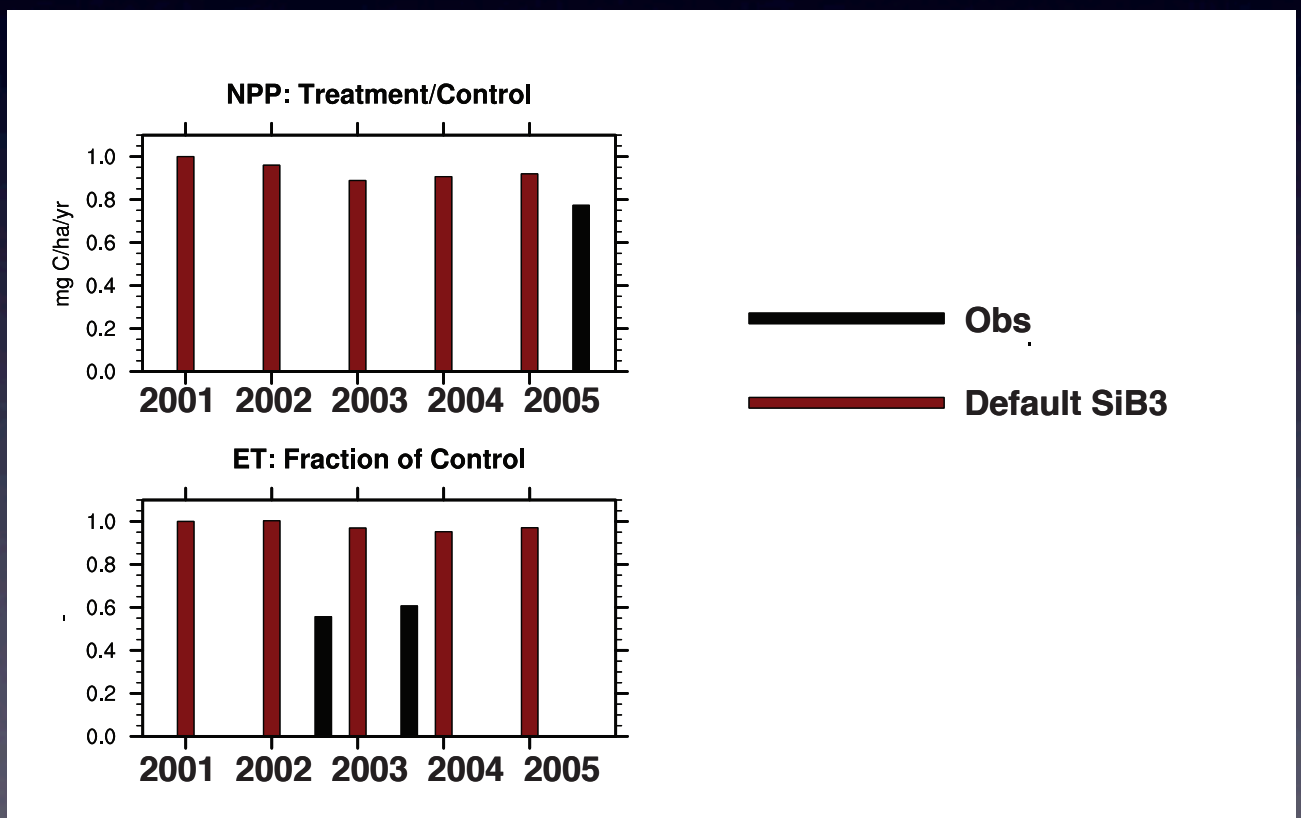
- Shallow roots best capture response
- Improvements with observed LAI & soil type



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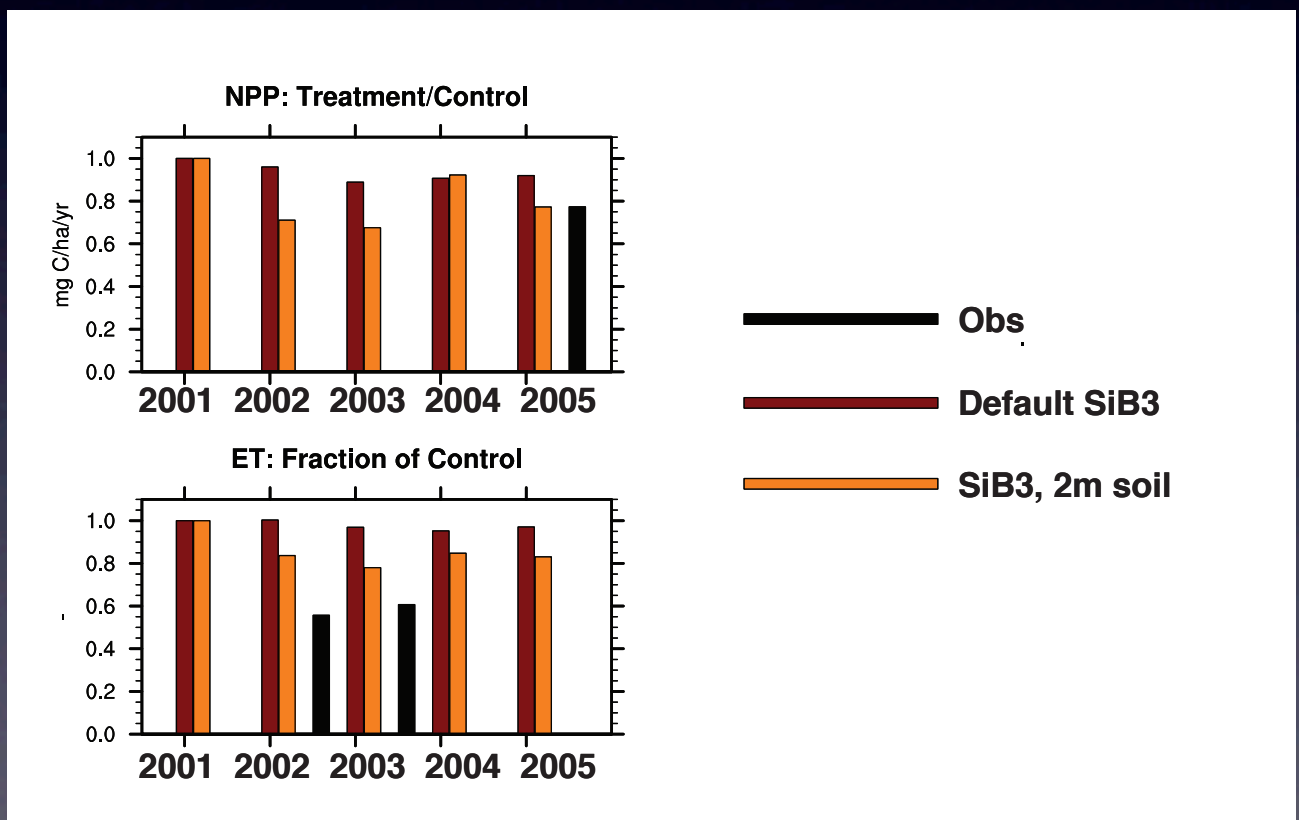

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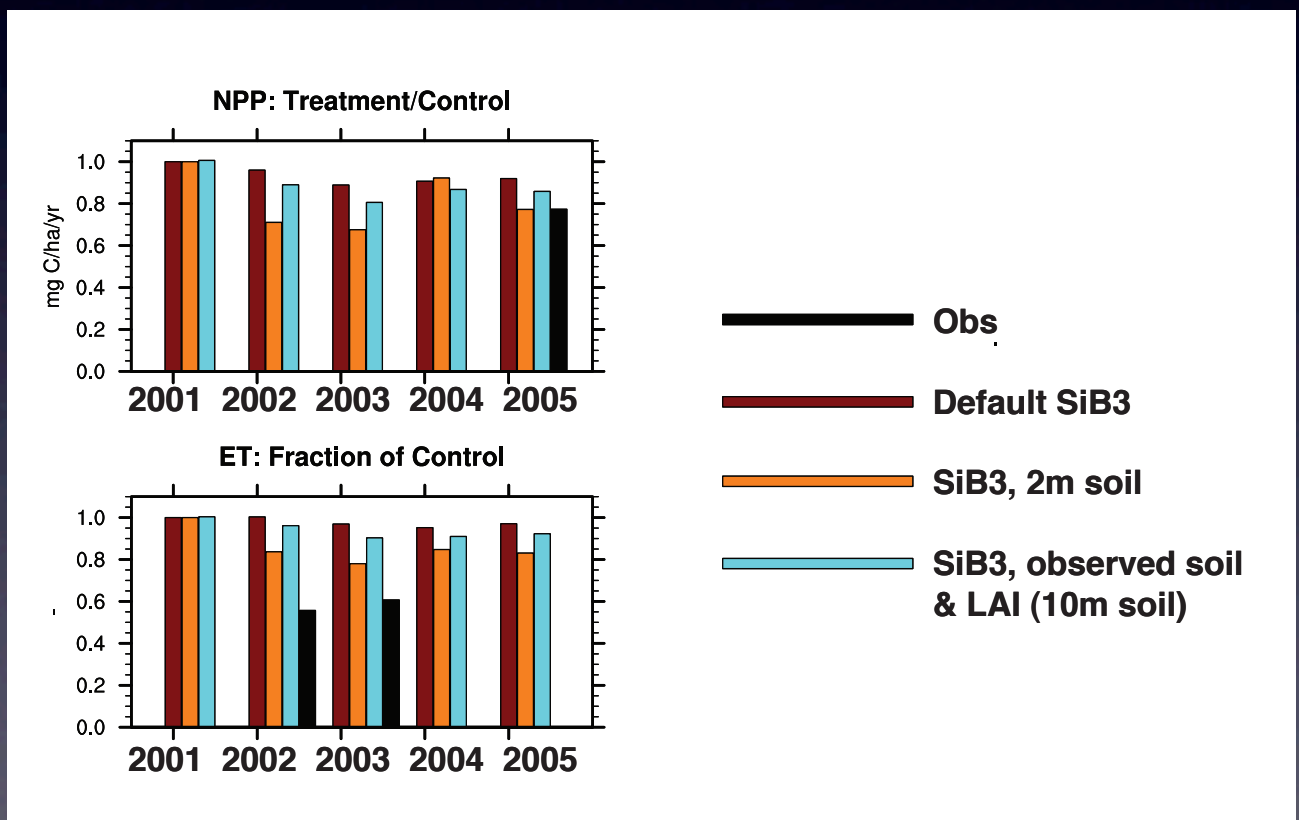
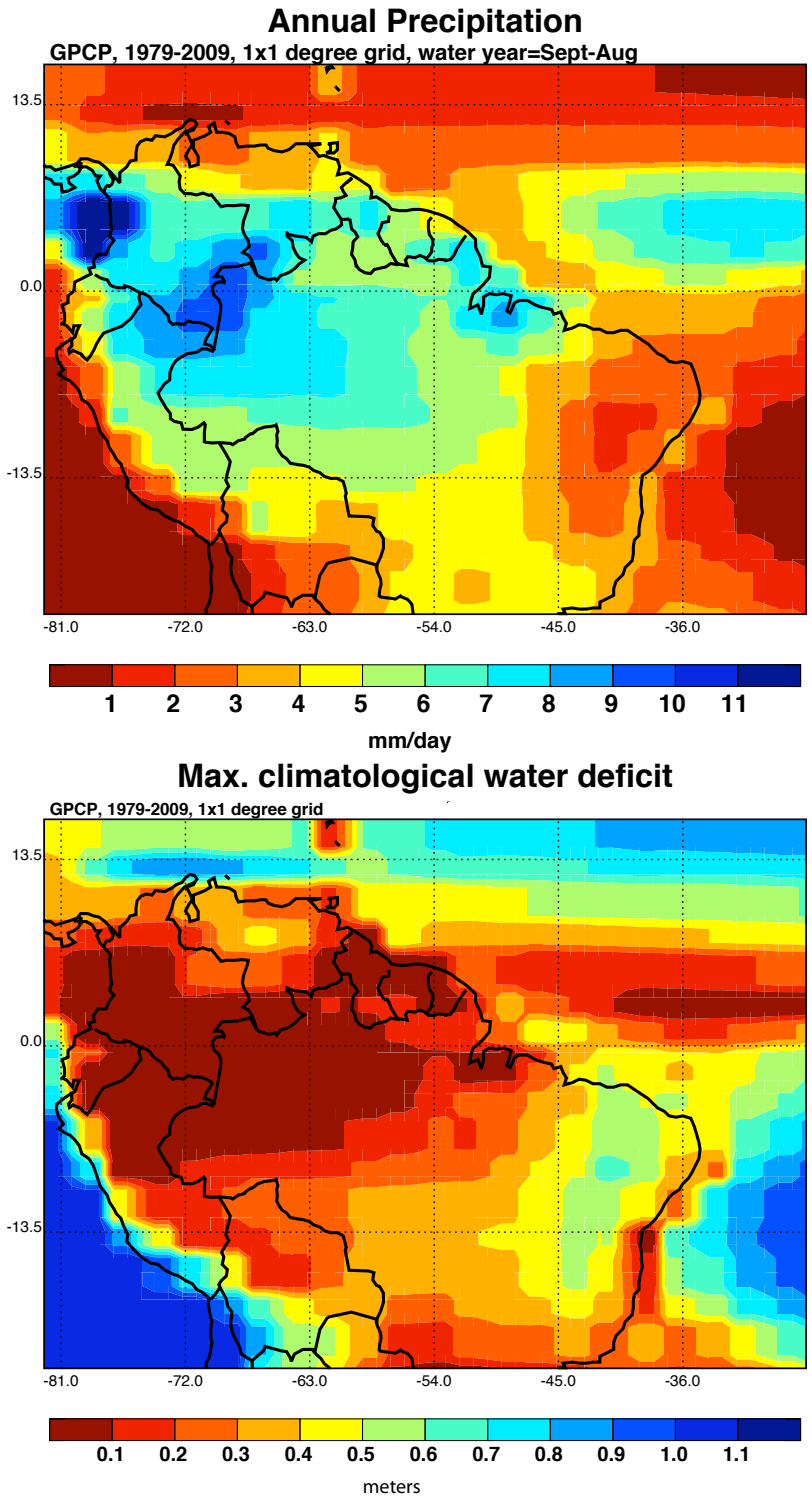
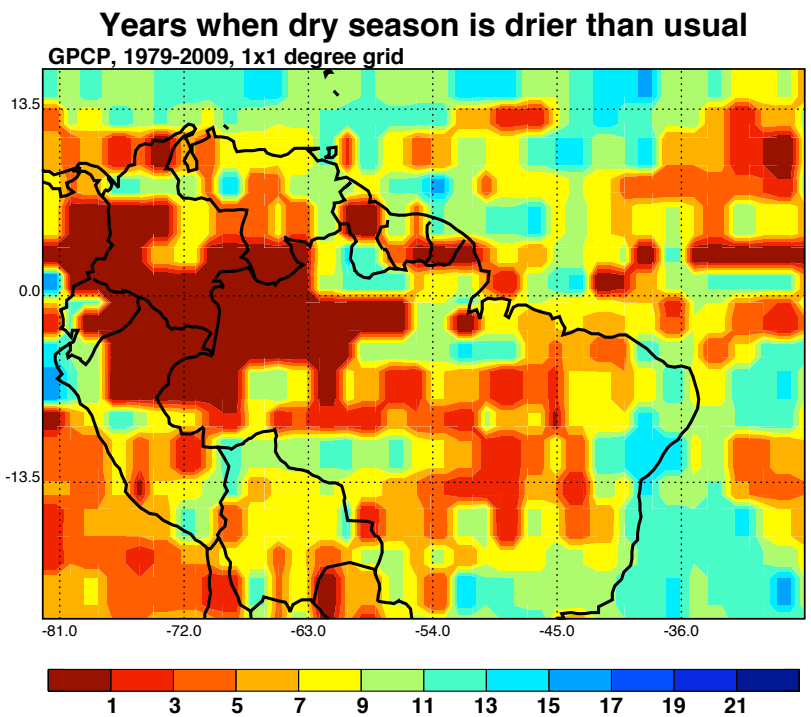


Simulating exclusions in SiB3: Conclusions

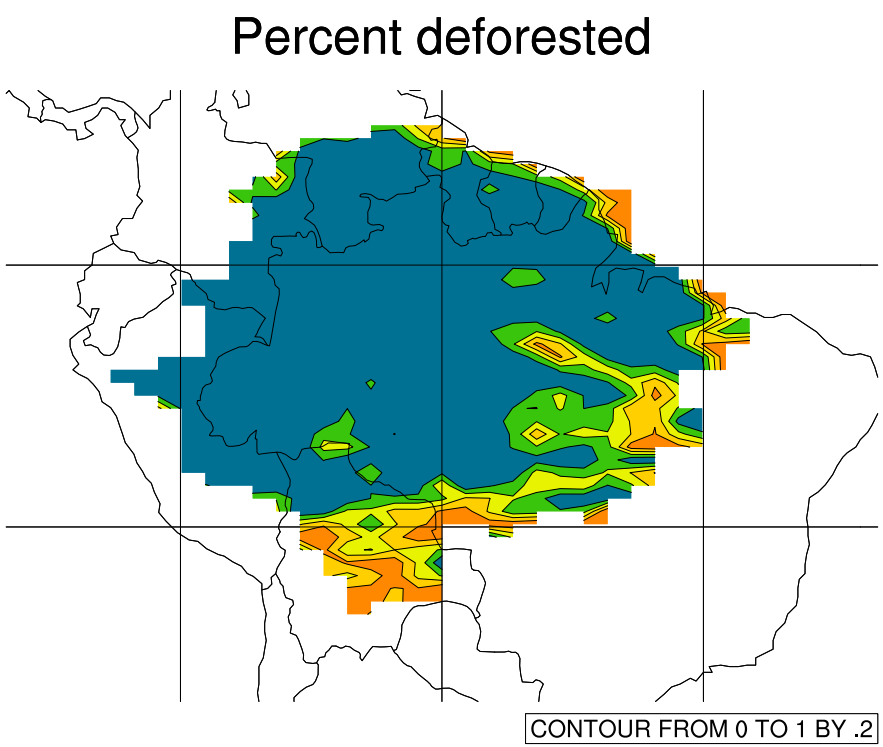
- Rooting strategies, soil hydraulics, and canopy adaptations to drought are essential for accurately capturing drought response
- These vary dramatically throughout the Amazon
- One strategy to improve SiB3 is to have spatially varying root depth, based on observations where possible

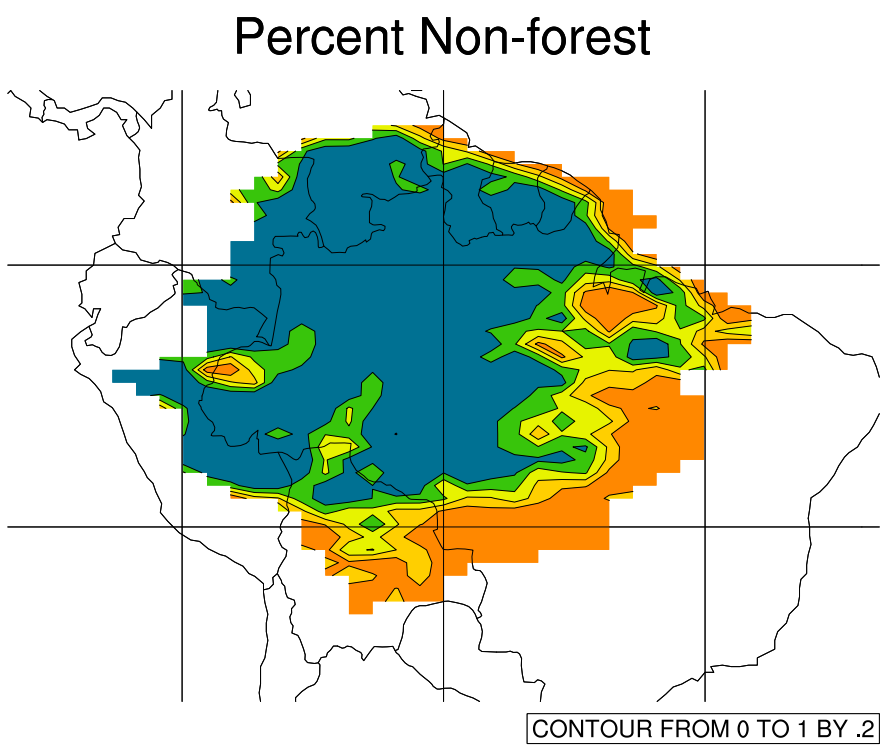
Precipitation statistics





Forest cover

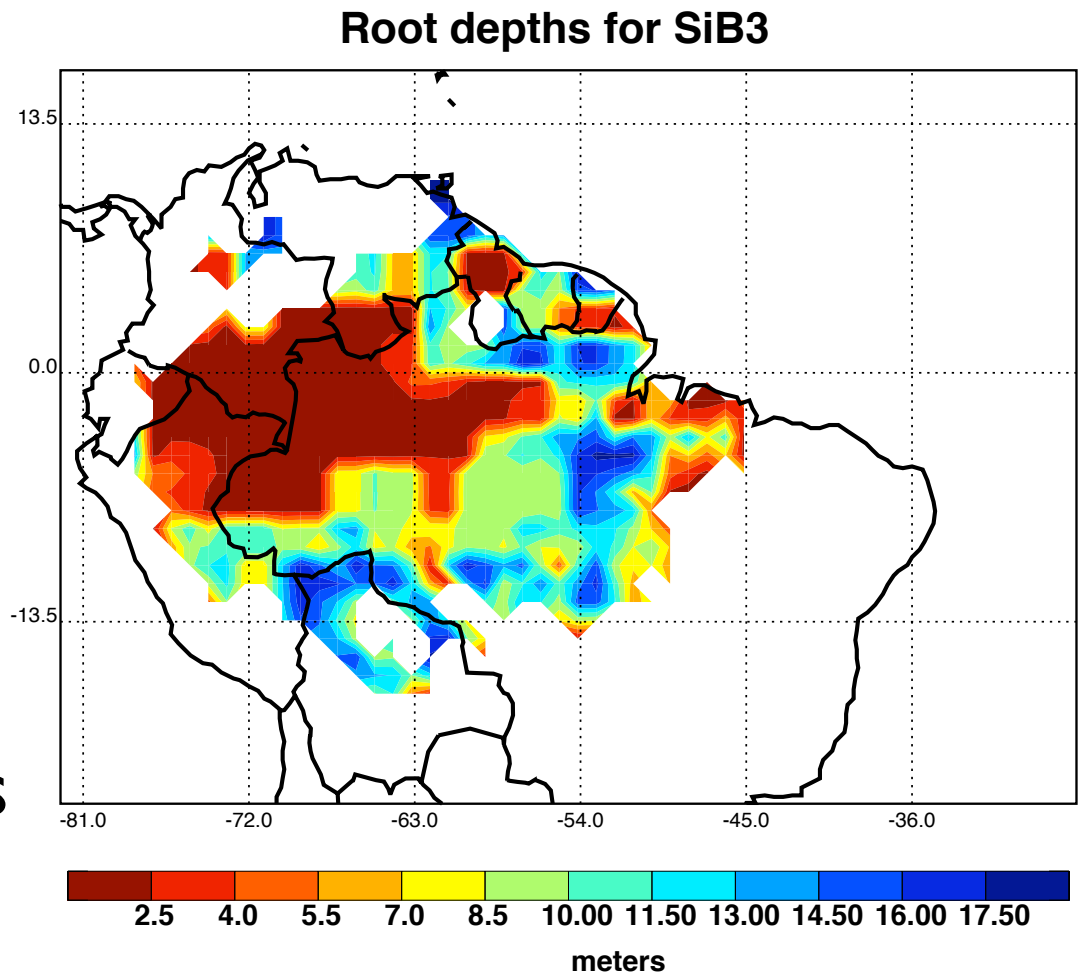




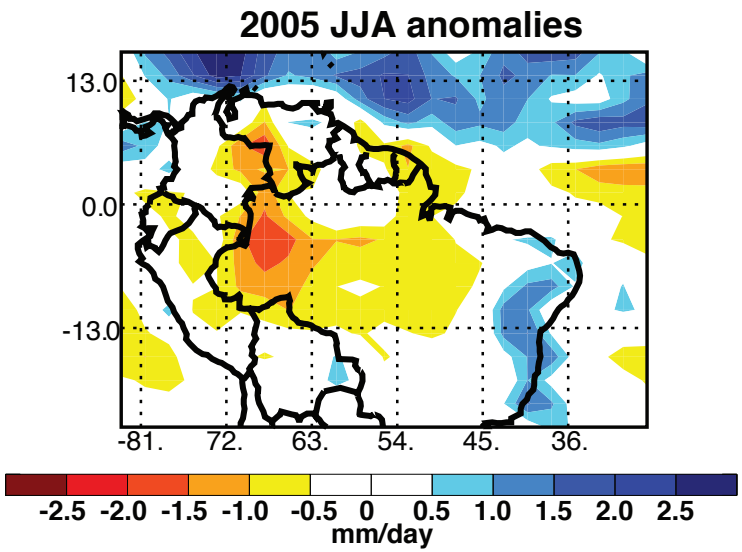
- 8 m roots in nonforest (ie: pasture)
- 0 m roots in deforested

Variable root depth

- Shallow roots where annual rainfall is high and dry seasons are less severe
- Deeper roots elsewhere
- Deforestation reduces root depth

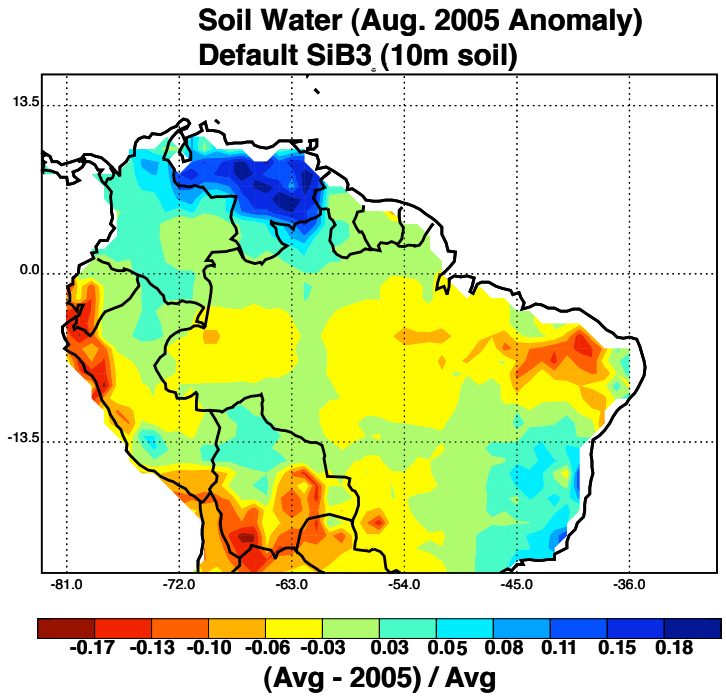


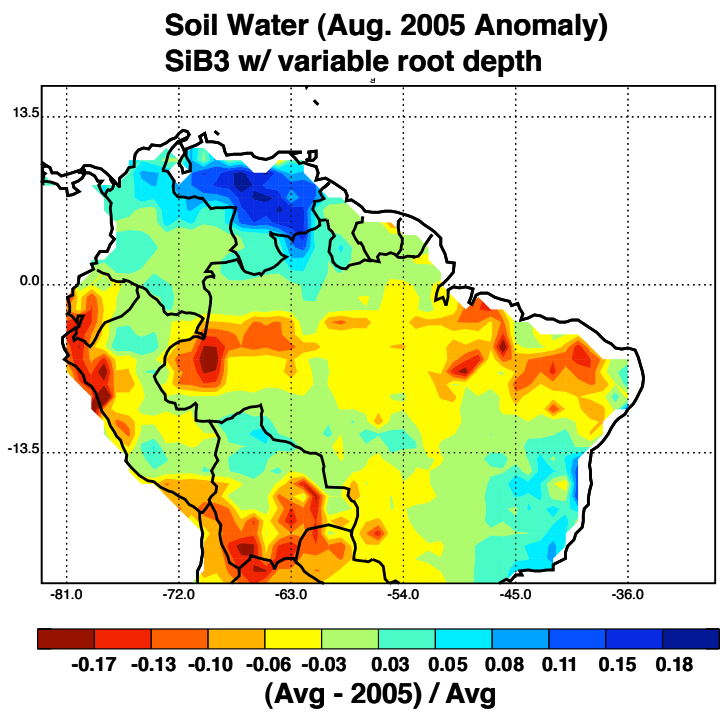
Results with varying root depth



2005 drought

- soil water deficits
- decreased latent heat from forest
- decreased carbon assimilation





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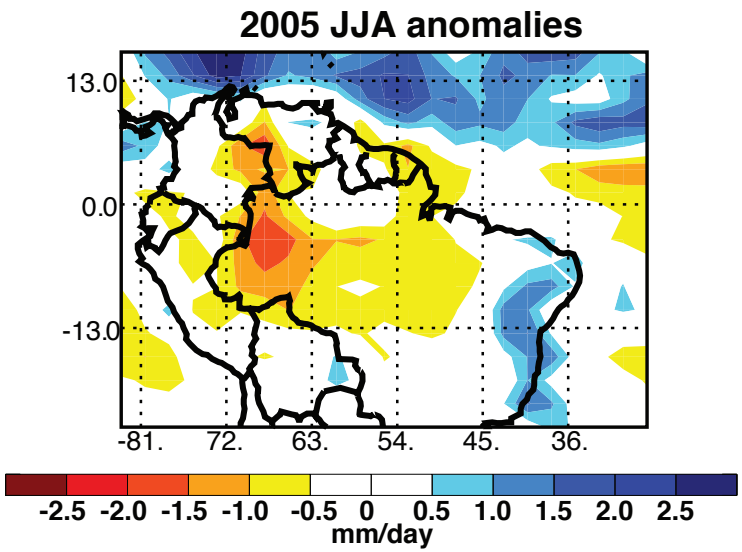

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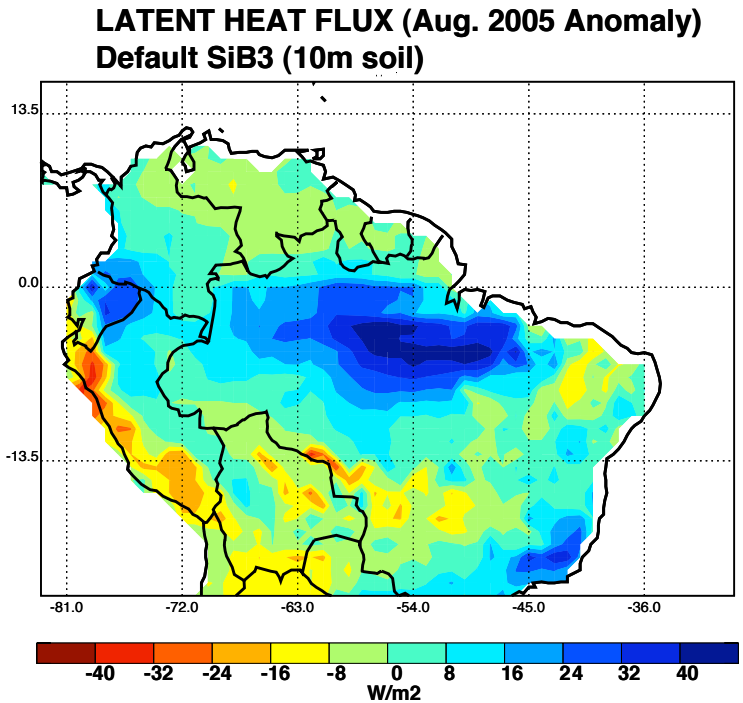

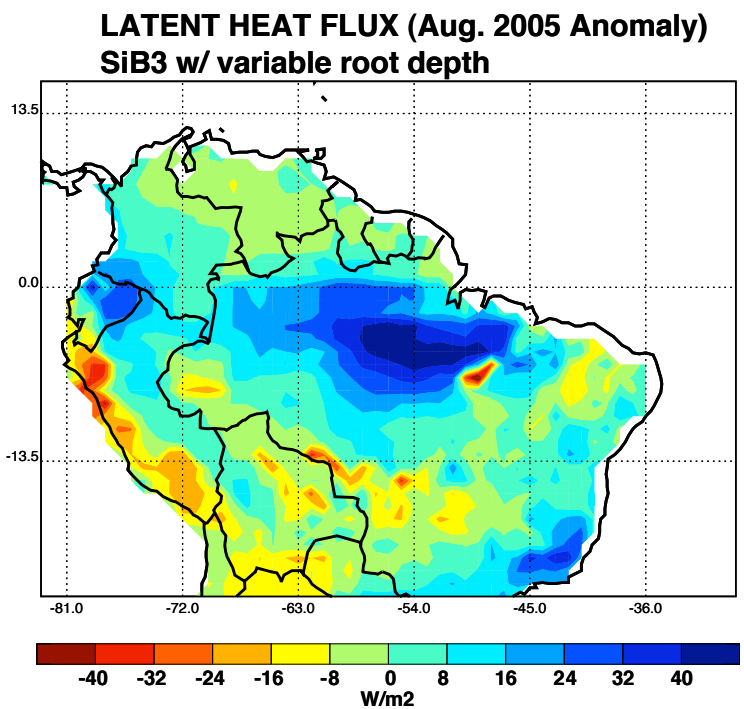

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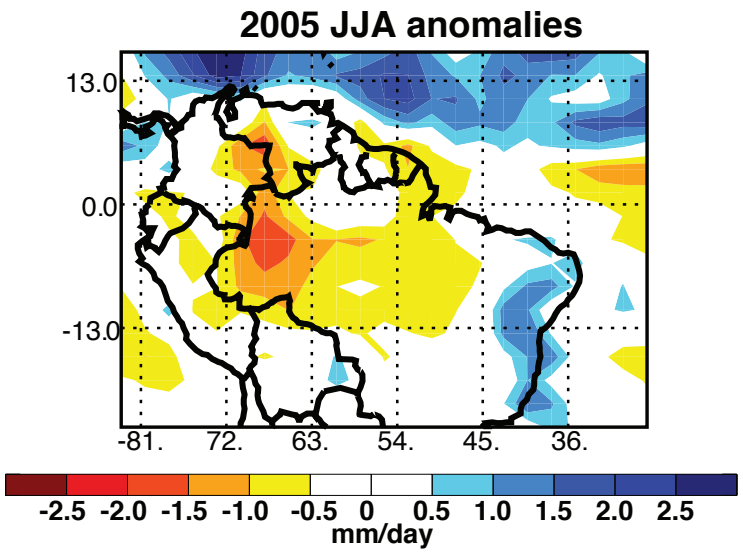

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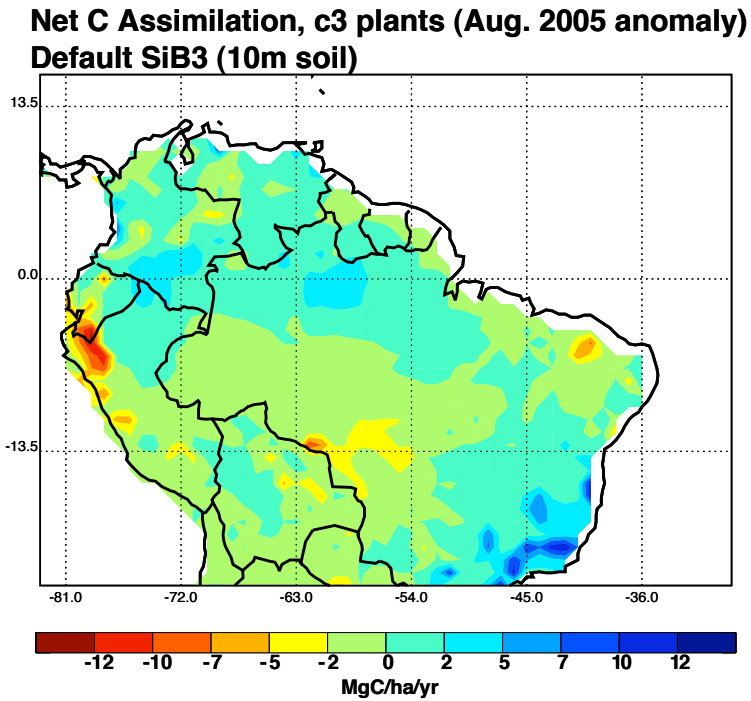

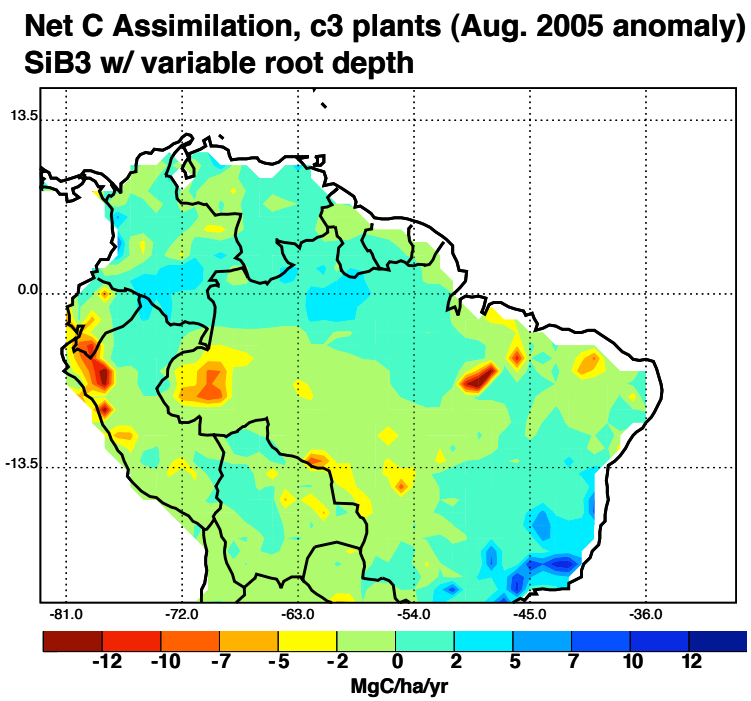

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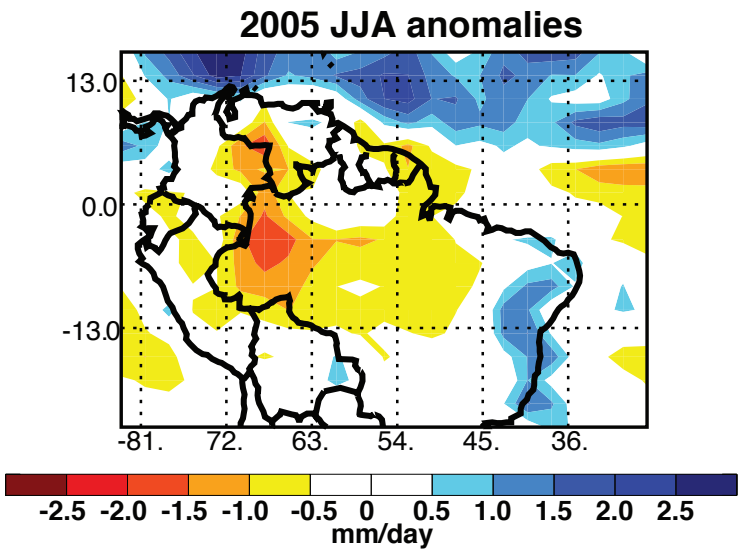

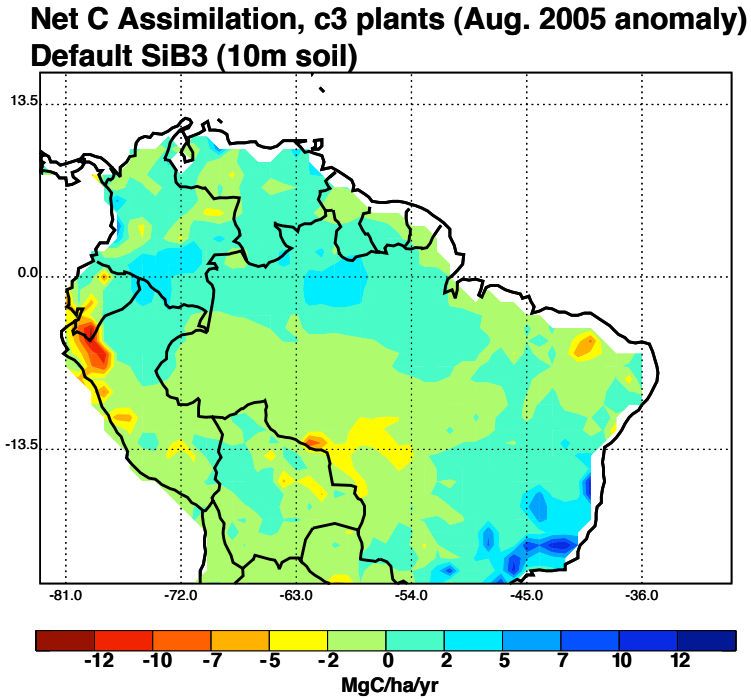

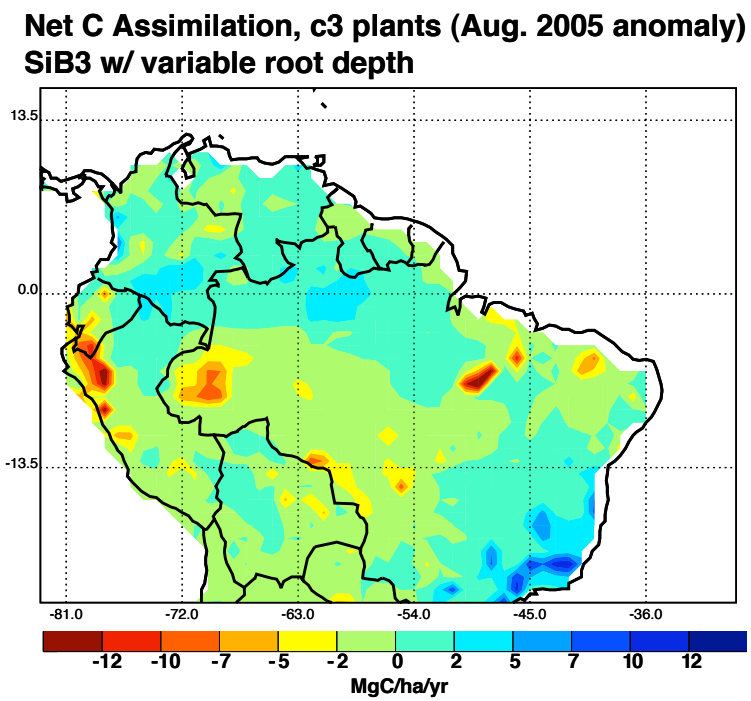

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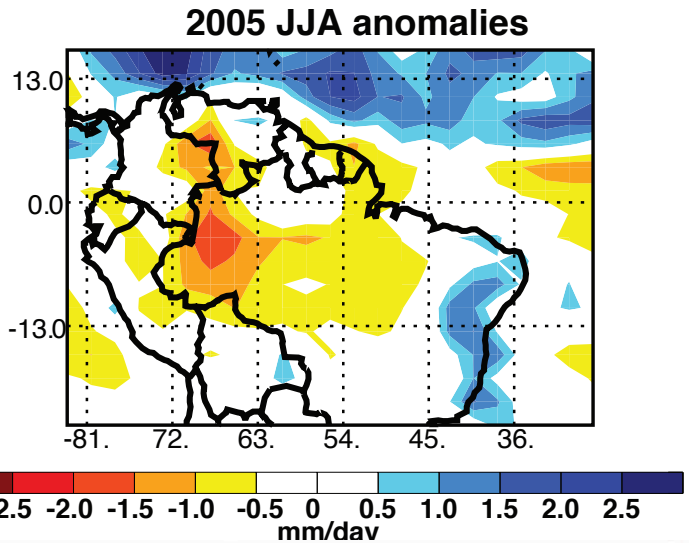

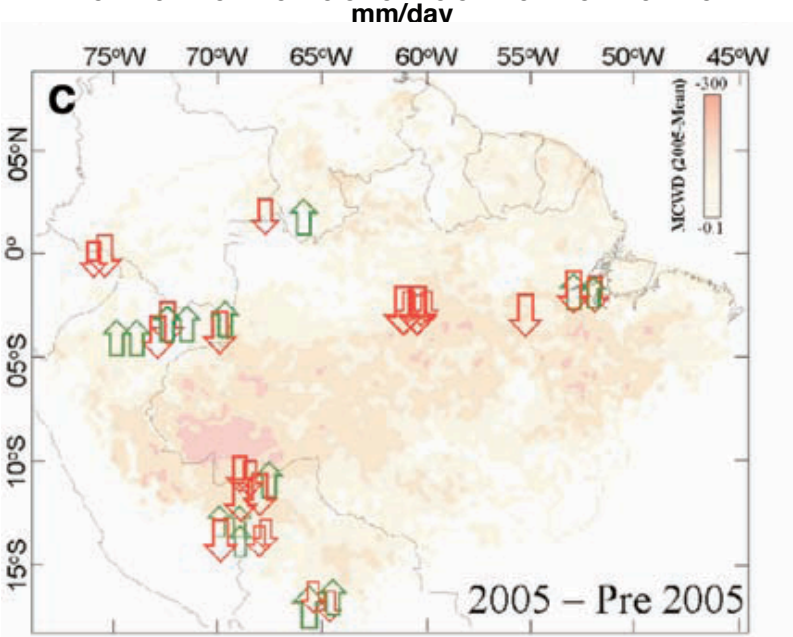

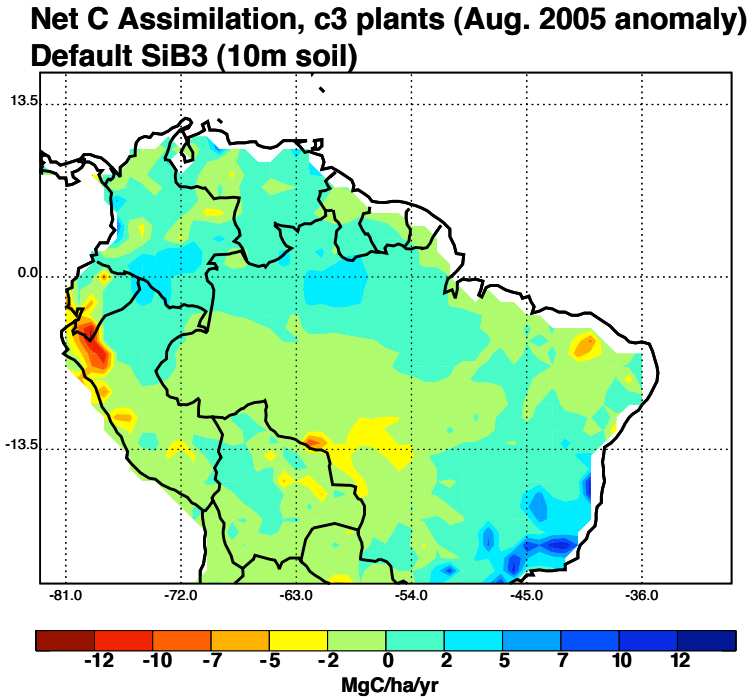

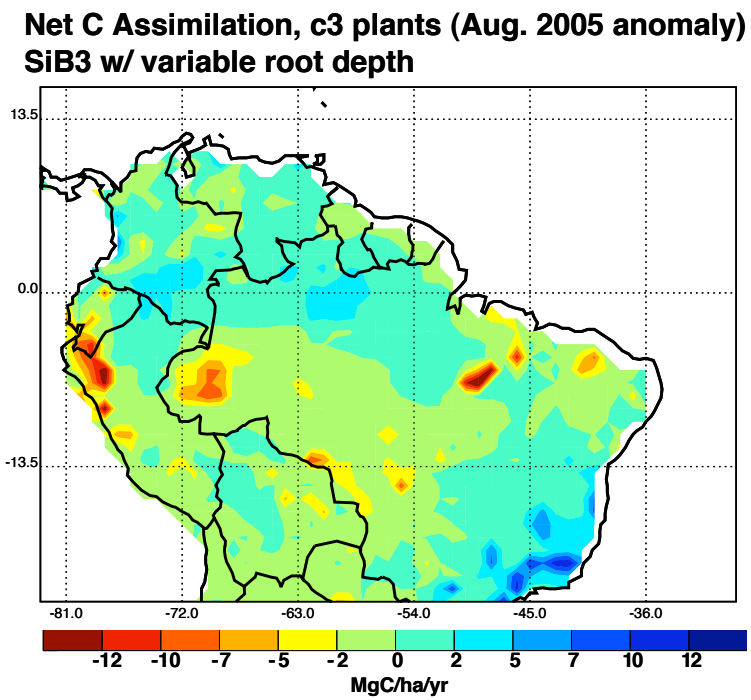

Phillips et al. 2009: Drought sensitivity of the Amazon rainforest, *Science*

Implications

- Variable root depth will increase or decrease forest's ability to survive strong droughts, hopefully in manner similar to observations
- Use in multiscale modeling will be more meaningful with more observations of tropical root depths and stand-level response to drought events
- Up to now, we have made SiB3 more resistant to droughts. This work will reverse that when appropriate.