CCSM Working Group Meetings

CLM-related model evaluations and improvements at the University of Arizona

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CLM-Related Progresses

CLM4 improvement

- Skin temperature diurnal cycle over arid regions (Zeng et al.)

Land-atmosphere interaction

- Land-precipitation coupling strength (Zeng et al.)
- Impact of interannual climatic variabilities on vegetation (Shao et al.)

CLM evaluations

- Monthly river flow prediction (or simulation) (Zeng et al.)
- CMIP5 carbon cycle (Shao et al.)
- Steady state of Fractional Cover/carbon (Sakaguchi et al.)
- Dynamic root function (Christoffersen et al.)
- PFT distribution across Amazon (Moreno et al.)

Ongoing work (not discussed here)

- Global 1 km hybrid 3-D hydrological modeling
- B2 Landscape Earth Observatory (LEO)

Improve the Skin Temperature Diurnal Cycle over Arid Regions (Zeng et al. 2012; in press)

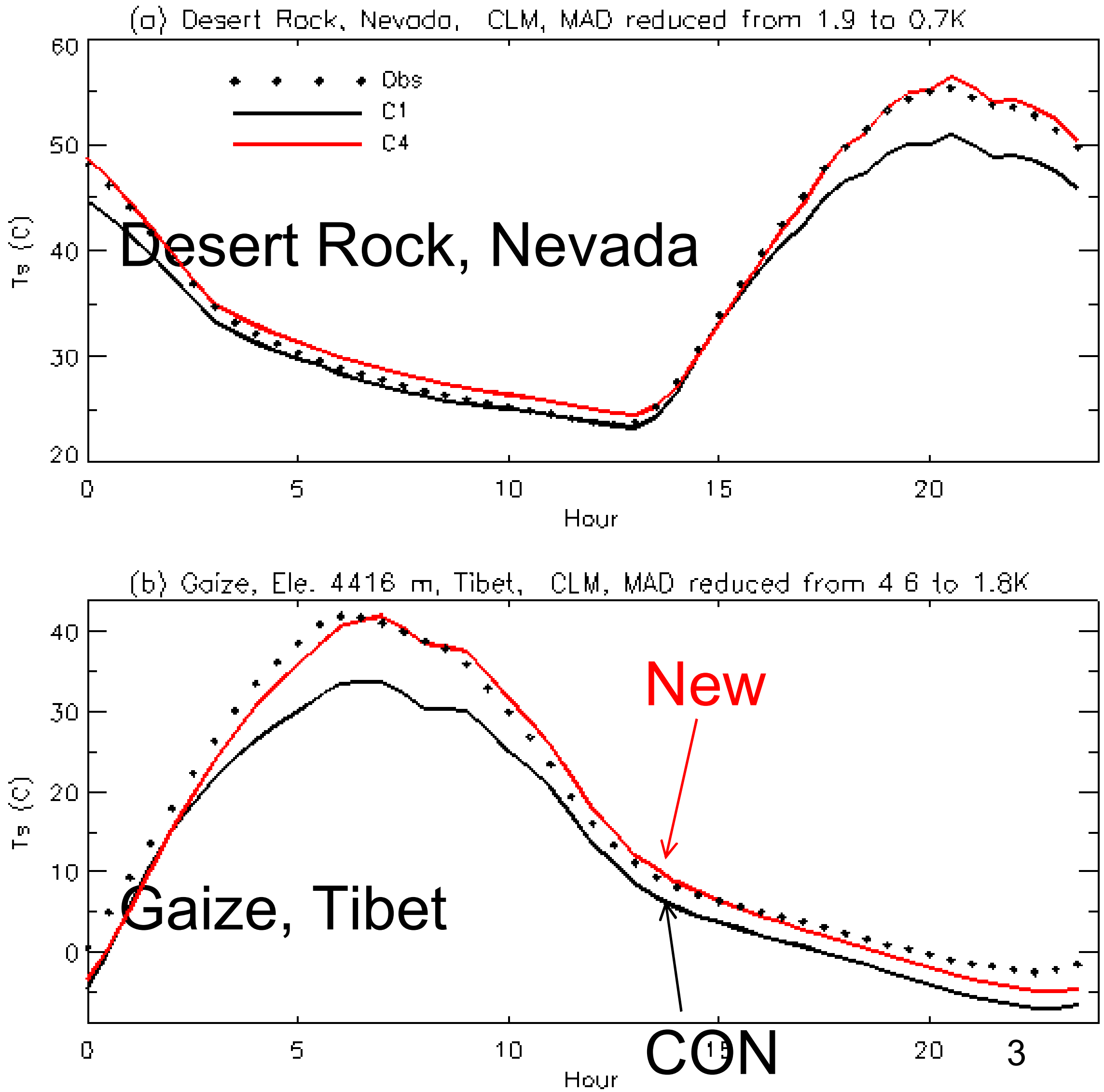
$\ln(z_{om}/z_{ot}) = 0.36\,(u_* z_{om}/\nu)^{0.5}$

$u_{*min} = 0.07\,\rho_o/\rho\,(z_{om}/z_{og})^{0.18}$

minimum K_{soil} = 0.75 $Wm^{-1}K^{-1}$

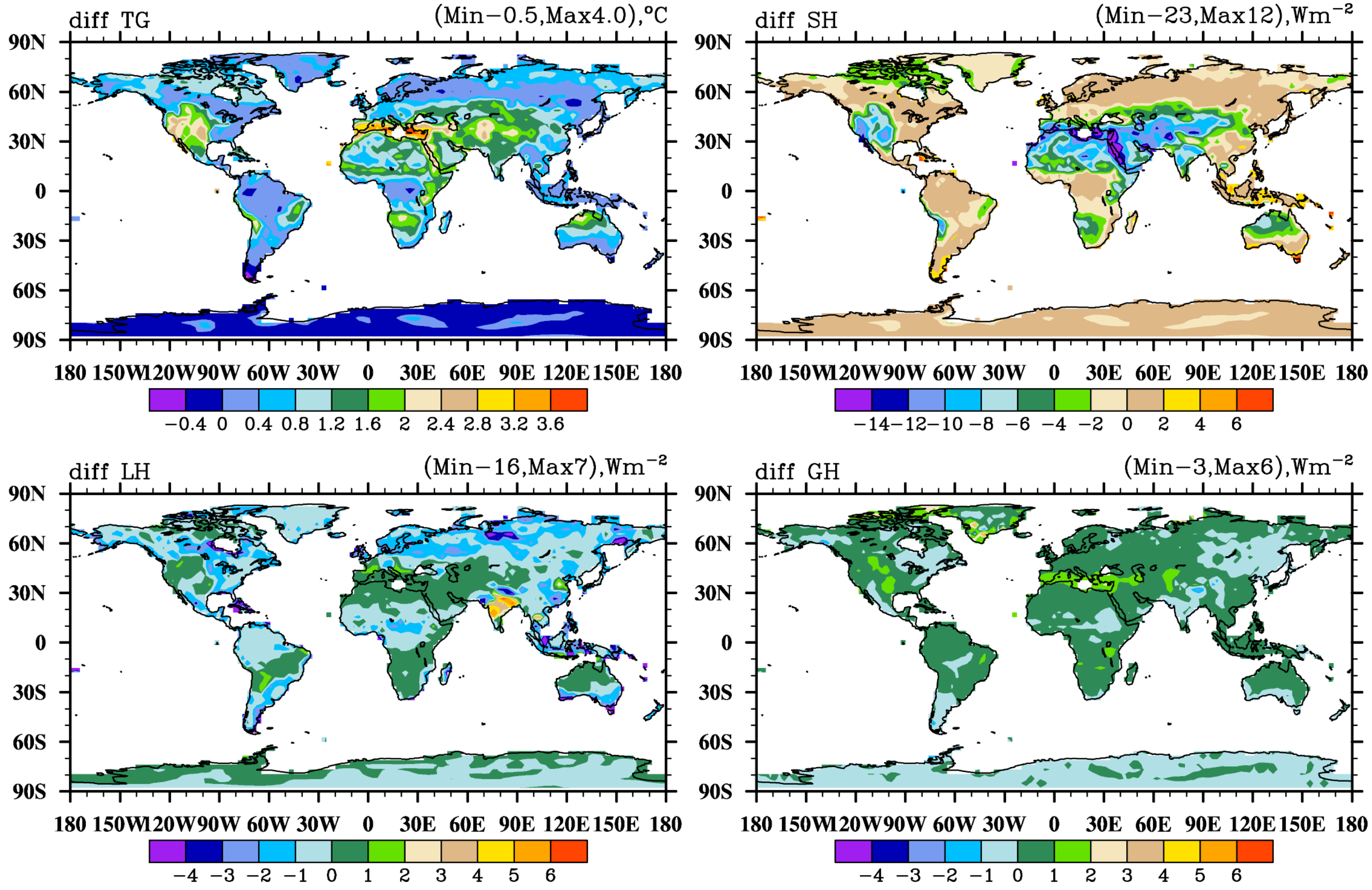
Mean absolute deviation (K)

	Desert Rock	Gaize
Con	1.9	4.6
New	0.7	1.8



New - Control

Global T42 July

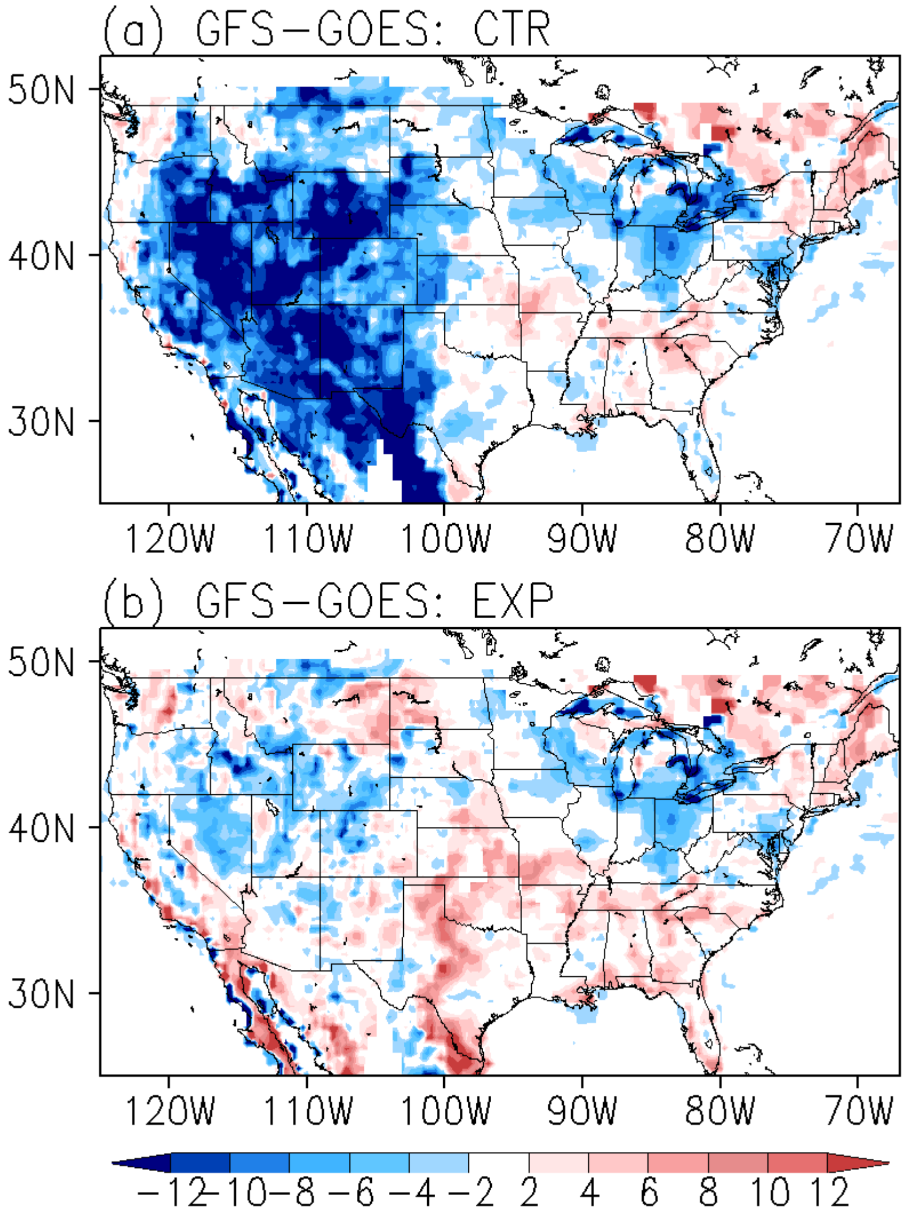


The same formulation for roughness length has been Implemented and tested in NCEP GFS operational Model (Zheng et al. 2012; in press)

Significant improvement over semi-arid regions

Significant increase in the number of surface-sensitive satellite brightness temperature data assimilated (not shown)

Skin temperature difference at 1800 UTC



Land-atmosphere interaction

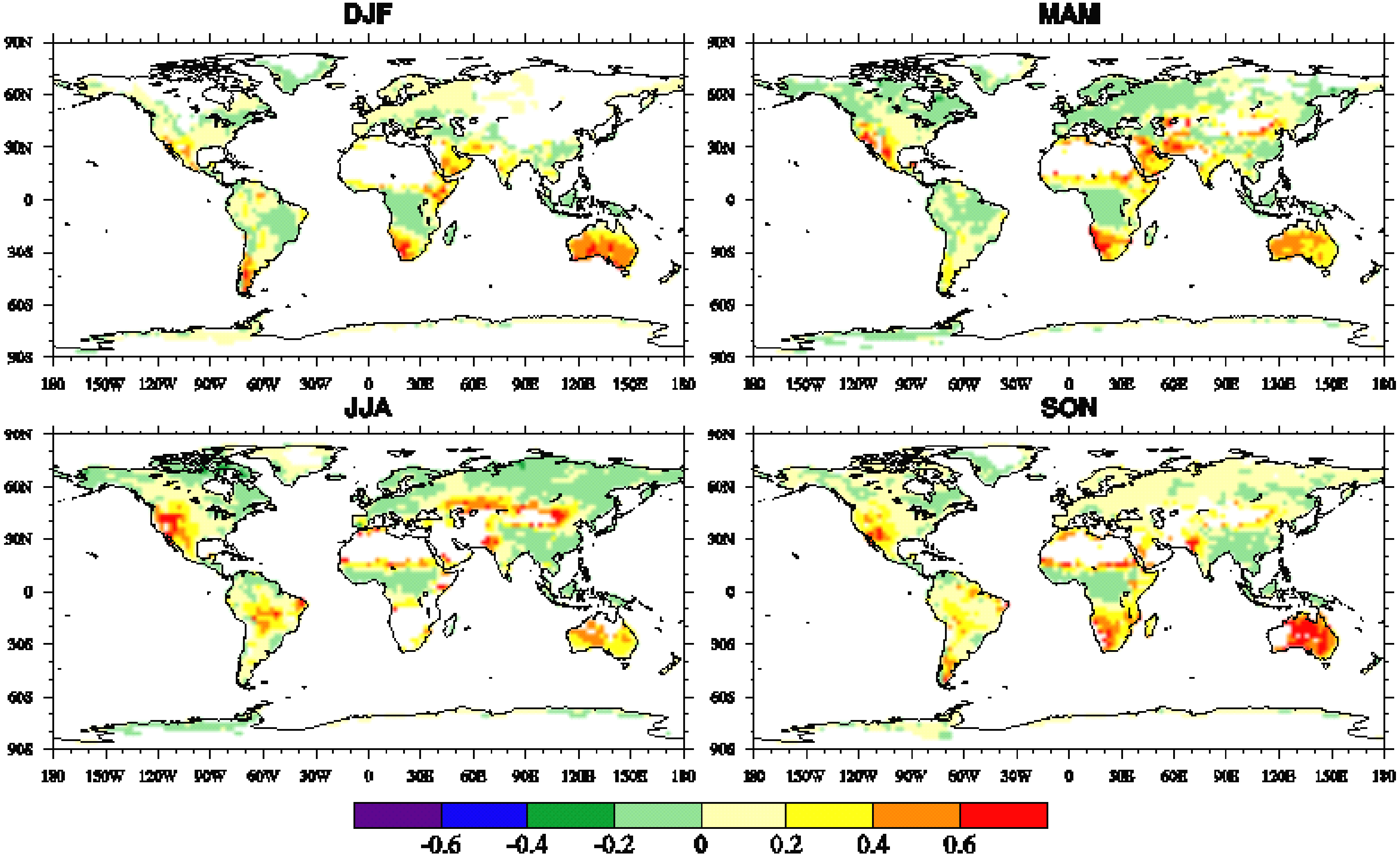
- ***Land-precipitation coupling strength (Zeng et al.)***
- Influence of interannual climatic variabilities on vegetation(Shao et al.)

Land-Precipitation Coupling Strength (Zeng et al. 2010)

$$\Gamma = \Sigma P'E' / \Sigma P'P'$$

E’, P’ are monthly deviations from climatology

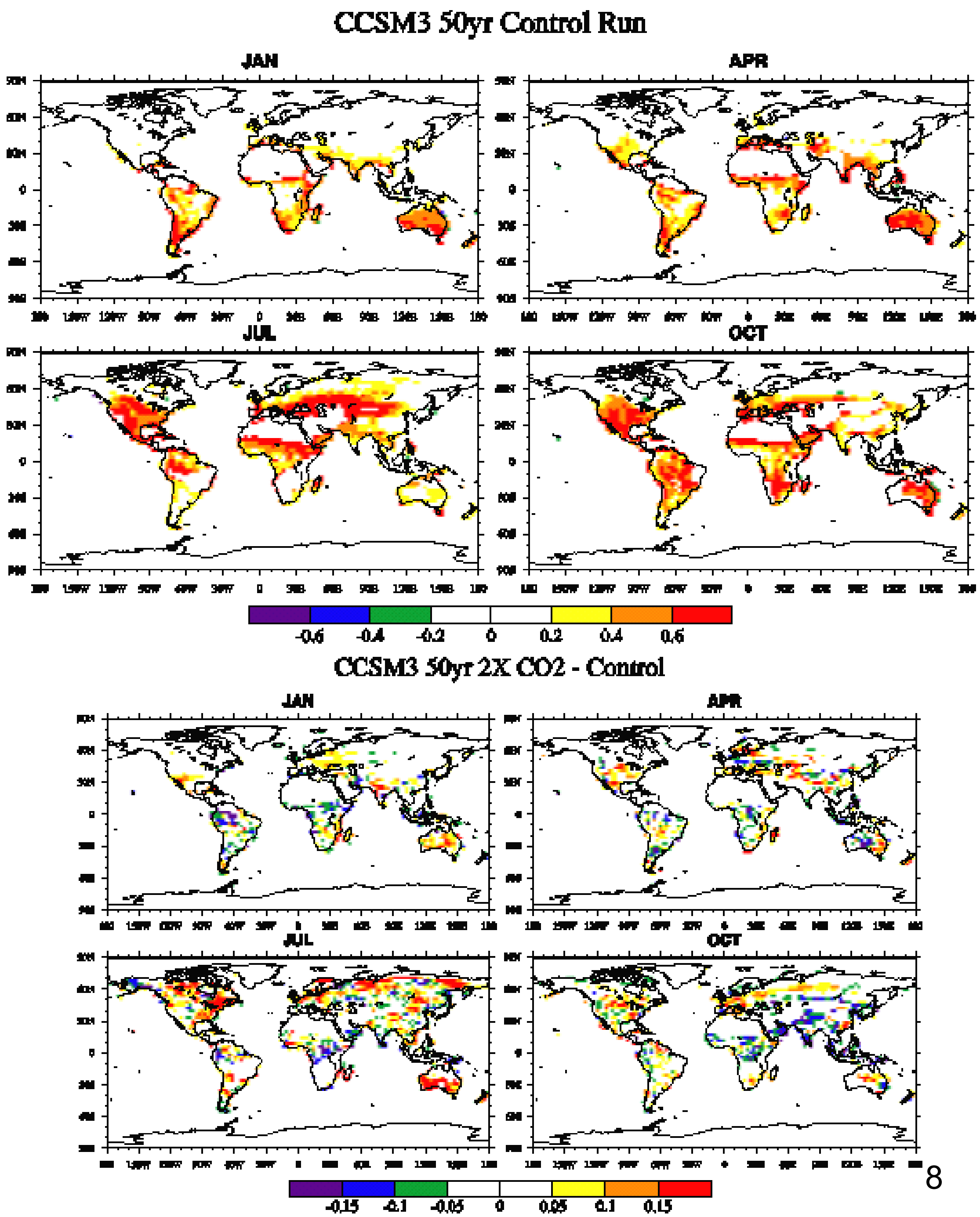
ECMWF 45yr Reanalysis



Γ provides a simple indicator to characterize a GCM's coupling strength

CCSM3 coupling is too strong

$2*CO_2$ increases the coupling strength over high latitudes in summer

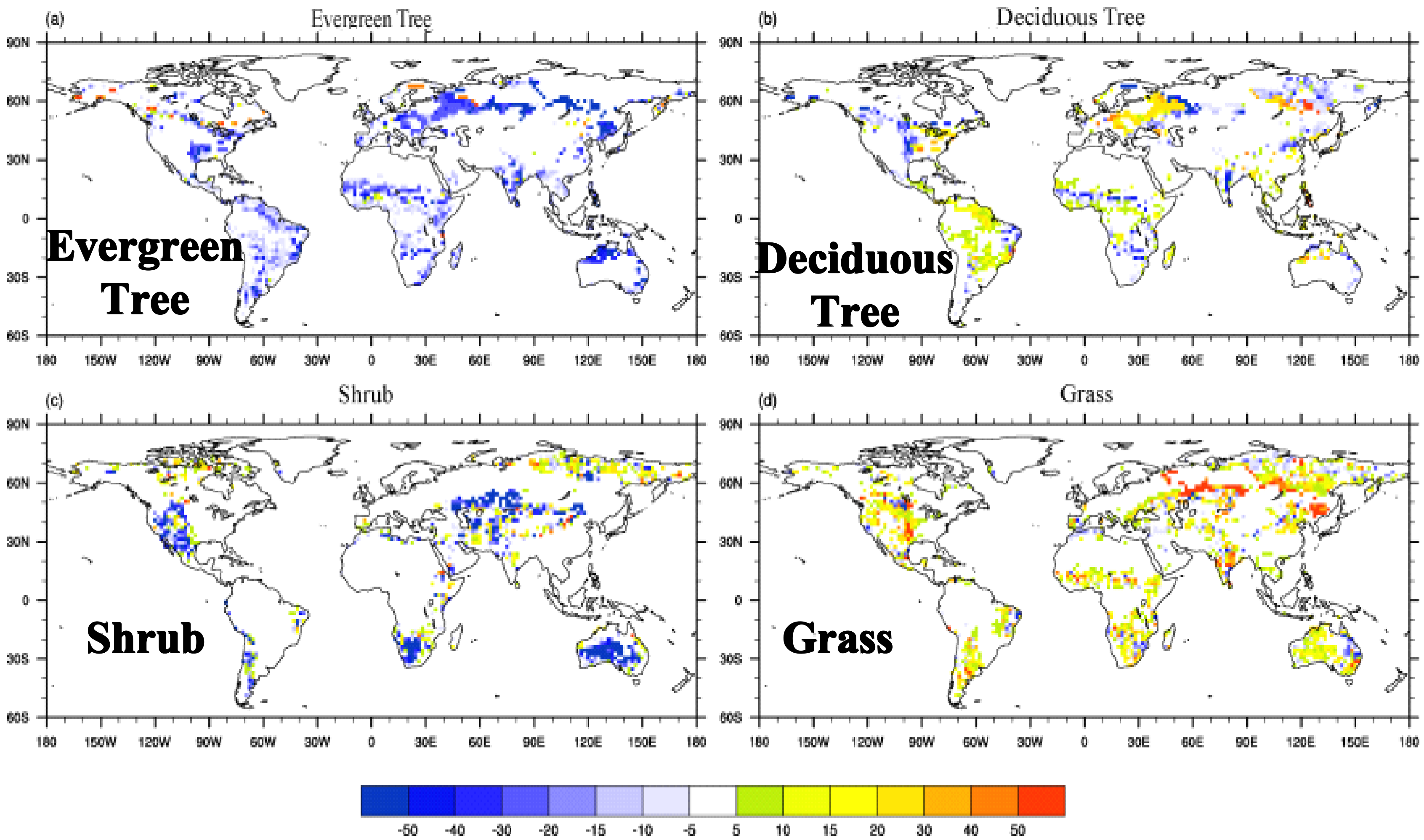


Land-atmosphere interaction

- Land-precipitation coupling strength (Zeng et al.)
- ***Impact of interannual climatic variabilities on vegetation (Shao et al.)***

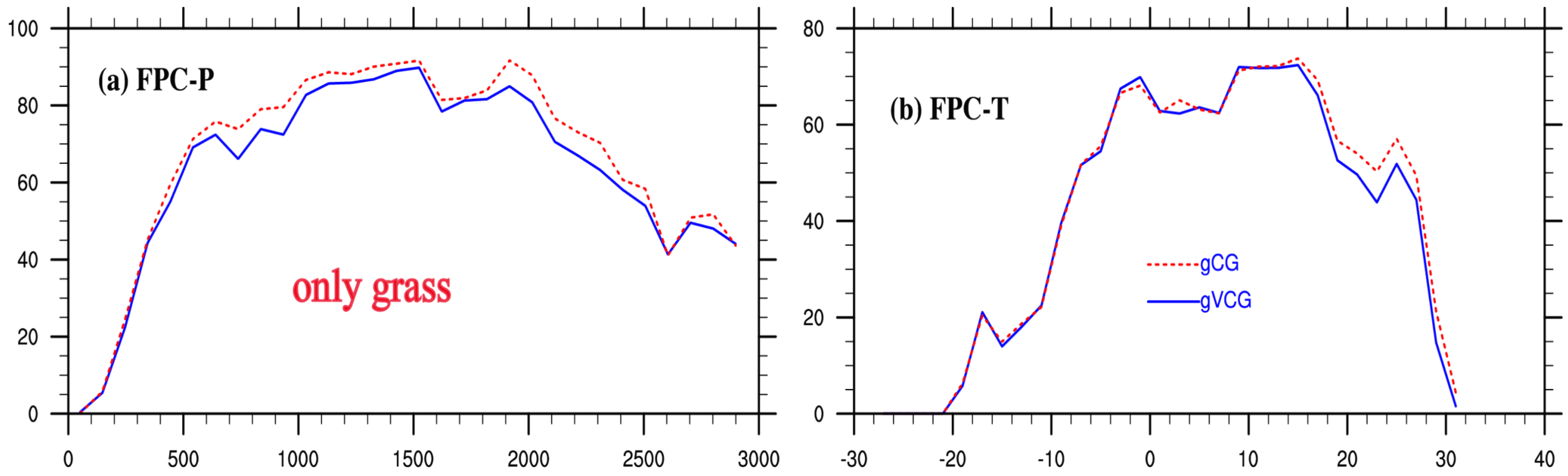
  - CLM/DGVM forced by observations from 1950-1999 versus from climatology.

Impact of Climatic Interannual Variabilities on Vegetation(Shao et al. 2011)



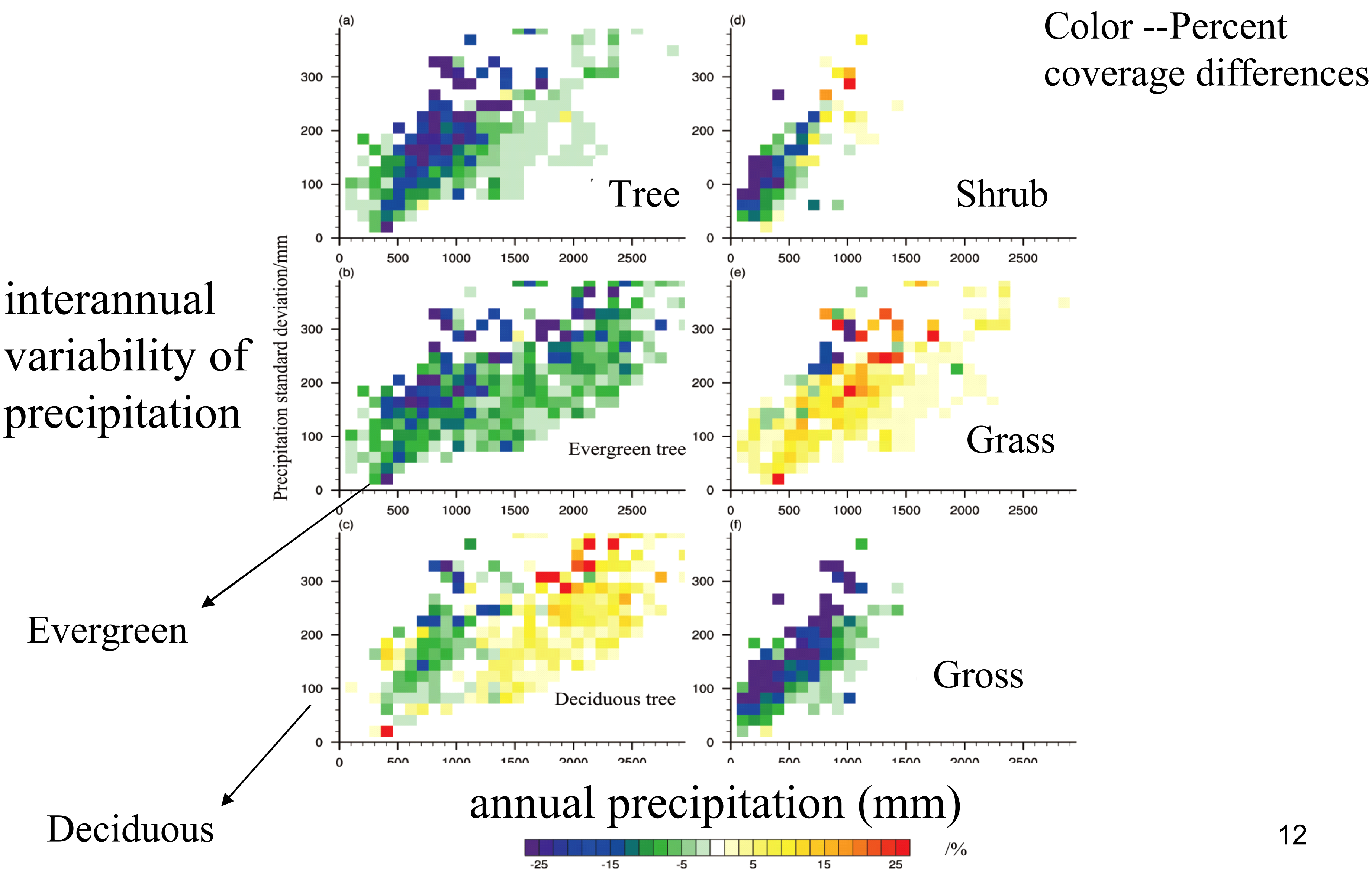
Is grass so sensitive to the climatic variability?

fractional cover distribution along the P&T



the expansion of grass is mainly due to the reduction of tree and shrub

Percent coverage differences in relation to mean and standard deviation of climatic factors



CLM evaluations

- ***Monthly river flow prediction (or simulation) (Zeng et al.)***
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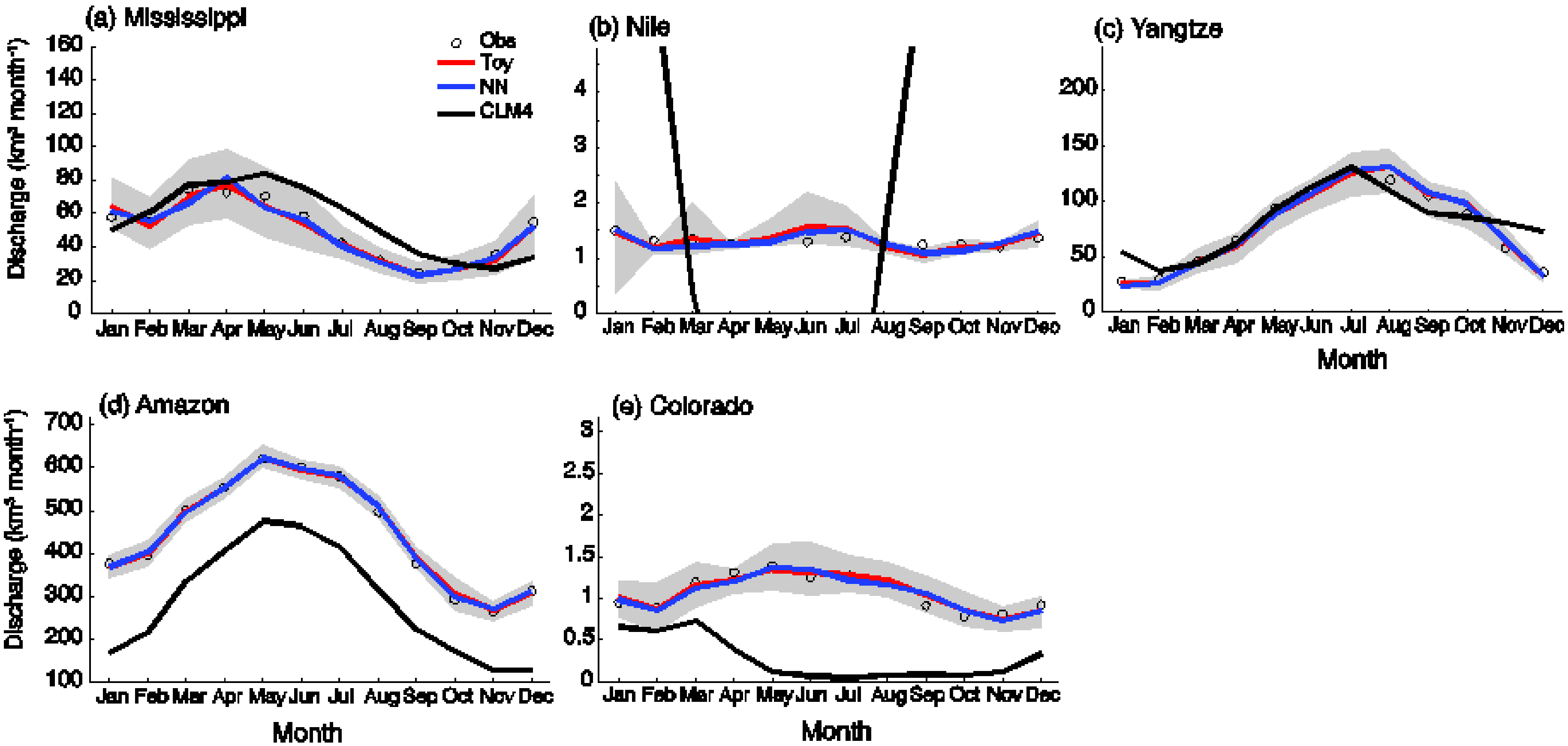
A water-balance based "toy" model (Zeng et al. 2012; in revision)

as good as a neural network for monthly river flow prediction, but the toy model is more robust. They are both much better than CLM4 simulation.



Modified coefficient of efficiency: 0.55-0.93 for Toy model
<0.1 for CLM4

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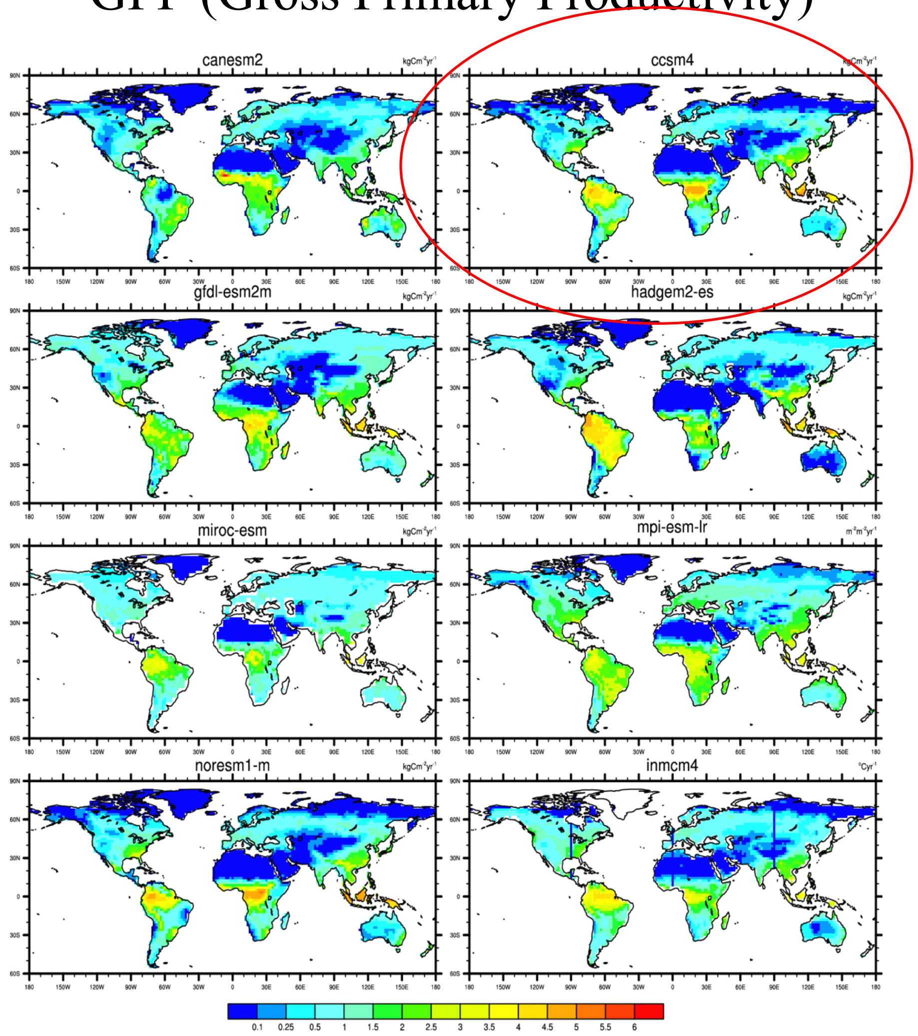
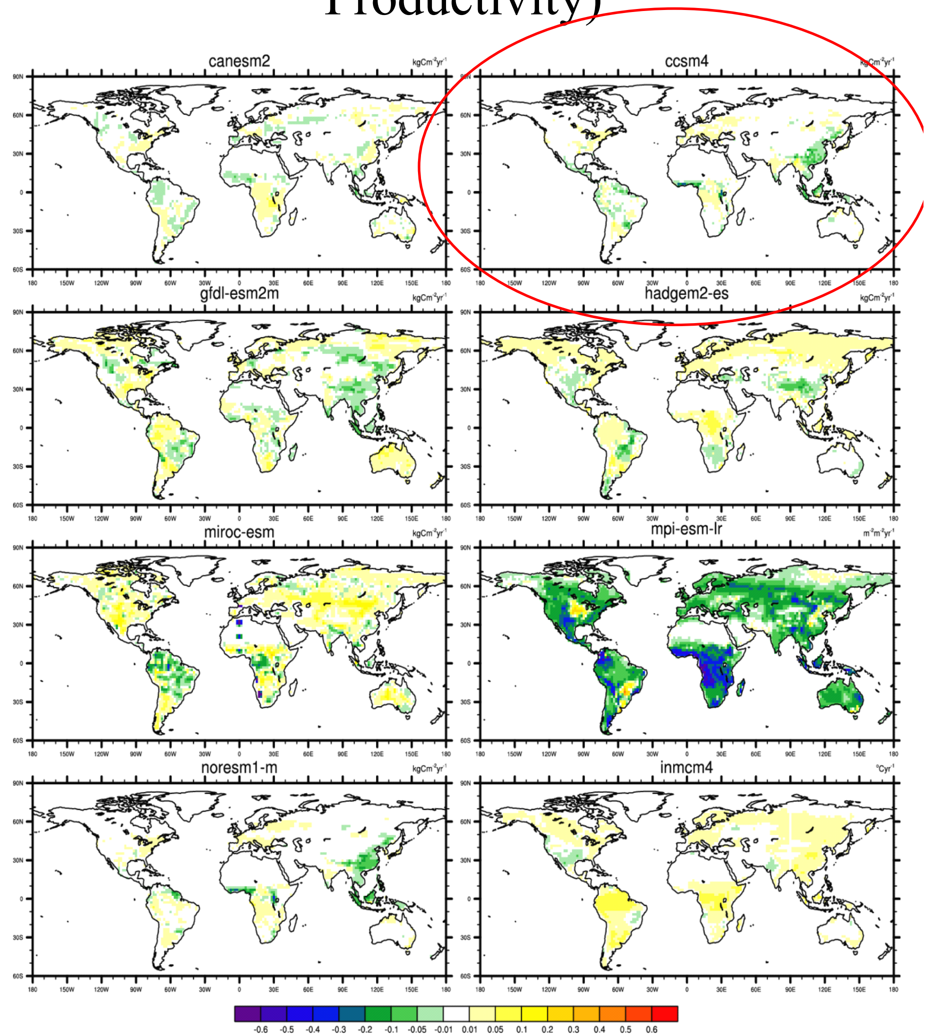
CMIP5: GPP /NBP in historical and RCP4.5 exp (Shao et al.)

GPP (Gross Primary Productivity)



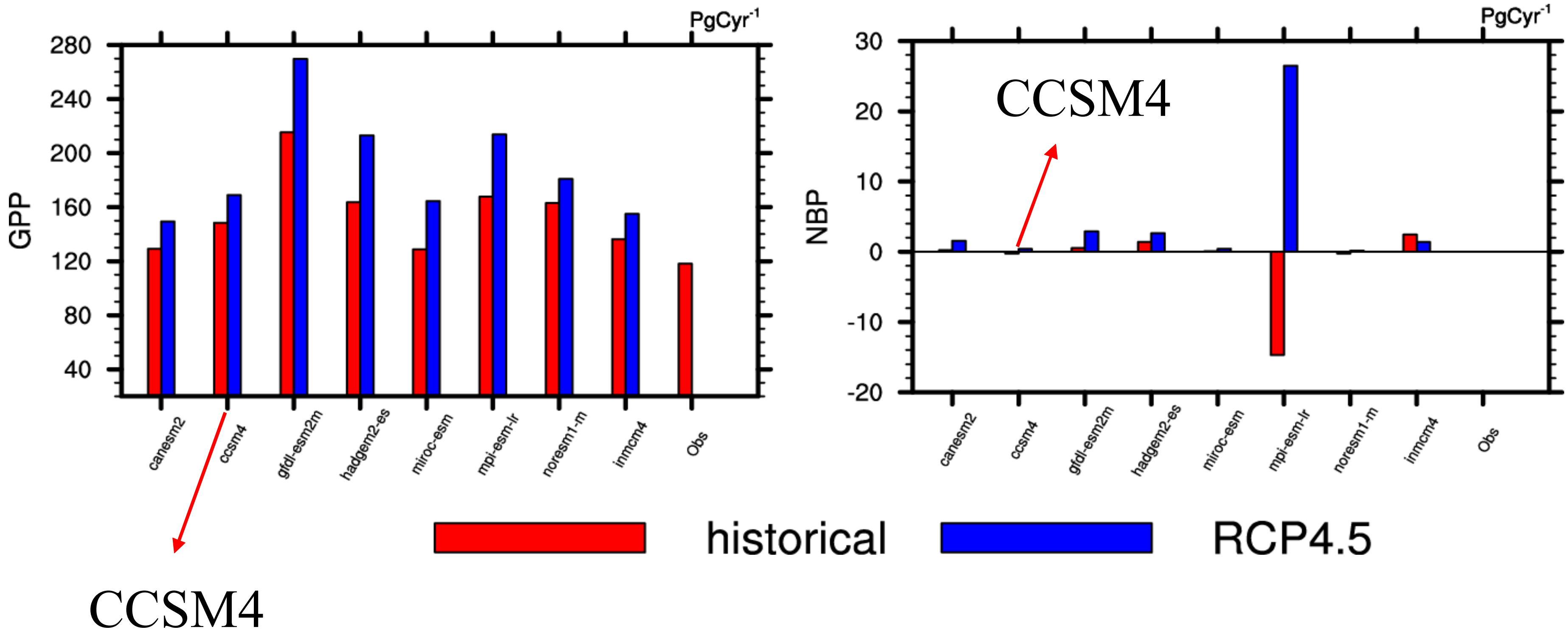
general pattern: similar
magnitude: very different

NBP (Net Biosphere Productivity)



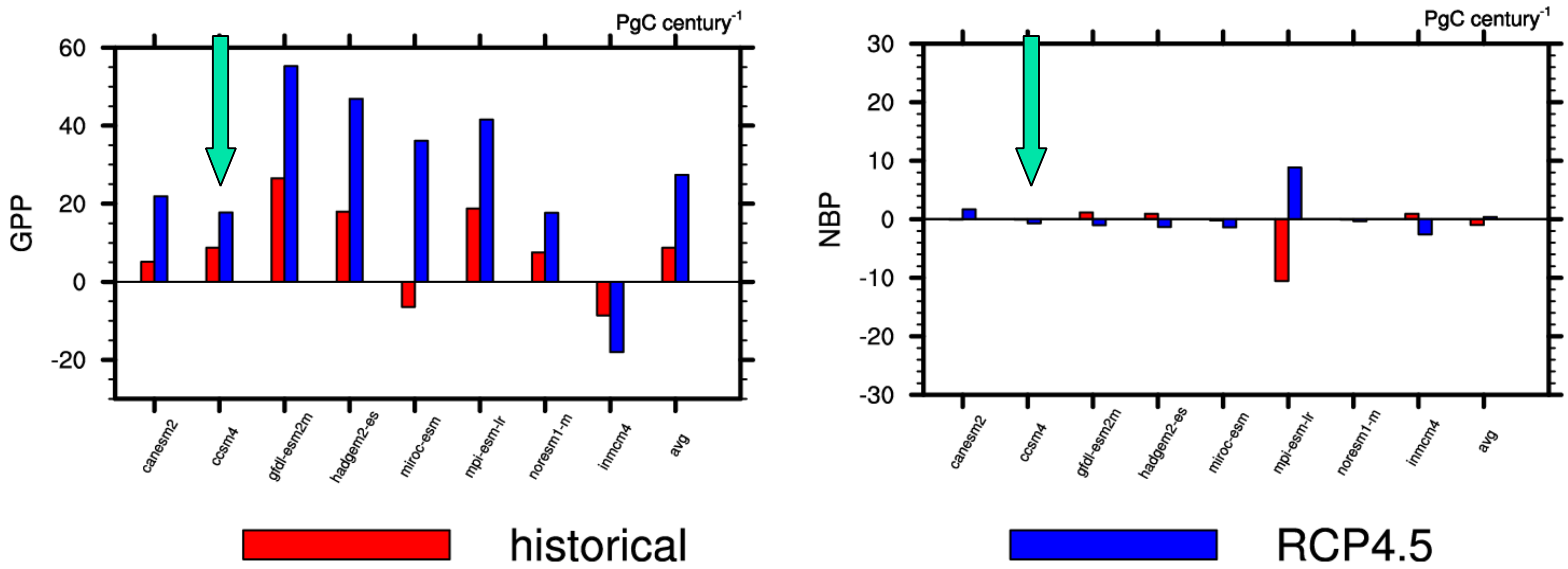
discrepancies exist

last 30 year average of global GPP and NBP

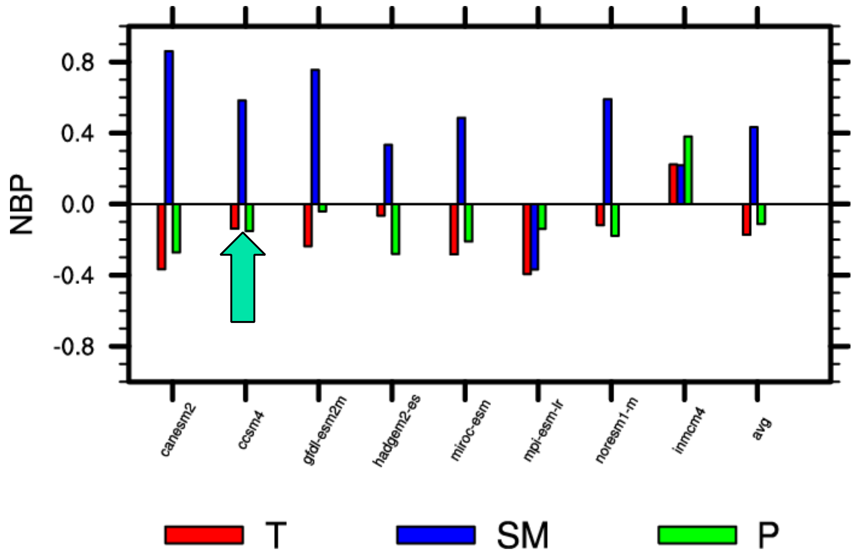


GPP : increased in every model; NBP: close to 0 for balance

Trend



correlations between global historical NBP and climatic variables



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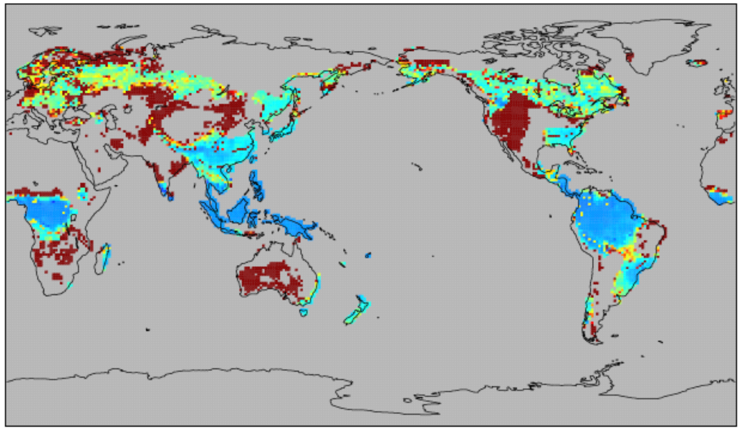
Years to Reach the Steady State of Fractional Cover (Sakaguchi et al.)

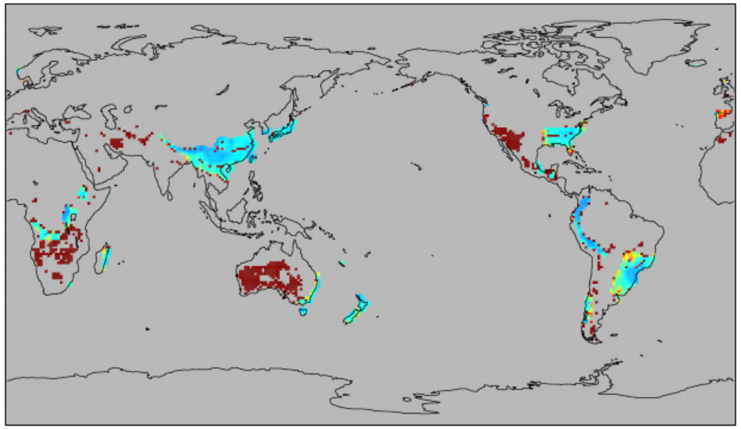
Evergreen Tree PFTs

FPC < 5% is not included

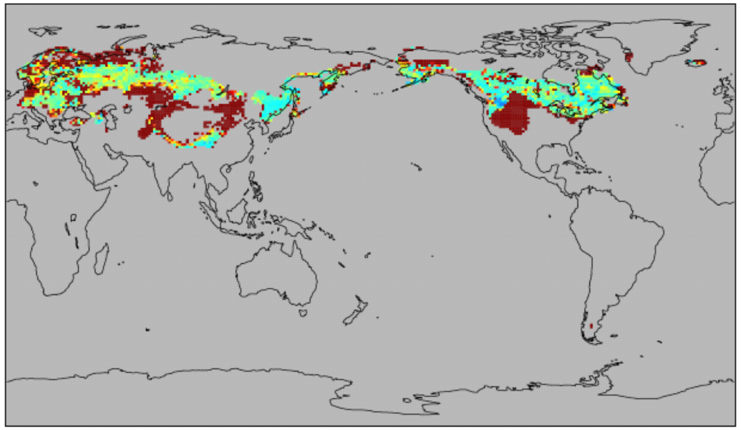
Average of the three evergreen PFTs



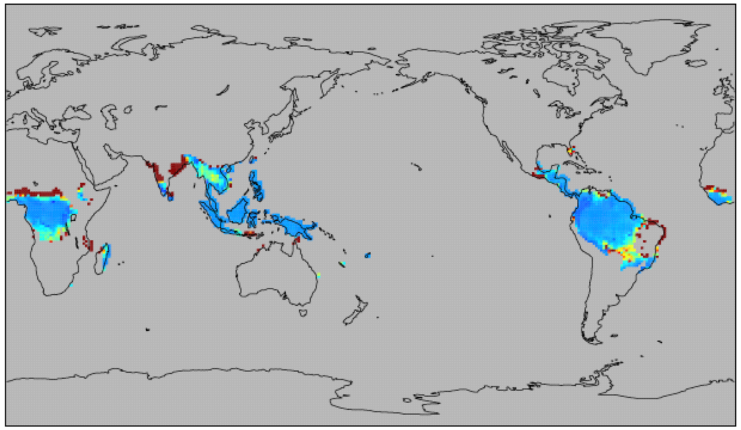
NET Temperate

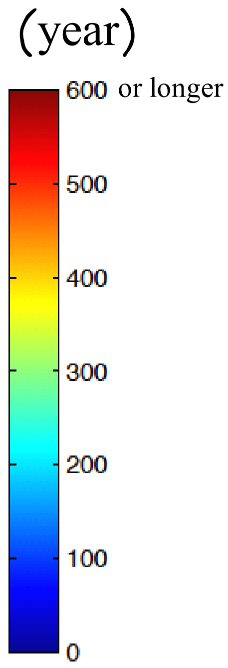


NET Boreal



BET Tropical





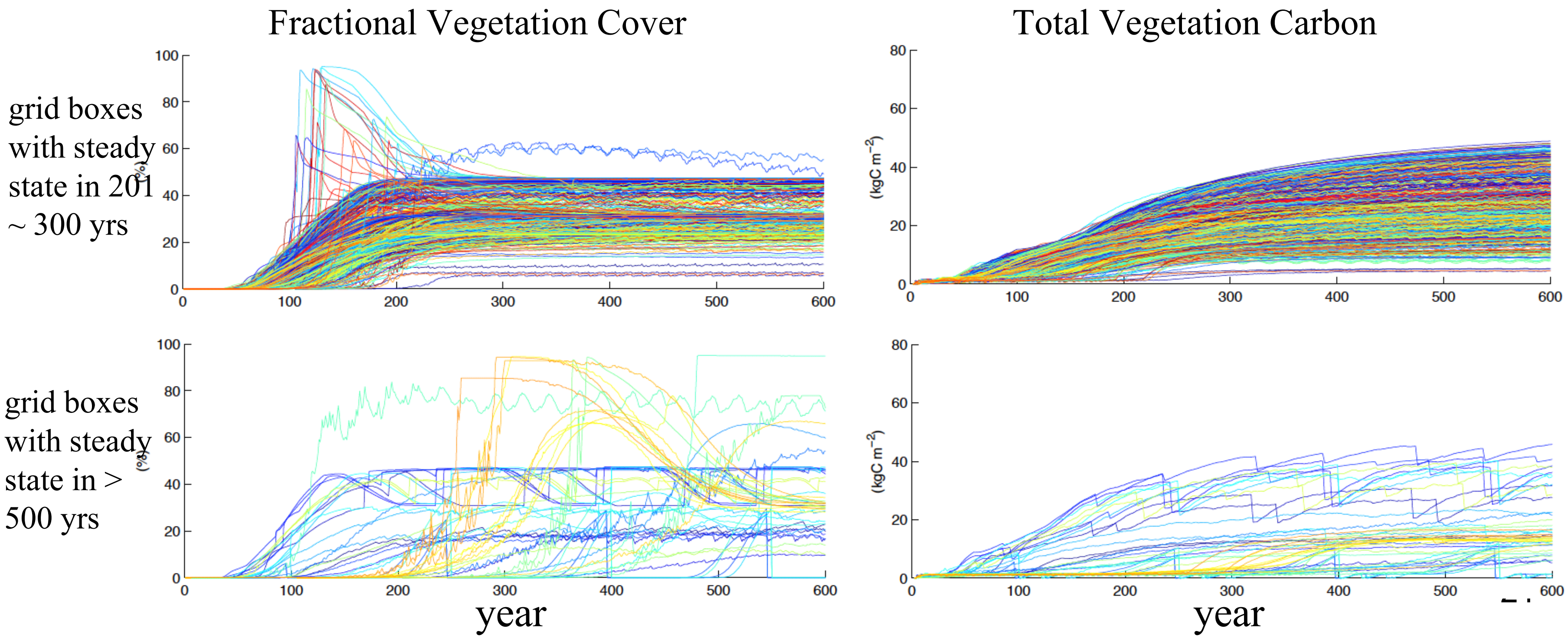
– Longer years for dry regions and for NET Boreal

Steady State of Fractional Cover

% of global grid boxes to reach steady state for tree PFTs.

	1 – 100	101 – 200	201 – 300	301 – 400	401 – 500	501 – 599	> 600 or unstable
NET temp	0	17	37	5	2	3	37
NET boreal	0	1	36	16	5	5	37
BET tropical	0	69	12	5	1	1	11
BDT tropical	0	77	14	5	2	1	2
BDT temp	1	30	36	8	5	5	15
BDT boreal	0	9	30	19	6	5	30

Example: NET temperate



CLM evaluations

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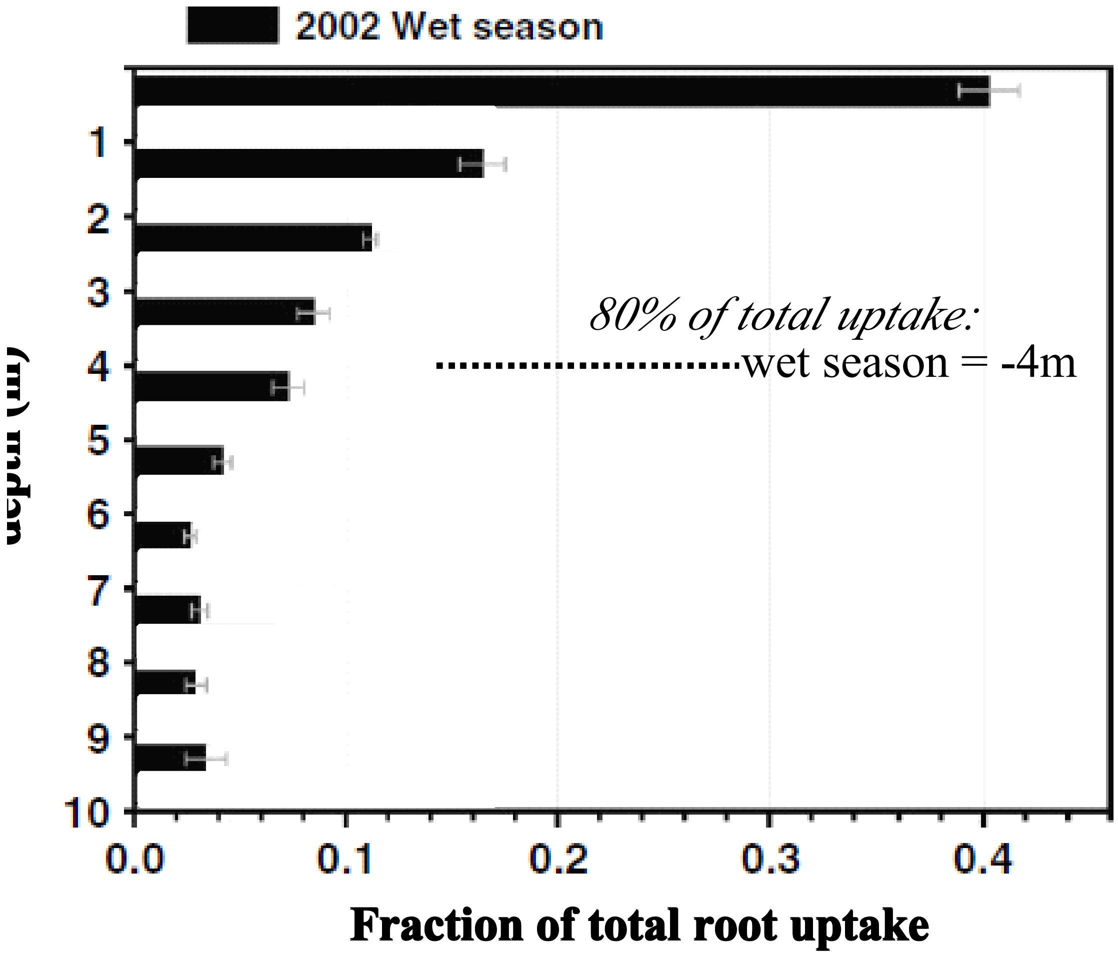
- ***Dynamic root function (Christoffersen et al.)***
- PFT distribution across Amazon (Moreno et al.)

Dynamic root function (Christoffersen et al., in prep)

Amazon: Observations indicate root uptake shifts to deeper layers during dry season

Tapajos site, observed changes in soil moisture attributed to root uptake



Taken from Bruno et al., 2006

- ***Can CLM and other models capture this dynamic aspect of root function?***

- Use a suite of models:
  - CLM3.5-DGVM, IBIS, JULES, ED2, SiB3, SPA
  - standardized soil physics
  - span range of complexity in treatment of root function

Dynamic root function (Christoffersen et al., in prep)

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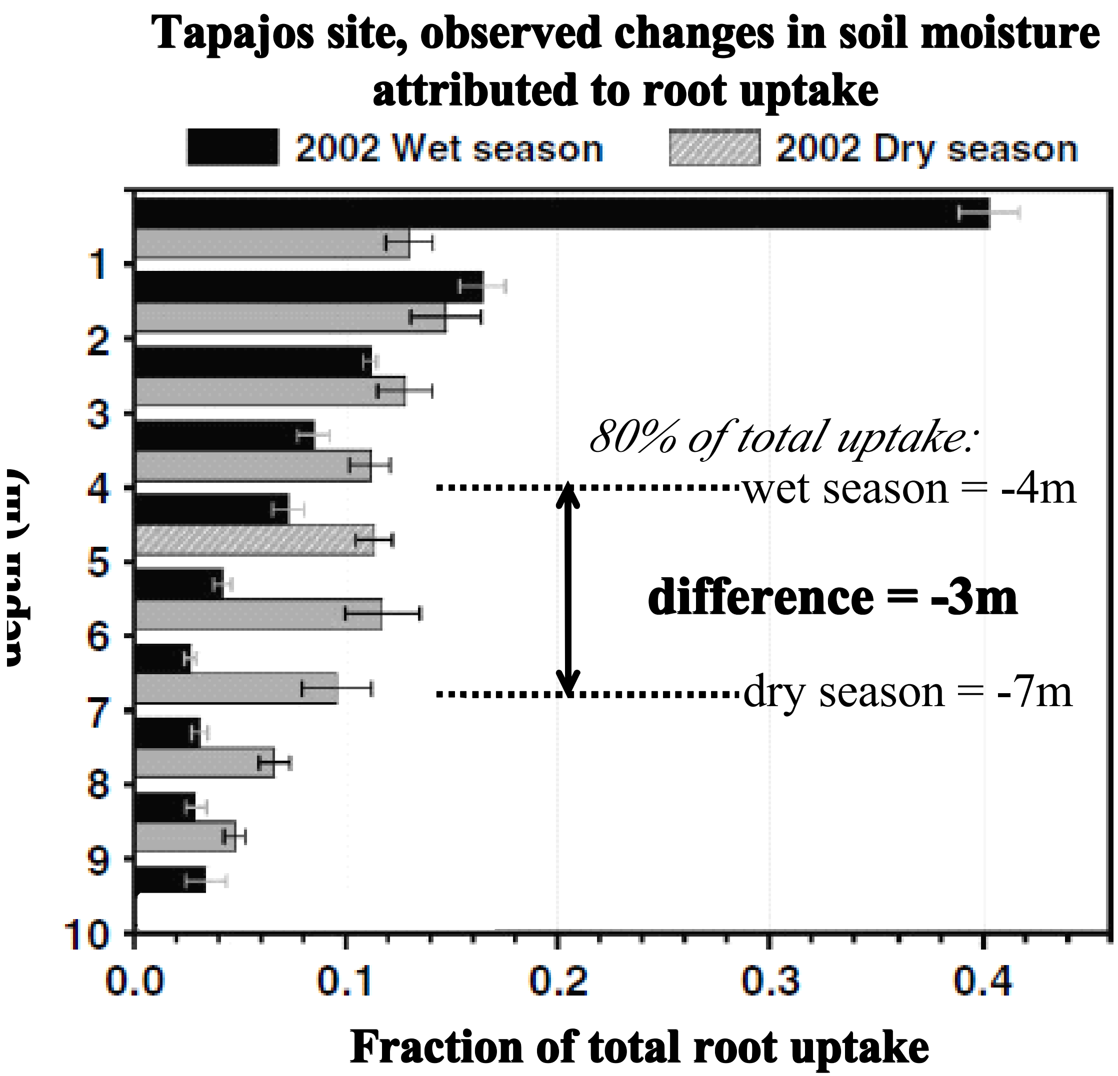

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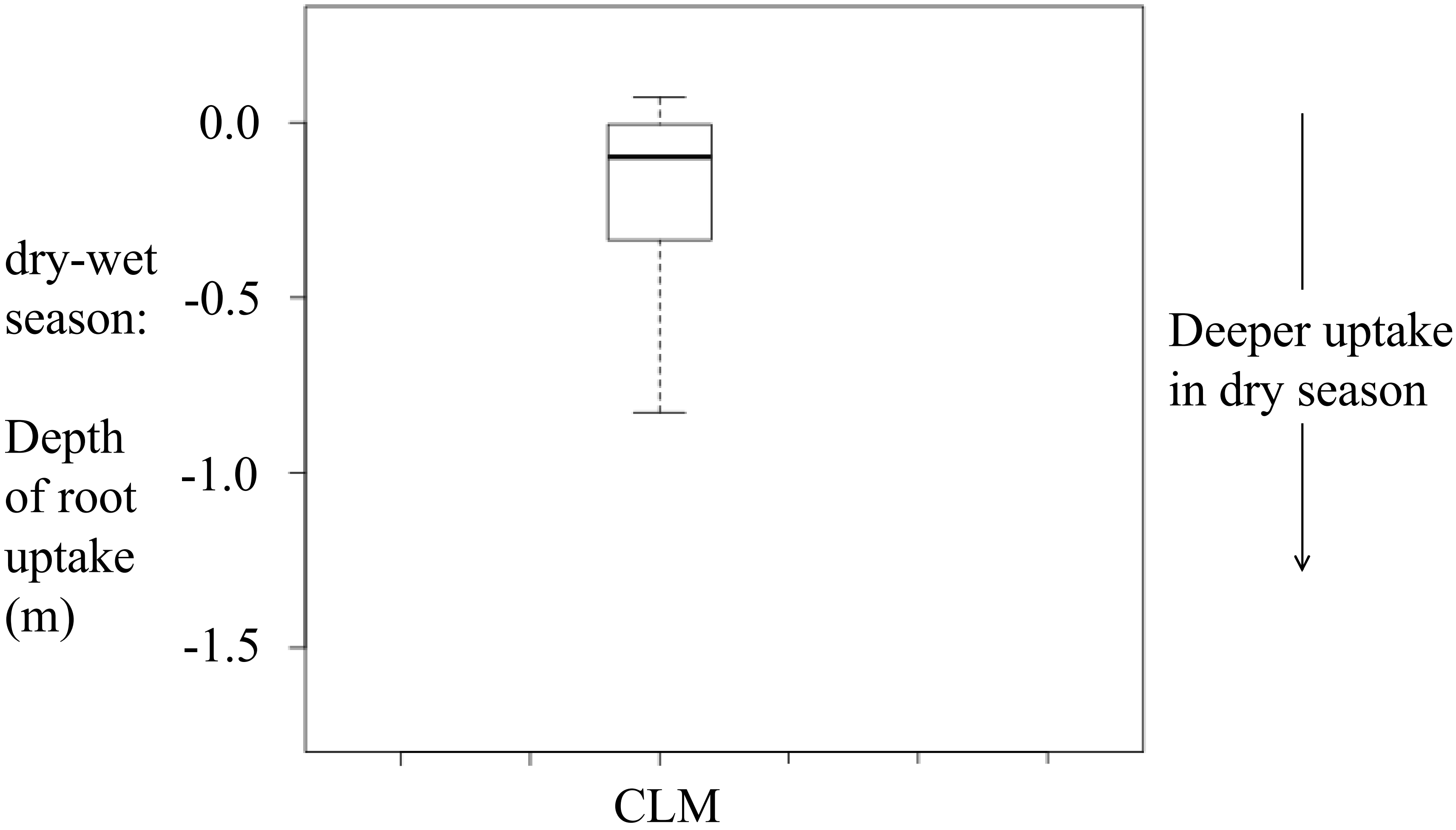
Which model best captures dynamic root behavior?

Difference between wet & dry season depth of root uptake across 4 forest sites



Christoffersen et al., in prep

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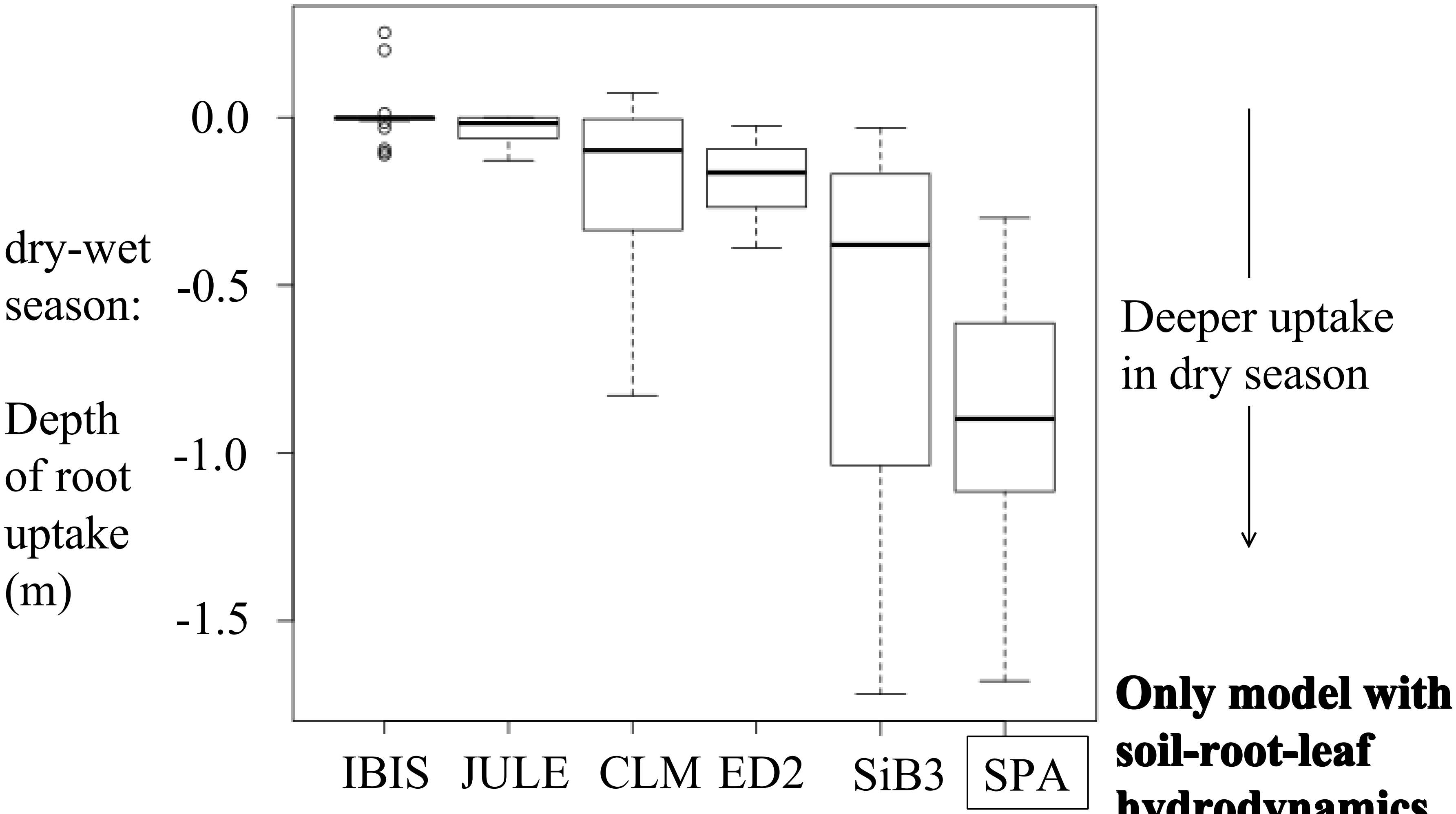

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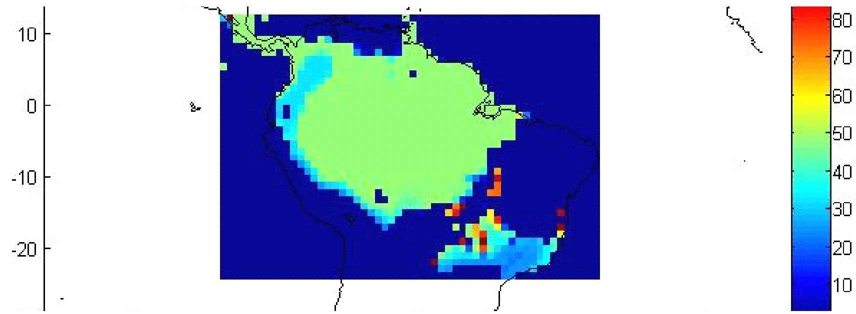
- ***PFT distribution across Amazon (Moreno et al.)***

PFT Distribution across Amazon in CLM4 (Moreno et al.)

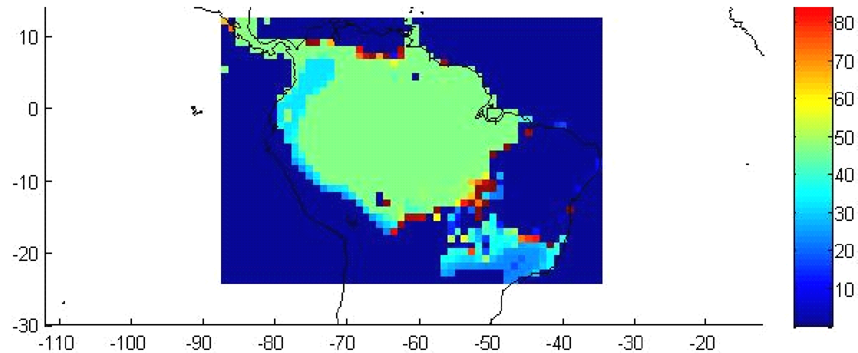
- PFT distribution, after 200 years, shows coverage of both tropical evergreen and deciduous trees.

- CLM4 over-represents deciduous tree cover in Amazonia.

Broadleaf Deciduous Tropical Tree (%)



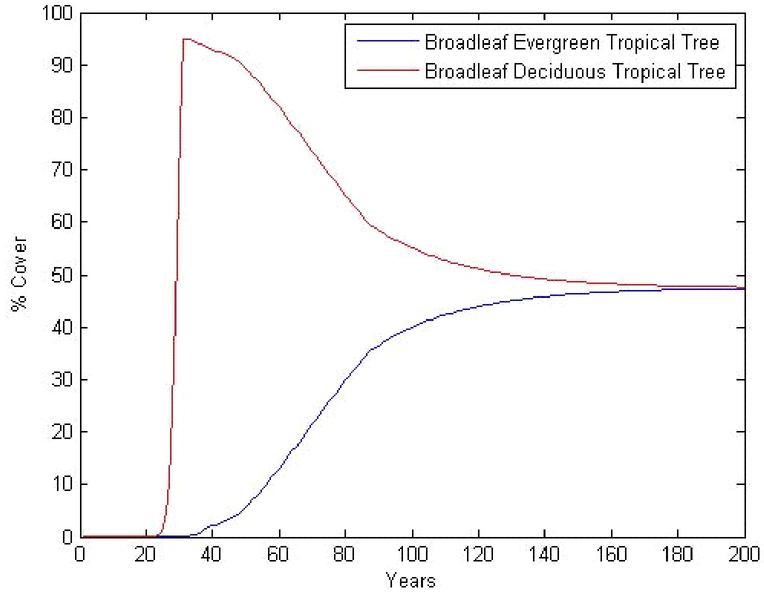
Broadleaf Evergreen Tropical Tree (%)



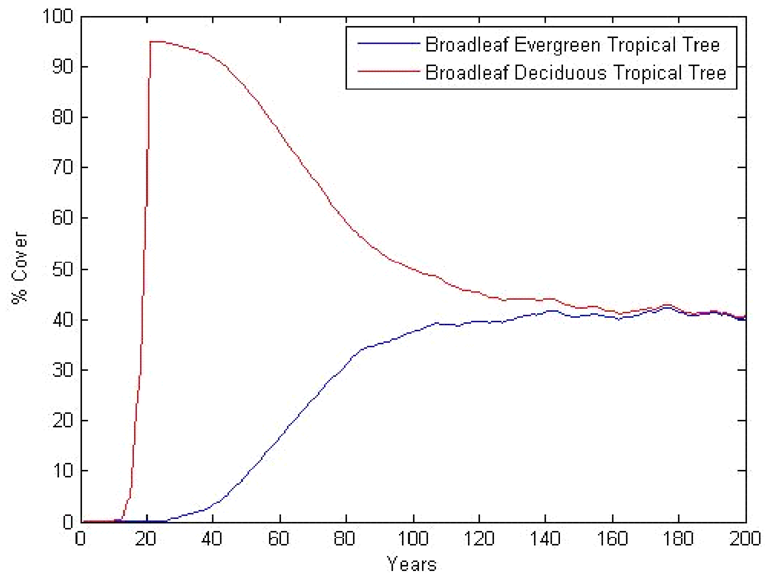
PFT Establishment

- Initially CLM populates the forest composition with the deciduous tropical trees
- Tropical evergreen trees are slow to establish and do not overtake the deciduous composition.

CAX site (%)



K67 site (%)



deciduous

evergreen

Summary

CLM4 improvement

- Developed formulations to improve skin temperature over arid regions

Land-atmosphere interaction

- Proposed a simple index for land-precipitation coupling strength
- Demonstrated the impact of interannual climate variability on plant distribution in CLM/DGVM

CLM evaluations

- Identified CLM deficiencies in monthly river flow simulation
- Analyzed the CMIP5 carbon cycle
- analyzed the spinup time in carbon/biomass in CLM-CNDV
- Demonstrated the need for dynamic root function
- identified the PFT distribution deficiency across Amazon in CLM-CNDV