

Understanding the drivers of regional tropical rainfall changes under warming

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Drivers of regional climate change under CO₂ forcing

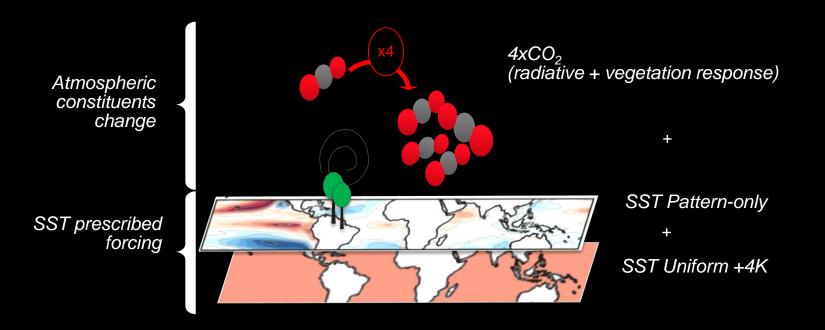


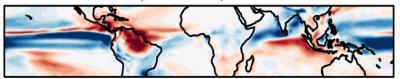
Figure from Marion Saint-Lu



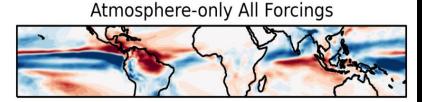
Drivers of Tropical Precipitation Change

Annual Precipitation Change HadGEM2

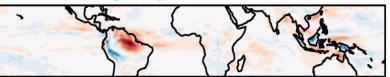
Coupled abrupt4xCO2



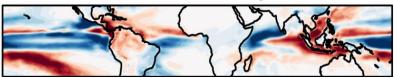
Veg Response to 4xCO2



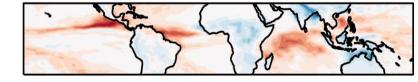
SST Pattern-Only

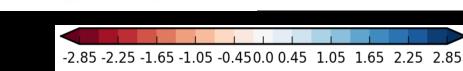


SST Uniform +4K



4xCO2 Rad.





 $mm \,\, day^{-1}$

Chadwick et al. 2017, Clim. Dyn.



Large Plant Physiological Effect on Rainfall Change in Tropical Forests

HadGEM2

Coupled abrupt4xCO₂

HadGEM2

Vegetation Response to $4xCO_2$

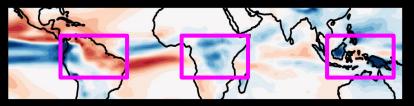


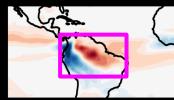
CCSM4

Coupled abrupt4xCO₂

CCSM4

Vegetation Response to $4xCO_2$







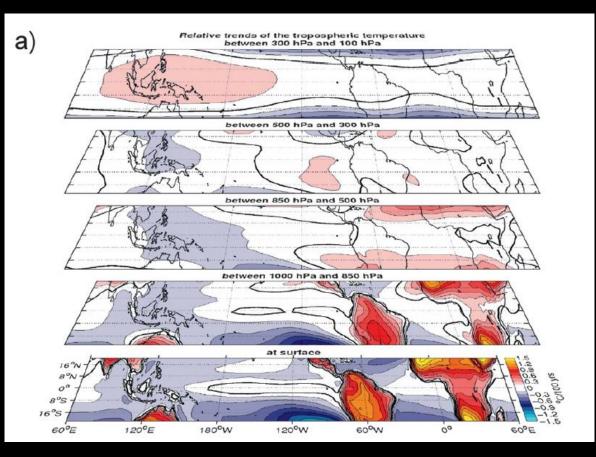
CNRM Coupled abrupt4xCO₂







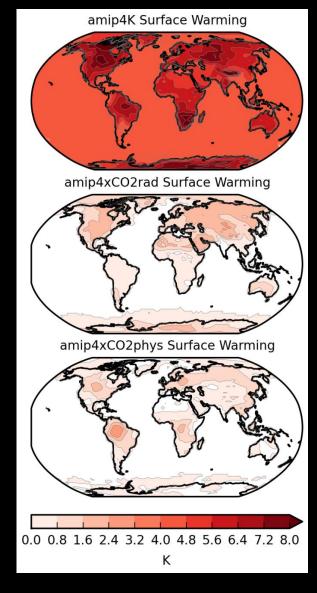
Influence of land warming on circulation change



Bayr & Dommenget, 2013, J. Climate



Sources of land warming



Land response to SST warming

Direct radiative warming from increased CO₂

Warming from plant stomatal response to increased CO₂



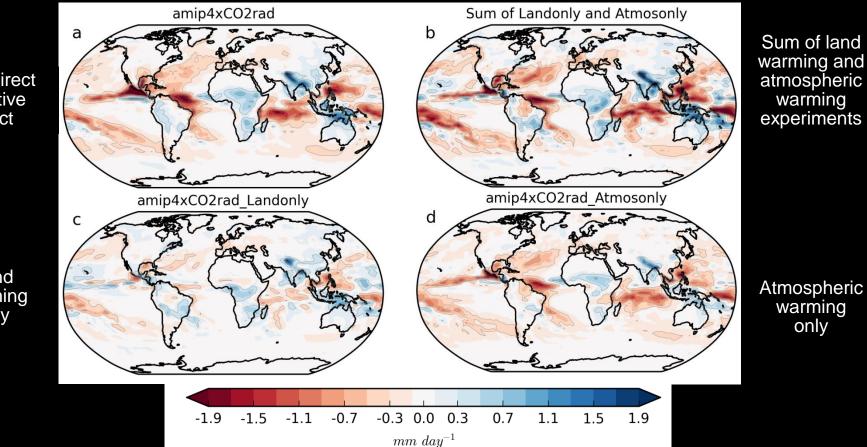
Experimental Design

- Atmosphere-only configuration of ACCESS1.0
- Surface temperature and soil moisture saved every 3 hours during initial amip, amip4xCO2, amip4xCO2rad and amip4K runs.
- These 3 hourly fields, interpolated and updated hourly, are then used to prescribe land surface properties in further AGCM experiments.



Direct CO₂ radiative effect

Annual Mean Precipitation Change



Total direct radiative effect

> Land warming only



Direct Atmospheric CO₂ effect on Monsoons

JJA Precipitation Inst. TOA rad. forcing а a **TOA** forcing -1.9 -1.5 -1.1 -0.7 -0.3 0.0 0.3 0.7 1.1 1.5 1.9 -9.5 -7.5 -5.5 -3.5 -1.5 0.0 1.5 3.5 5.5 7.5 9.5 Inst. sfc. rad. forcing PMSL/850hPa winds е b Surface forcing $1 m s^{-1}$ -2.85 -2.25 -1.65 -1.05 -0.45 0.0 0.45 1.05 1.65 2.25 2.85 -9.5 -7.5 -5.5 -3.5 -1.5 0.0 1.5 3.5 5.5 7.5 9.5 Inst. atm. rad. forcing Tropospheric temperature C Atmospheric forcing -7600.0 -6000.0 -4400.0 -2800.0 -1200.0 0.0 1200.0 2800.0 4400.0 6000.0 7600.0 -9.5 -7.5 -5.5 -3.5 -1.5 0.0 1.5 3.5 5.5 7.5 9.5



Direct Atmospheric CO₂ effect on Monsoons

JJA AEI Rad. AEI а b SH LH d С

-19.0 -15.0 -11.0 -7.0 -3.0 0.0 3.0 7.0 11.0 15.0 19.0 $W m^{-2}$



Plant physiological effect

Annual Mean Precipitation Change

Sum of Landonly and Vegonly

amip4xCO2phys

-1.9

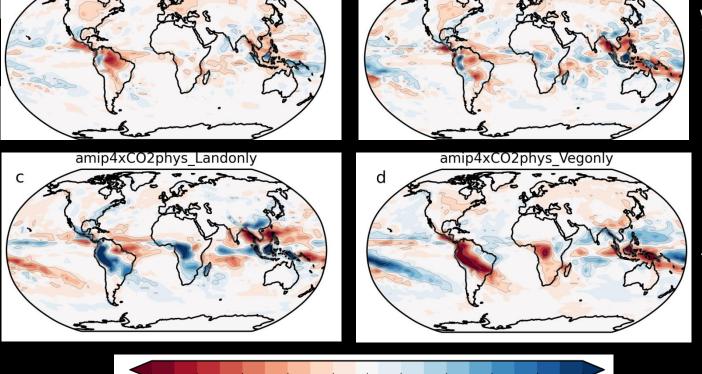
-1.5

-1.1

-0.7

Total plant physiological effect

а



-0.3 0.0 0.3

 $mm \ day^{-1}$

0.7

1.1

1.5

1.9

b

Sum of land warming and transpiration change experiments

Plant transpiration change only

Land warming only





- The balance of mechanisms driving precipitation change differs by region. SST pattern change is dominant over the tropical oceans, and also influential over some land regions.
- The direct atmospheric radiative effect of CO2 strengthens the West African and Asian monsoon circulations, due to differing atmospheric adjustments over land and ocean.
- In tropical forest regions, the vegetation response to CO2 plays a major role in driving precipitation change.
- CO2-induced reductions in plant transpiration actually drive precipitation increases in some forest regions, due to associated land warming.