Understanding the drivers of regional tropical rainfall changes under warming

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Drivers of regional climate change under CO_2 forcing

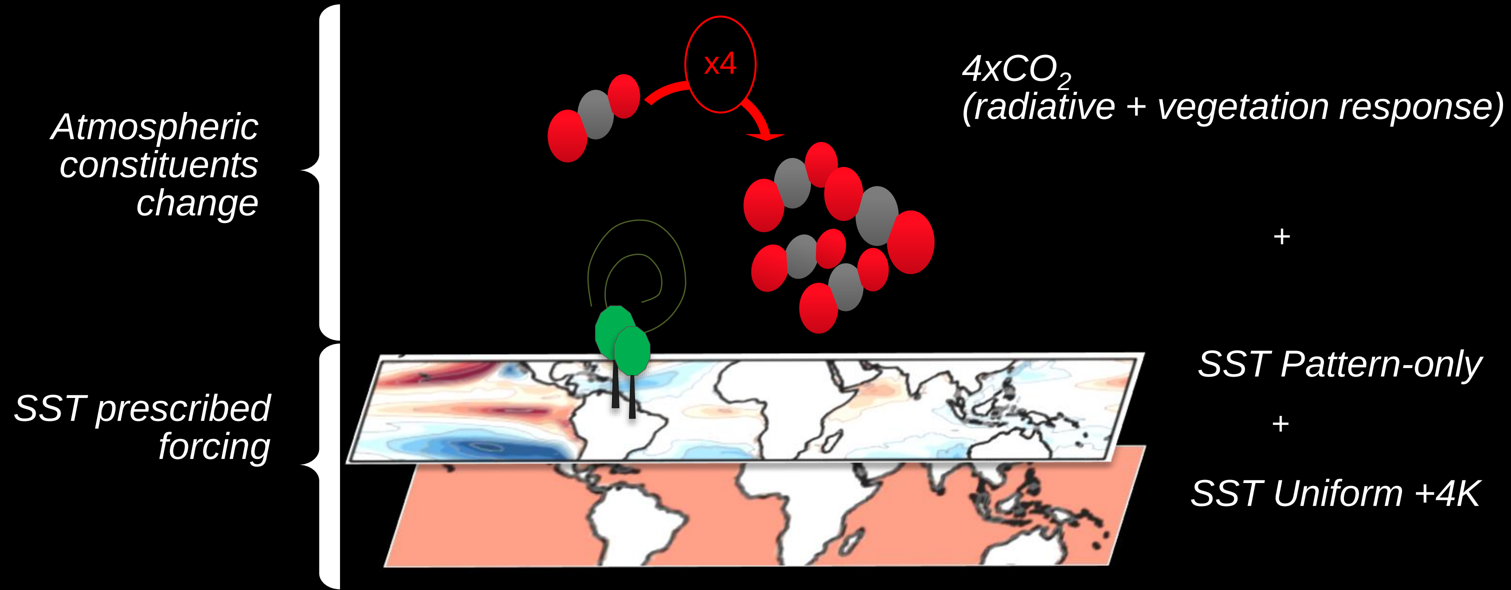
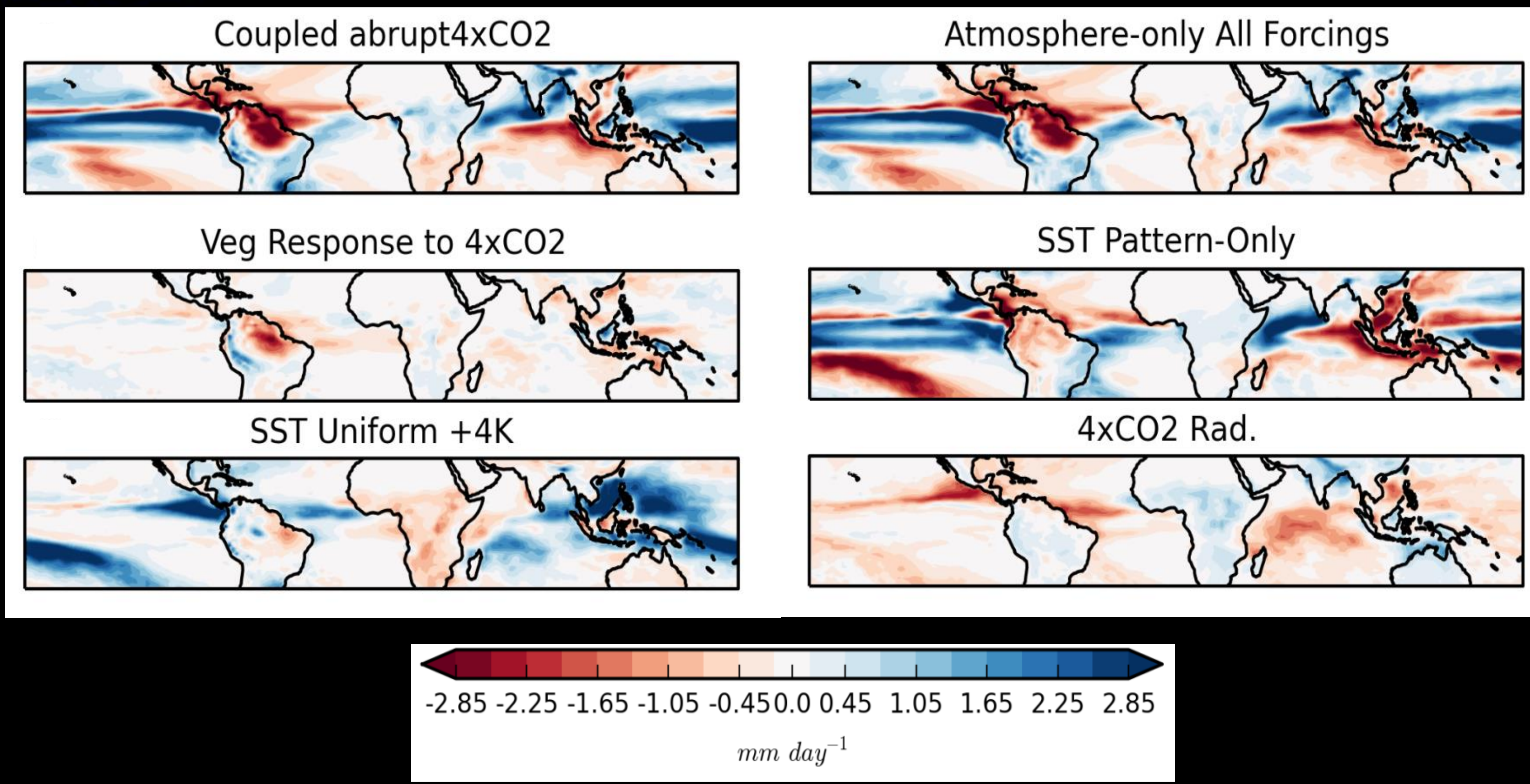


Figure from Marion Saint-Lu

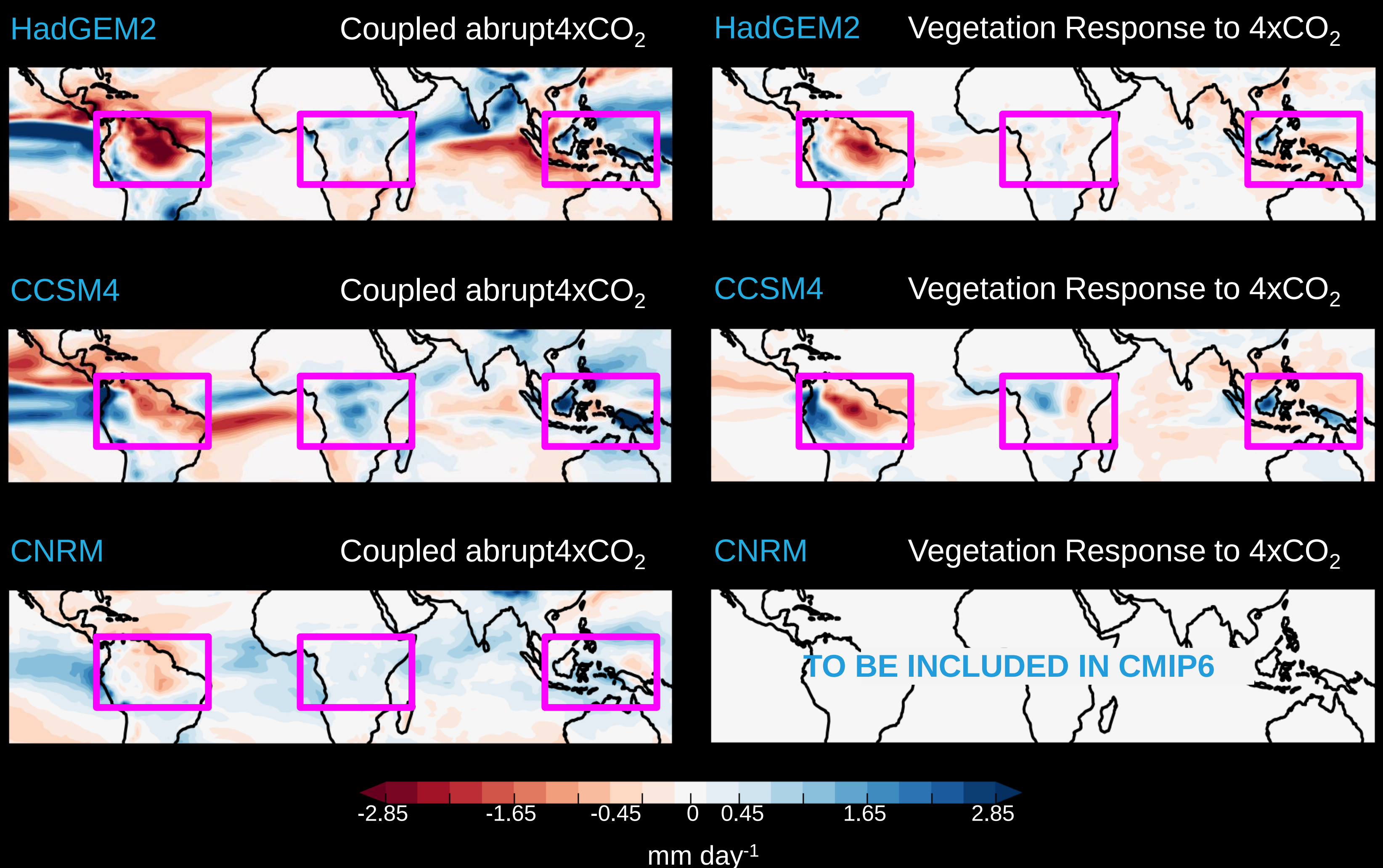
Drivers of Tropical Precipitation Change

Annual Precipitation Change HadGEM2

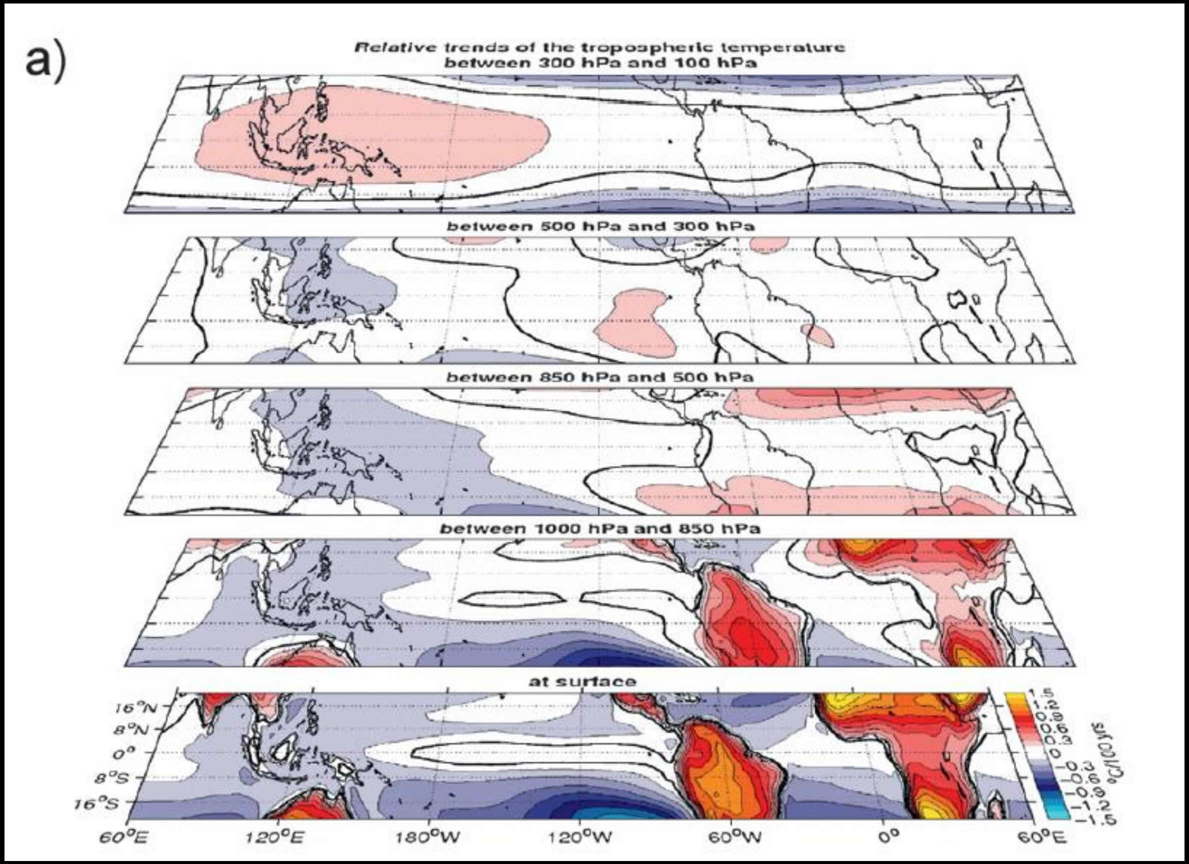


Chadwick et al. 2017, Clim. Dyn.

Large Plant Physiological Effect on Rainfall Change in Tropical Forests

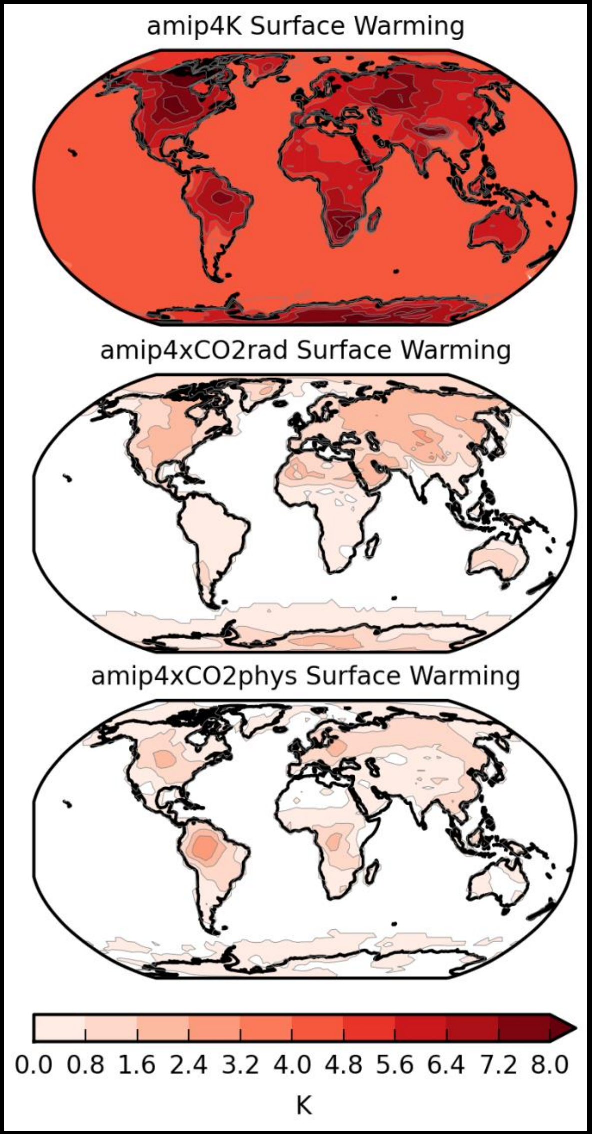


Influence of land warming on circulation change



Bayr & Dommenget, 2013, J. Climate

Sources of land warming



Land response to SST warming

Direct radiative warming from increased CO_2

Warming from plant stomatal response to increased CO_2

Experimental Design

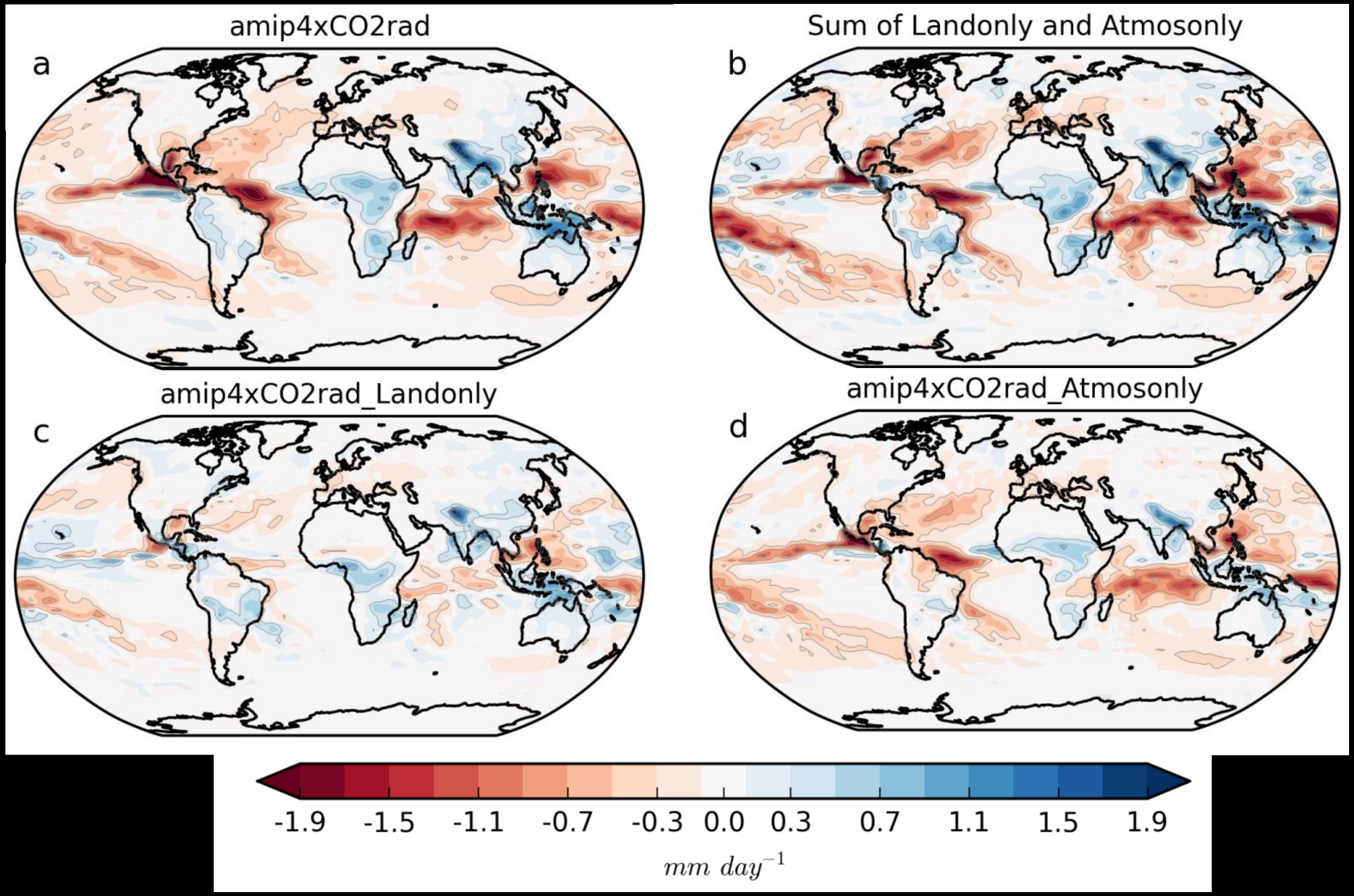
- Atmosphere-only configuration of ACCESS1.0
- Surface temperature and soil moisture saved every 3 hours during initial amip, amip4xCO2, amip4xCO2rad and amip4K runs.
- These 3 hourly fields, interpolated and updated hourly, are then used to prescribe land surface properties in further AGCM experiments.

Direct CO_2 radiative effect

Annual Mean Precipitation Change

Total direct radiative effect

Sum of land warming and atmospheric warming experiments



Land warming only

Atmospheric warming only

Direct Atmospheric CO_2 effect on Monsoons

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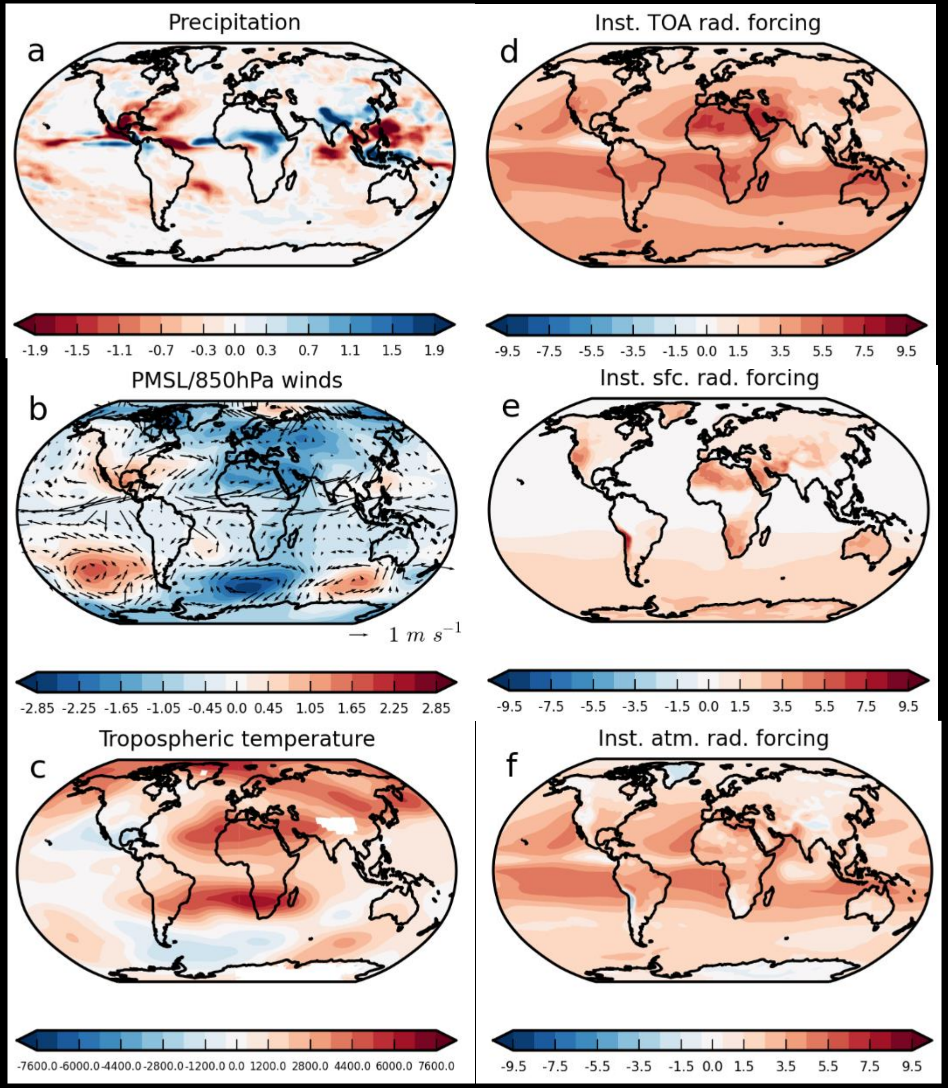
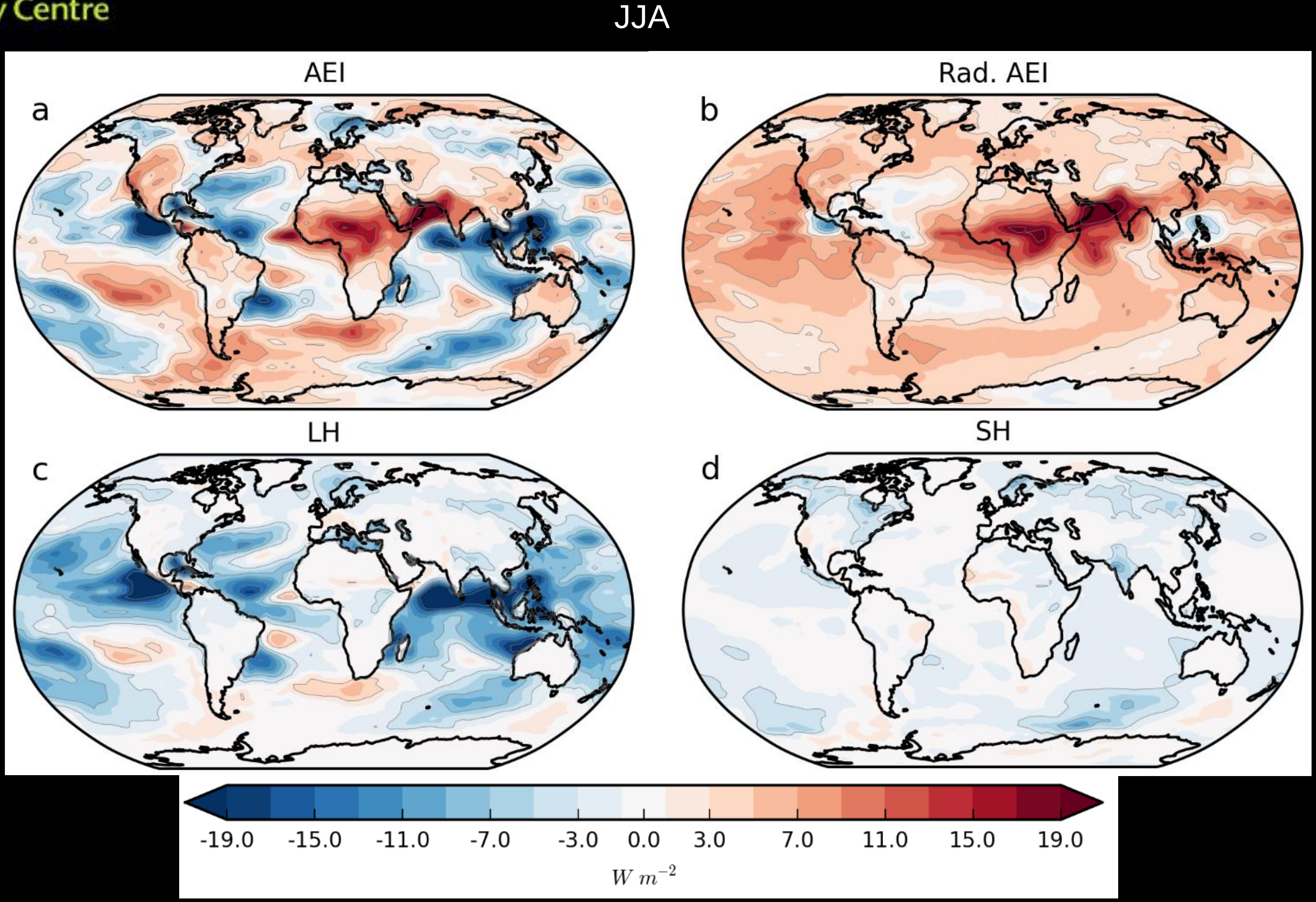


TOA forcing

Surface forcing

Atmospheric forcing

Direct Atmospheric CO_2 effect on Monsoons



Plant physiological effect

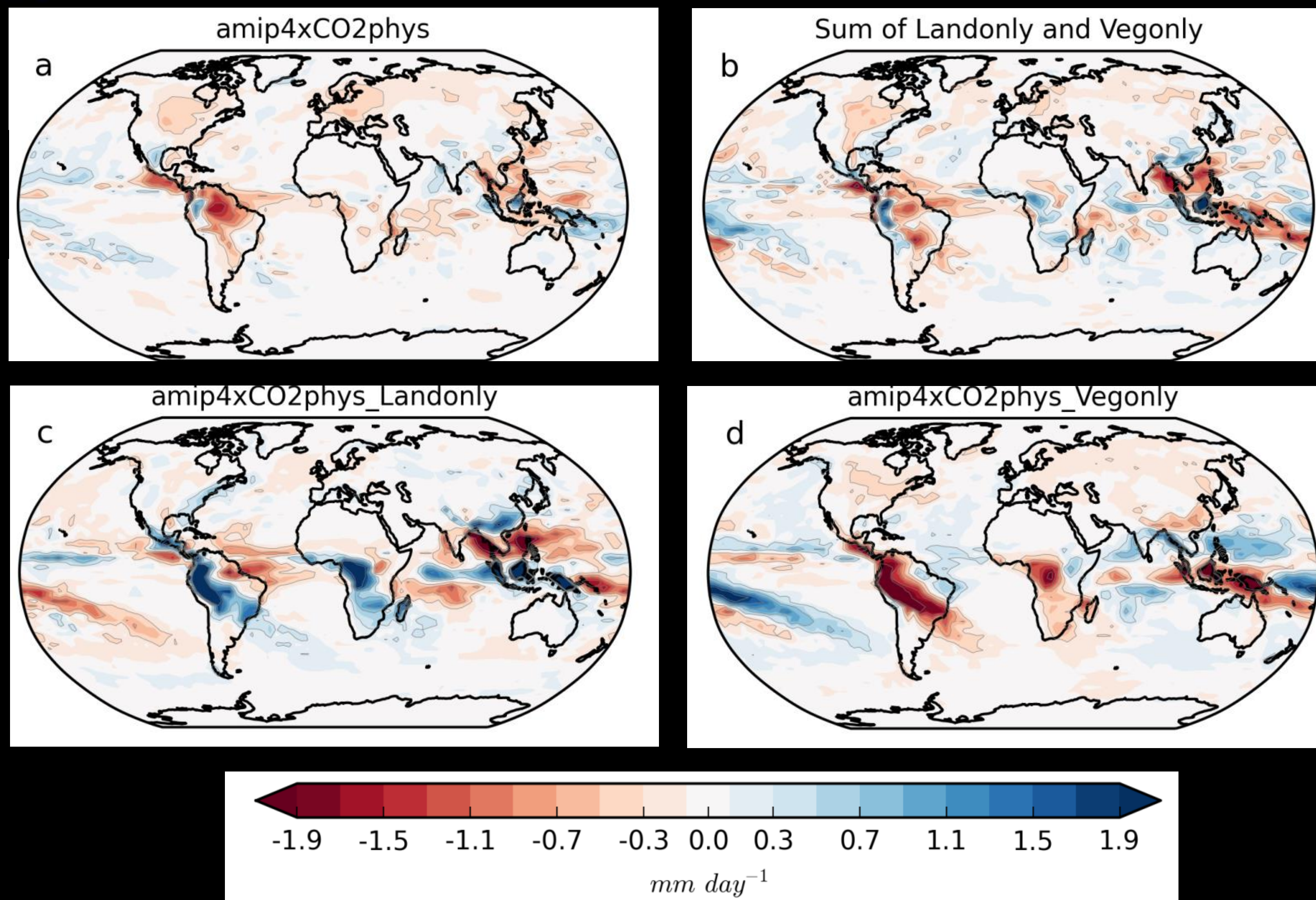
Annual Mean Precipitation Change

Total plant physiological effect

Sum of land warming and transpiration change experiments

Land warming only

Plant transpiration change only



Summary

- 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.