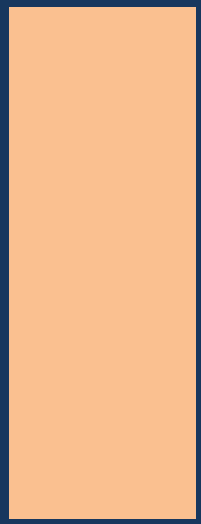
TRACMIP:
Tropical Rain belts with an Annual cycle and Continent Model Intercomparison Project

Michela Biasutti and Aiko Voigt (tracmip@gmail.com)



Simulations by: Jürgen Bader, Simona Bordoni, Francis Codron, Ross D. Dixon, Sarah Kang, Nicholas P. Klingaman, Ruby Leung, Jian Lu, Elizabeth A. Maroon, Sonali McDermid, Jong-yeon Park, Romain Roehrig, Brian E. J. Rose, Jeongbin Seo, Thomas Toniazzo, Masakazu Yoshimori, Aiko Voigt
And help from: Jacob Scheff, Brian Mapes, and Lucas R. Vargas Zeppetello

If these models, despite their different assumptions, lead to similar results, we have what we can call a robust theorem that is relatively free of the details of the model. **Hence, our truth is at the intersection of independent lies.**

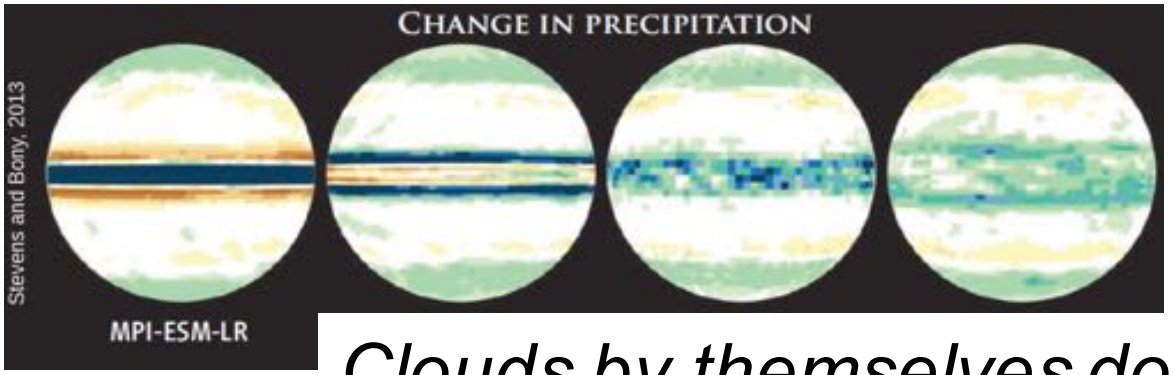
Richard Levins (1966).

The strategy of model building in population biology. In E. Sober (Ed.), Conceptual issues in evolutionary biology (First ed., pp. 18–27). Cambridge, MA: MIT Press.

WCRP Grand Challenge on Clouds Circulation and Climate Sensitivity:

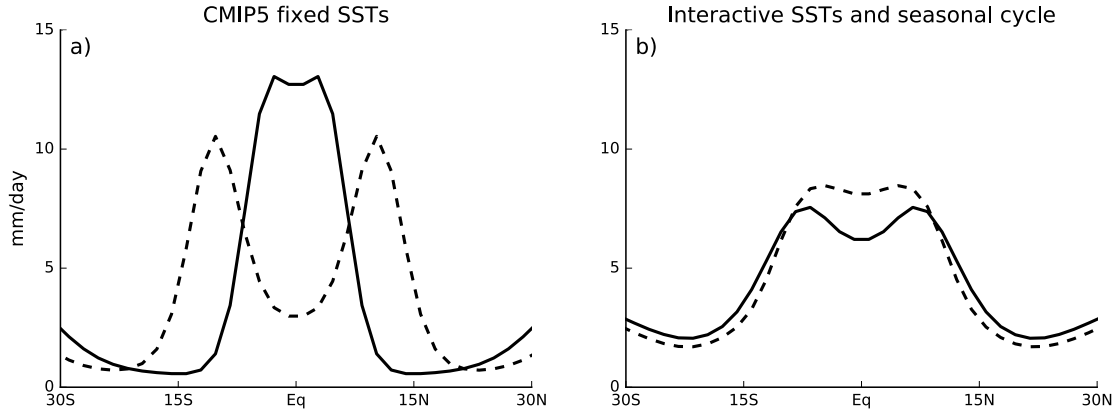
What controls the position, strength and variability of tropical rain belts?

Lesson from APE/CFMIP/CMIP5:



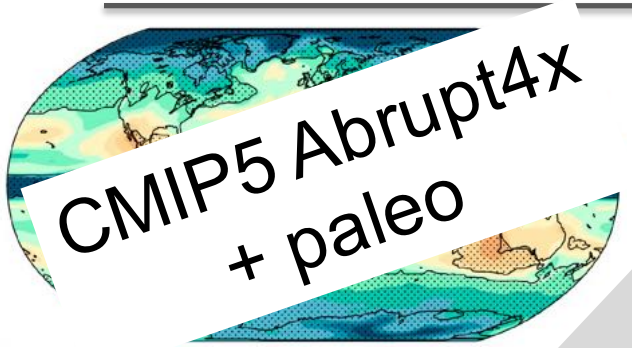
Clouds by themselves do a lot...

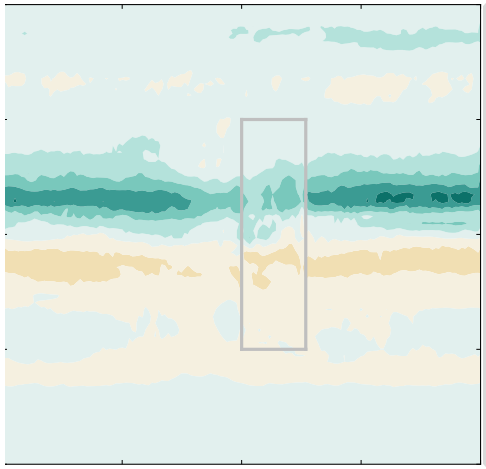
Lesson from the hierarchy:



How much depends on what else is allowed to change...

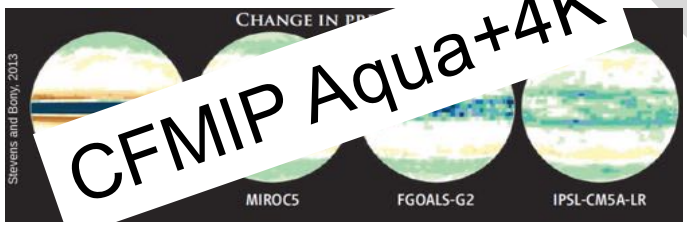
TRACMIP fills a gap in the CMIP5 hierarchy





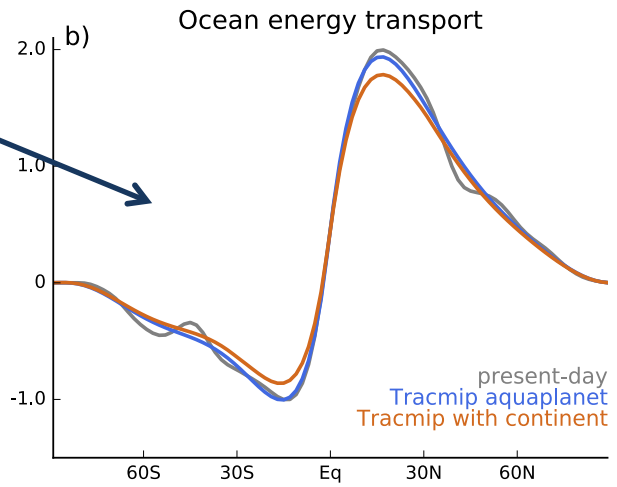
TRACMIP

1. Targets the essential dynamics of tropical rain belts with interactive SST (slab ocean)
2. Considers the main forced cycles (diurnal and annual)
3. Compares zonally symmetric (ITCZ) to zonally asymmetric ("monsoon") case
4. Considers both future (CO_2) and past (precession) forcings



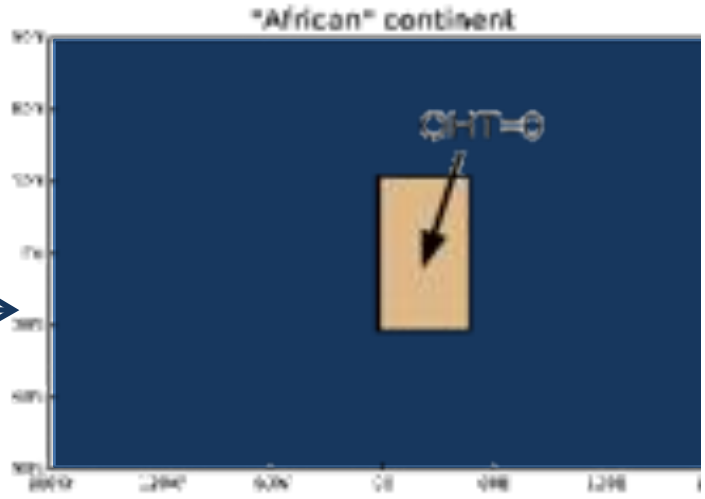
TRACMIP:
Tropical **R**ain belts with an **A**nnual cycle and **C**ontinent **M**odel **I**ntercomparison **P**roject

EXPERIMENT NAME	LAND CONFIGURATION	CO_2	ECCENTRICITY	OHT
AquaCTL	none	present-day	ε = 0	✔
Aqua4xCO_2	none	4 times present day	ε = 0	✔
LandCTL	jello tropical	present-day	ε = 0	✔
Land4xCO_2	jello tropical	4 times present day	ε = 0	✔
LandOrbit	jello tropical	present-day	ε = 0.02	✔

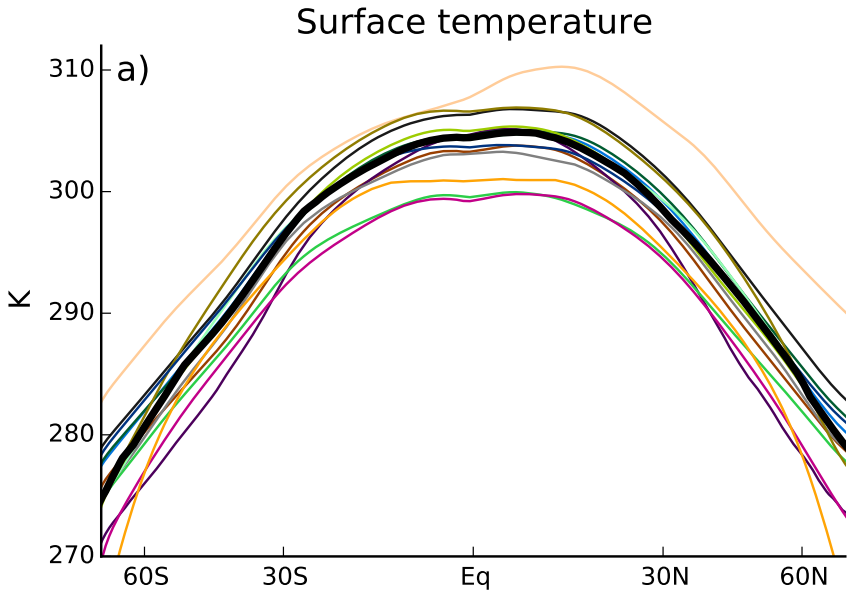


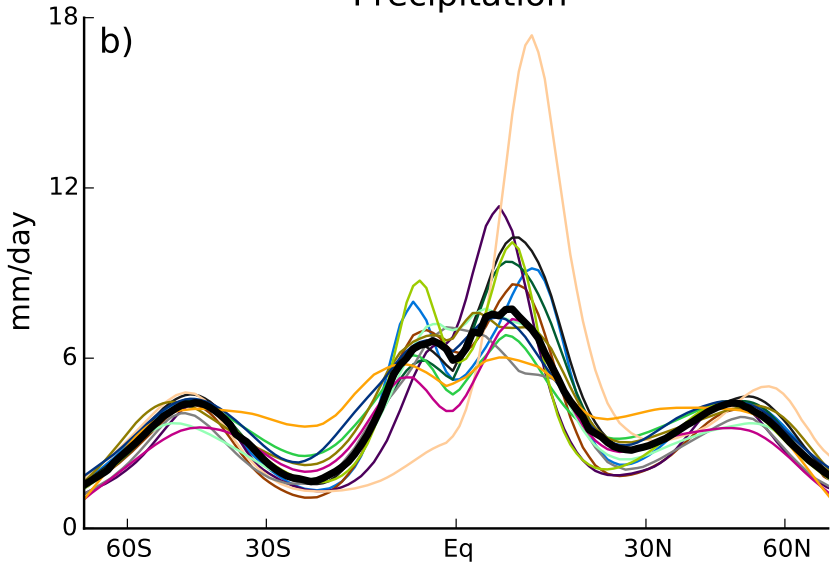
Heat converges in the NH: inter-hemispheric asymmetry!

no OHT;
small heat capacity;
brighter color;
double evaporative resistance.



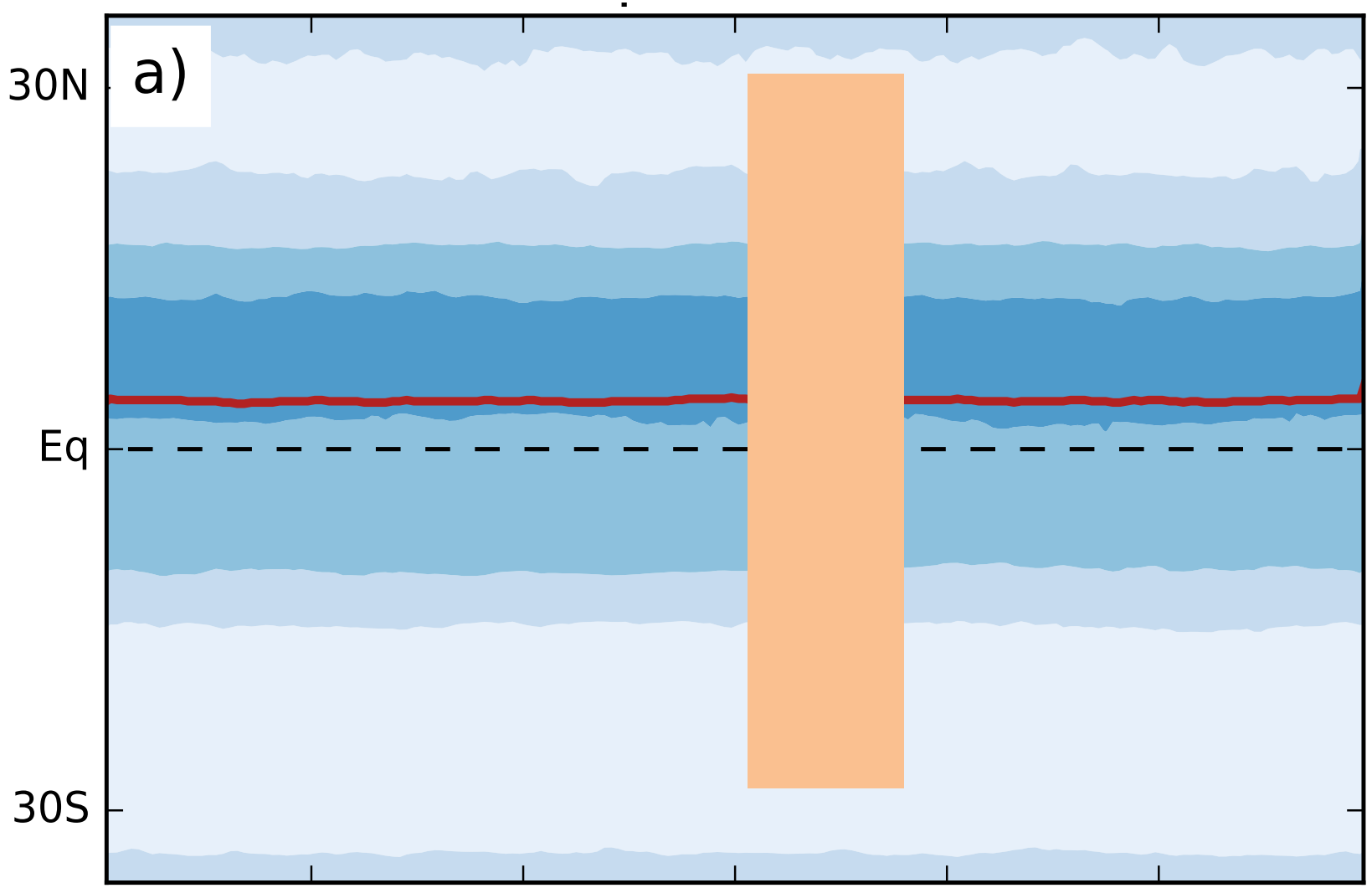
AquaCTL: Earth-like basic state, CMIP5-like spread



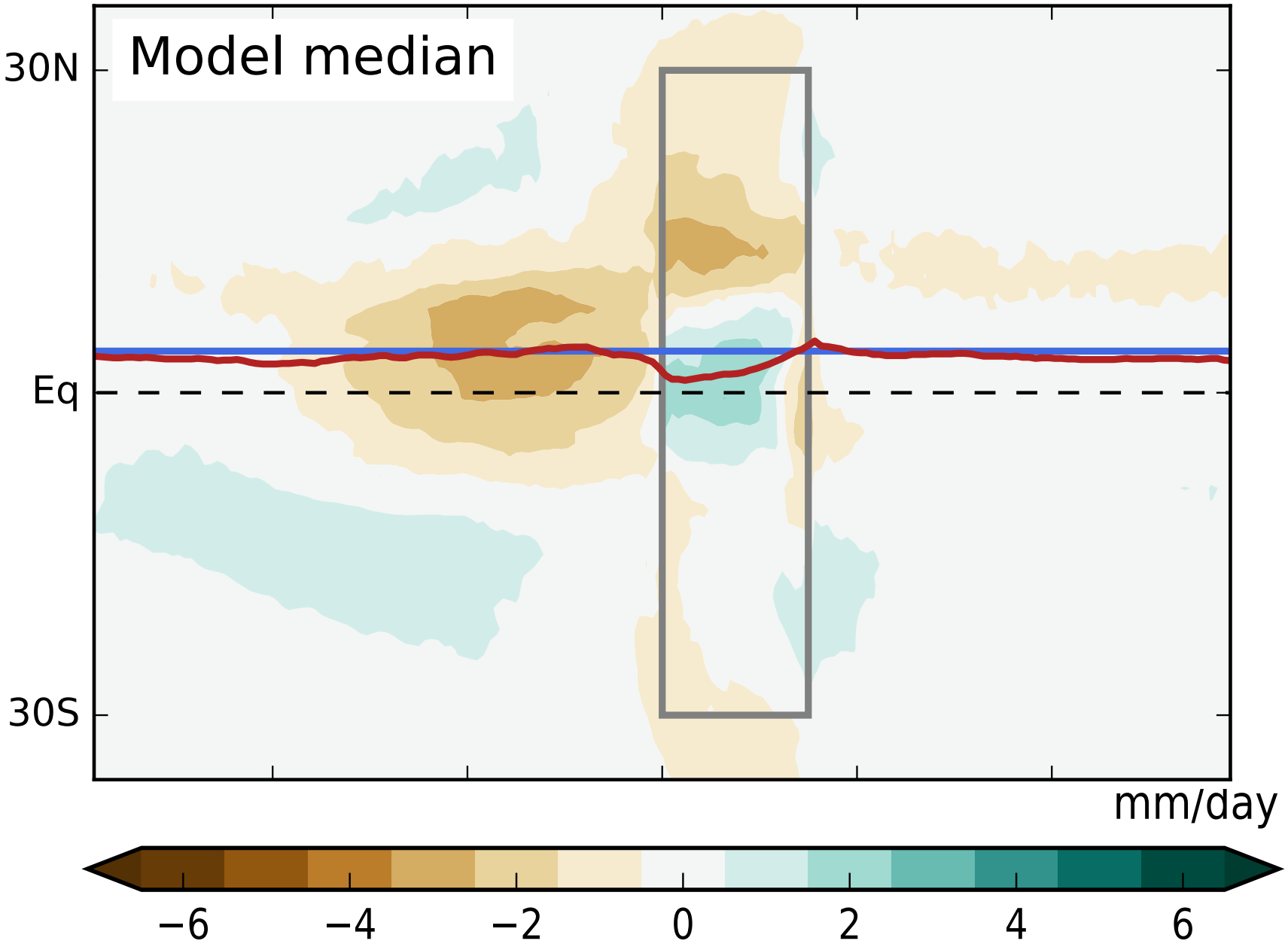


1 AM2.1
2 CAM3
3 CAM4
4 CAM5Nor
5 CNRM-AM5
6 ECHAM6.1
7 ECHAM6.3
8 GISS ModelE2
9 LMDZ5A
10 MetUM-CTL
11 MetUM-ENT
12 MIROC5
13 MPAS
14 CALTECH

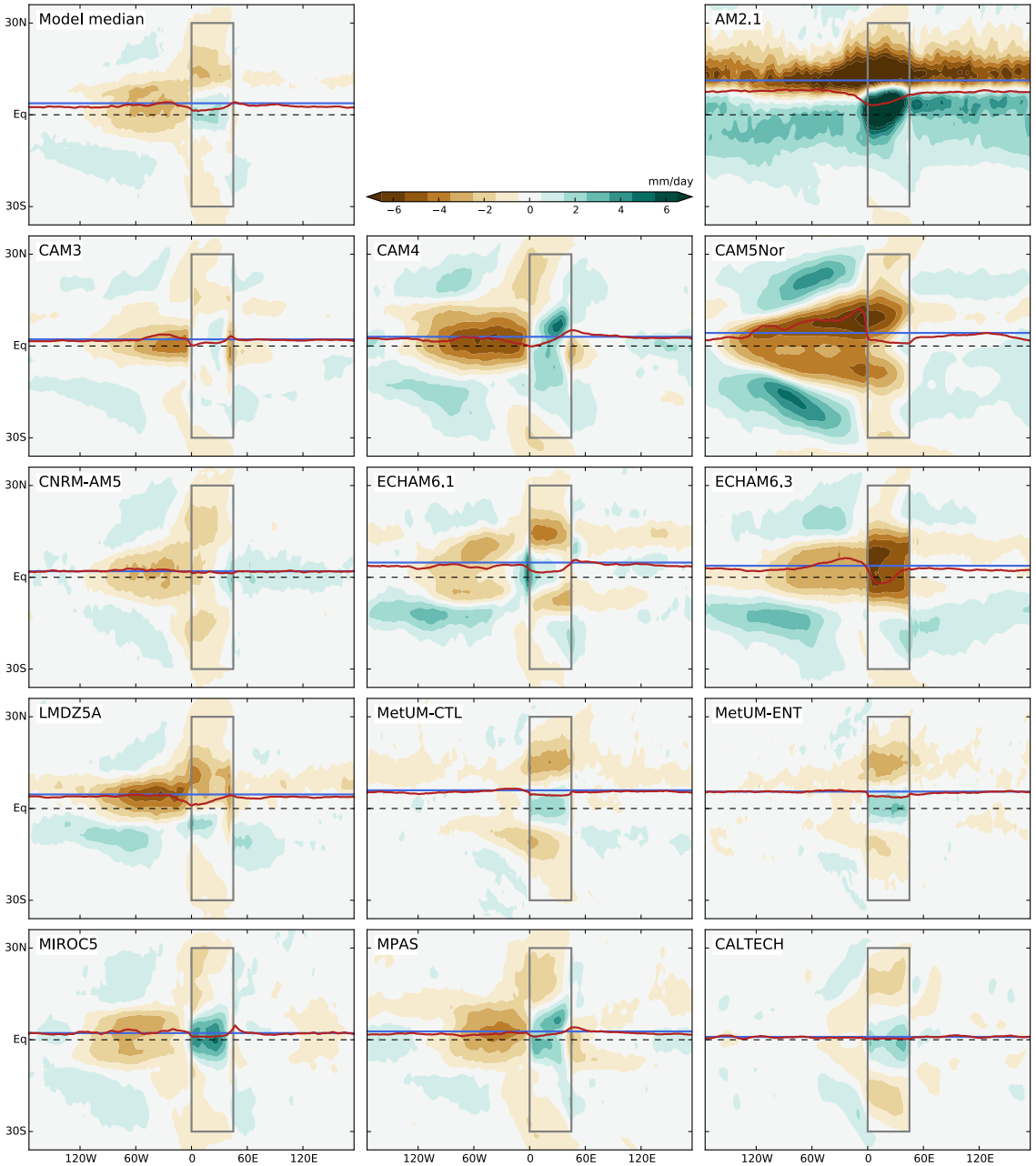
Control Annual Mean Precipitation:



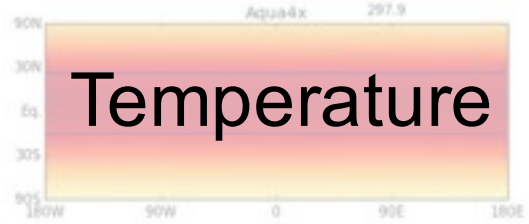
LandCTL: Large response to the inclusion of a continent

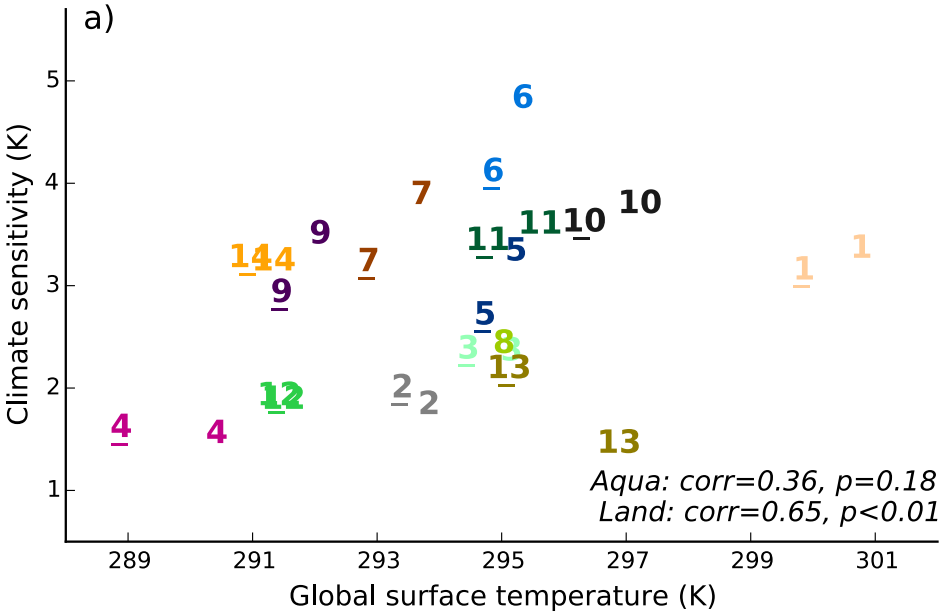


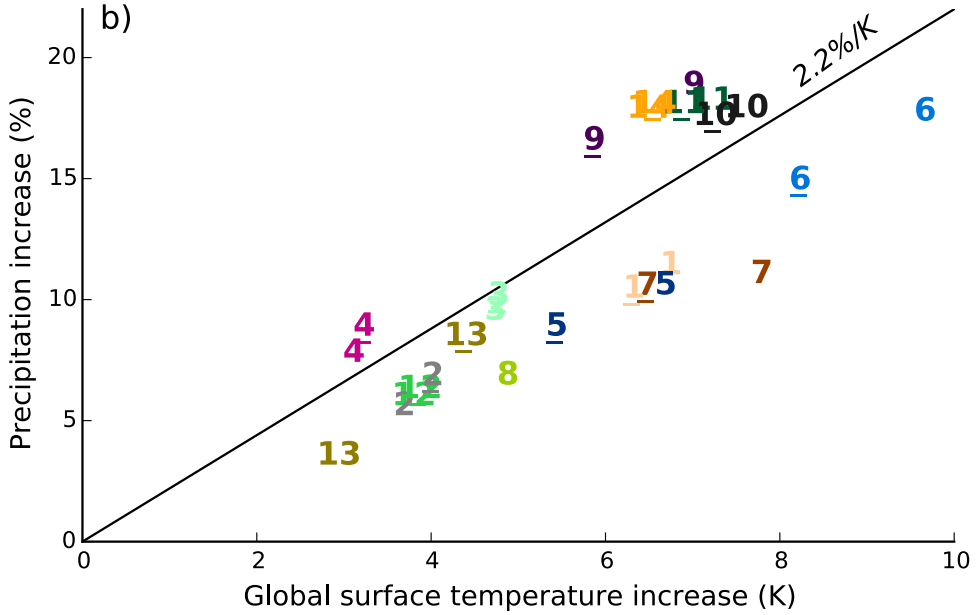
The ensemble spread!



Aqua4xCO: global mean anomalies

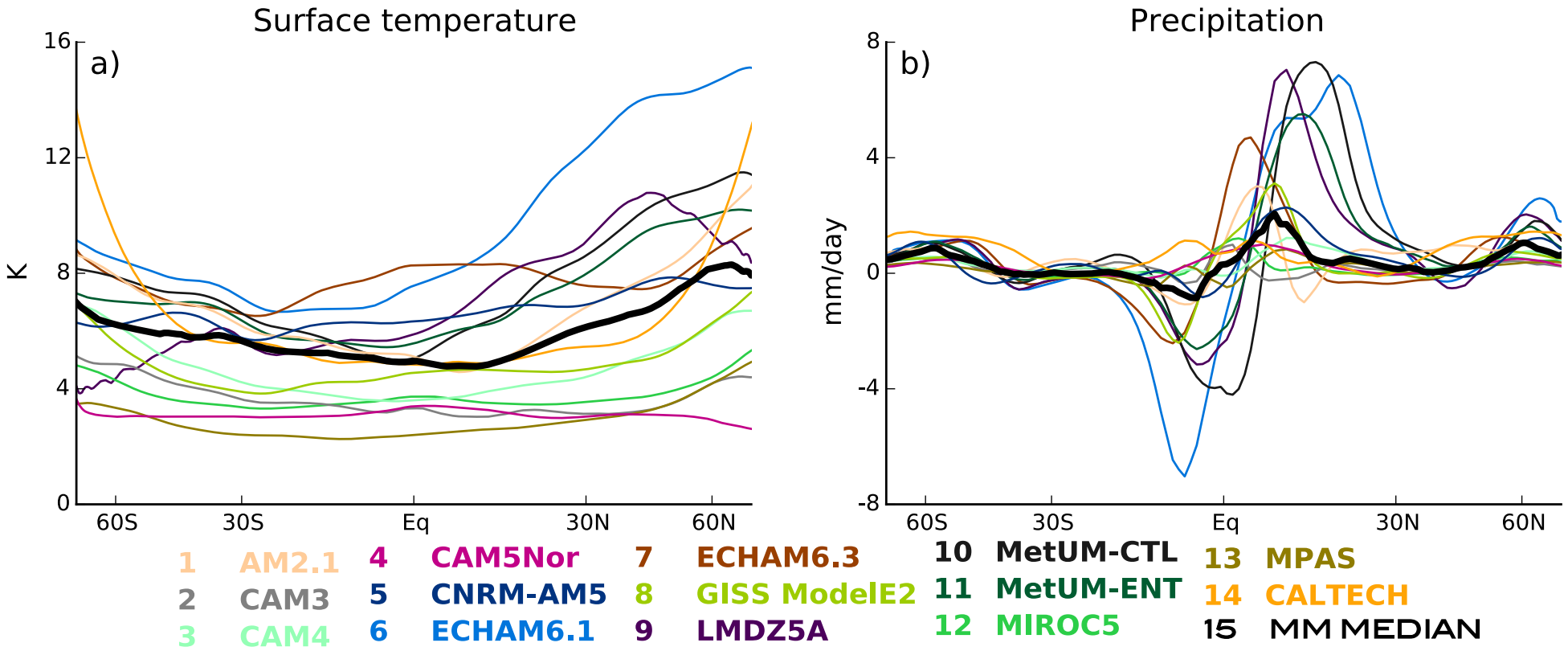






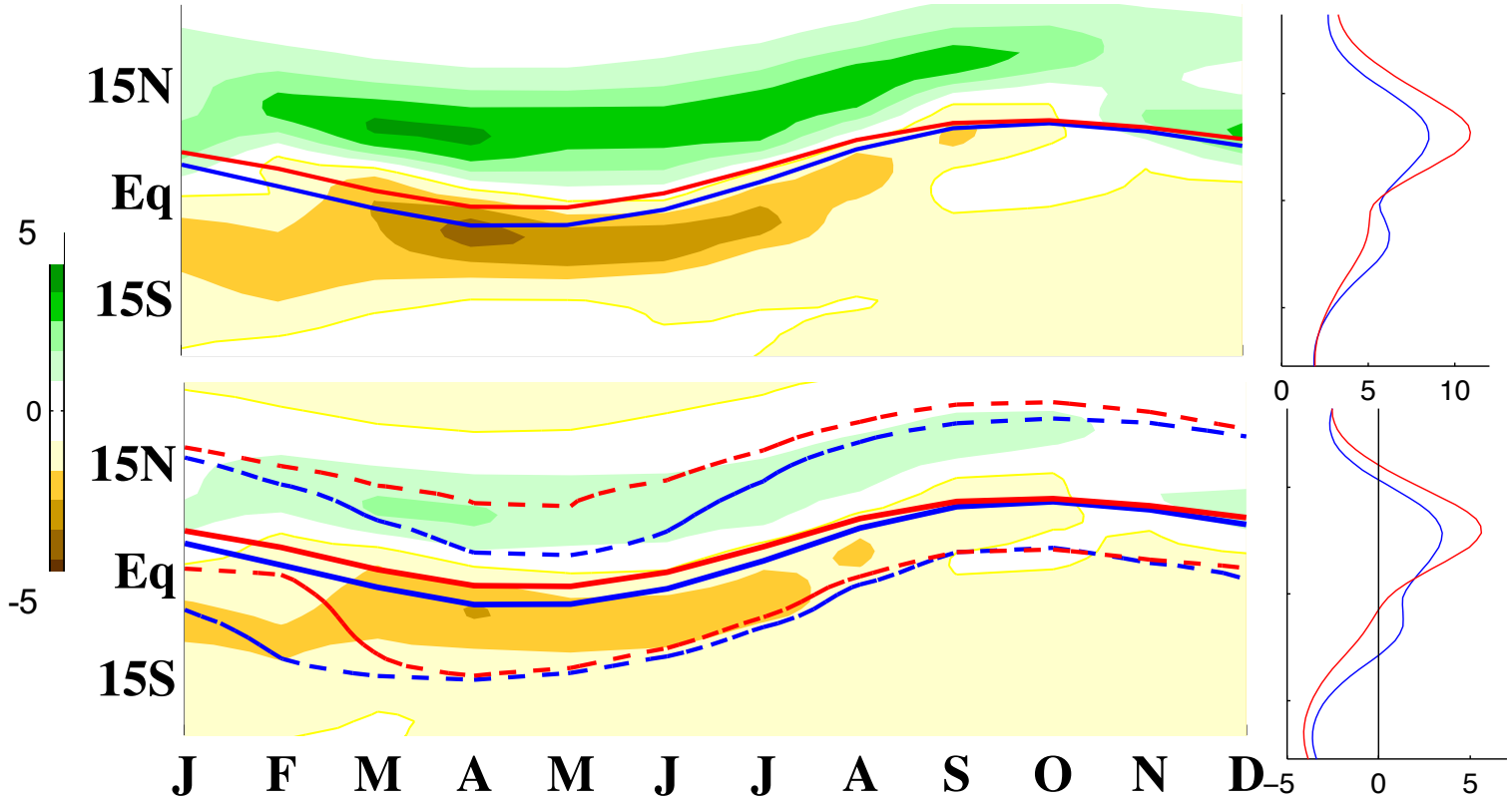
- Spread similar to CMIP5
- Hint of dependence of climate sensitivity to basic state

Aqua4xCO2: annual mean, zonal mean anomalies



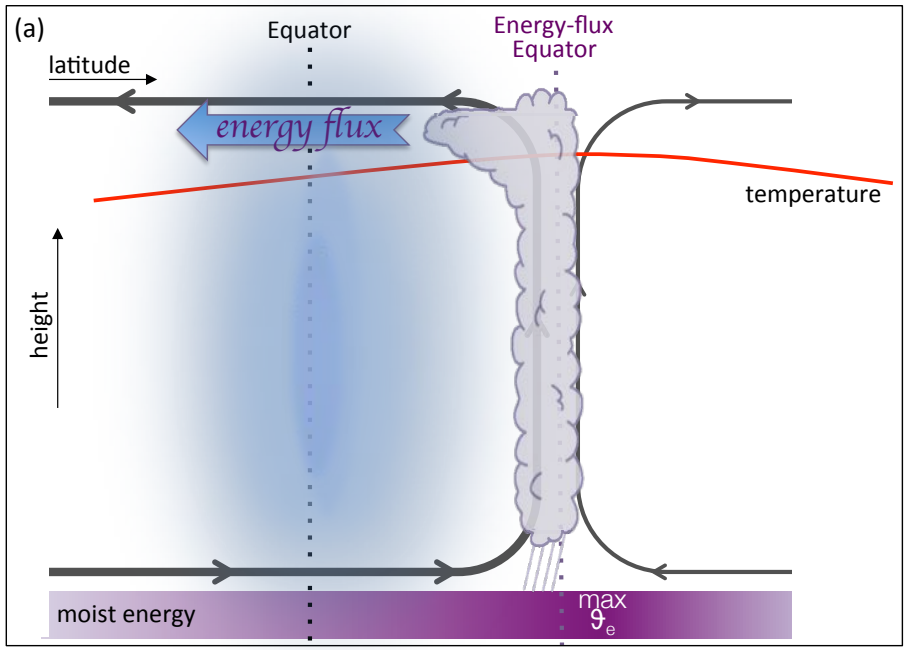
- In the comprehensive GCMs (**only**):
  - "**Arctic** amplification" (without ice or ocean circulation… T-dependent water/cloud feedbacks?)
  - Poleward displacement of the ITCZ

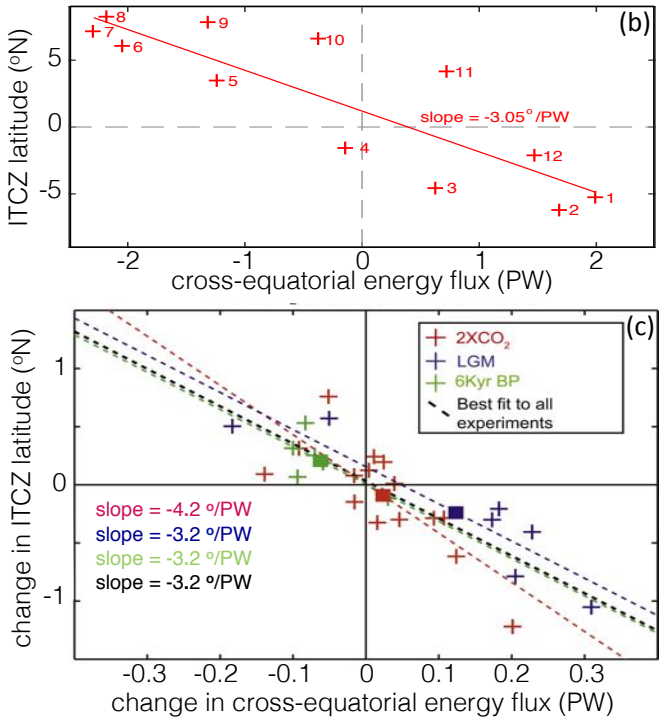
Aqua4xCO2: seasonality of ITCZ



- The northward shift of the ITCZ is muted in SON.
- The width of the ITCZ is reduced via a reduction of its seasonal range

Energetic Constraints on the ITCZ:

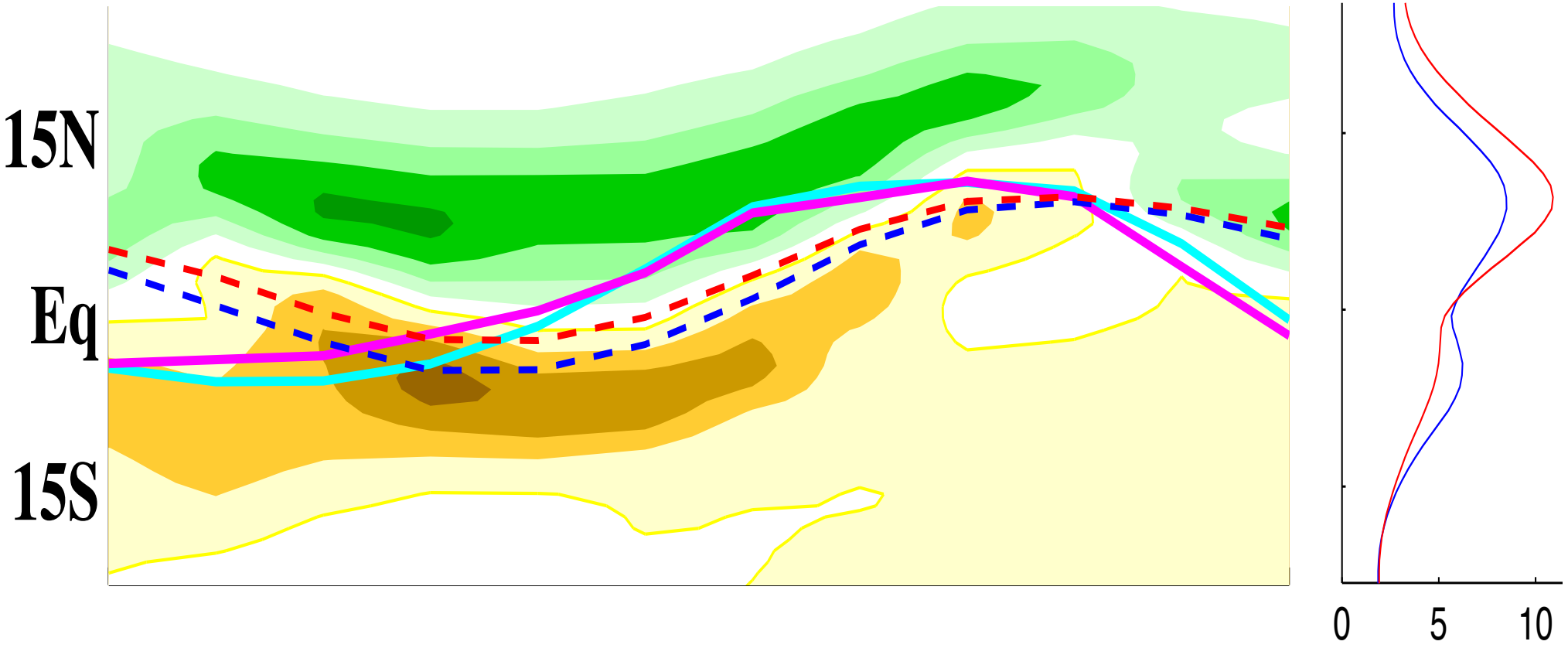




The EFE is determined by both the *transport across* and the *input into* the equator of moist static energy (Schneider & Co)

The relationship between TRA_0 and the ITCZ carries over *from the seasonal cycle to climate change* (Donohoe & Co)

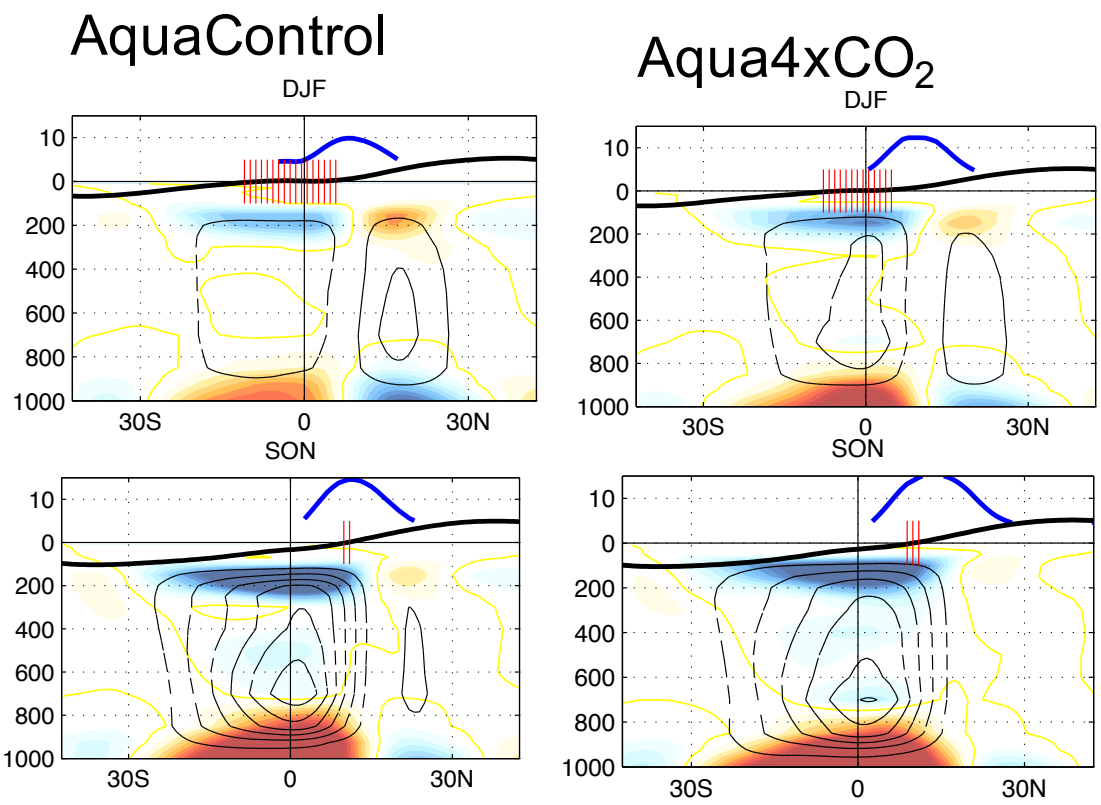
Energy flux changes are expected with an ITCZ shift:



- The northward shift of the ITCZ is muted in SON.

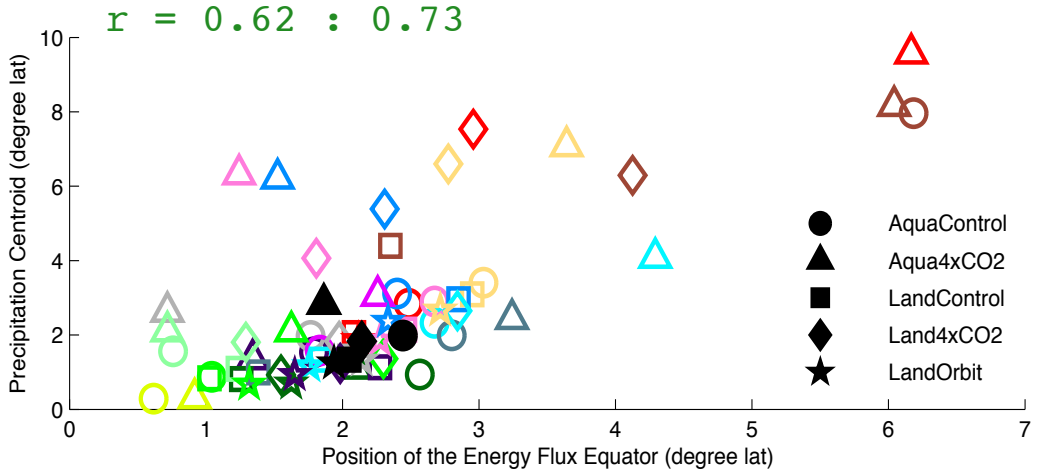
How good a match is the EFE?

Energy Frameworks (1)

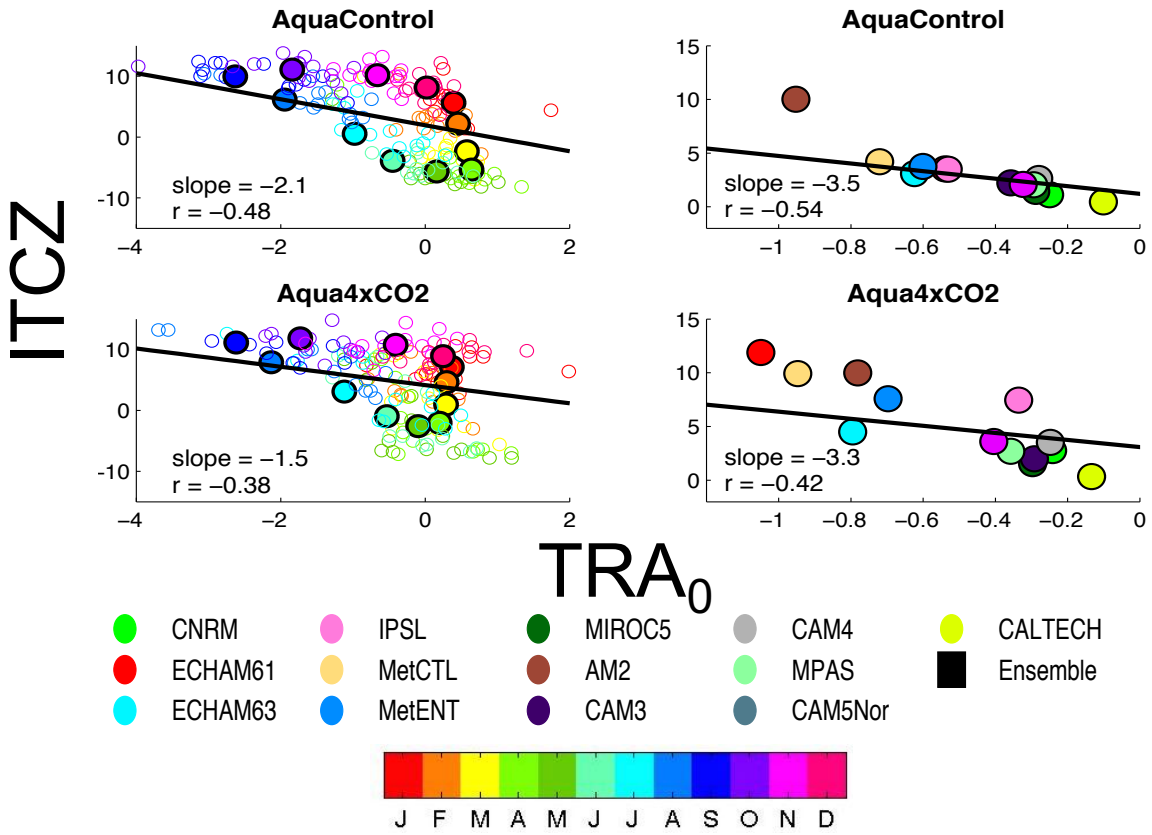


The EFE (energy flux equator) is not very well defined (most of the year).

Its changes explain 40% to 50% of the annual mean climate change signal in the ITCZ position:

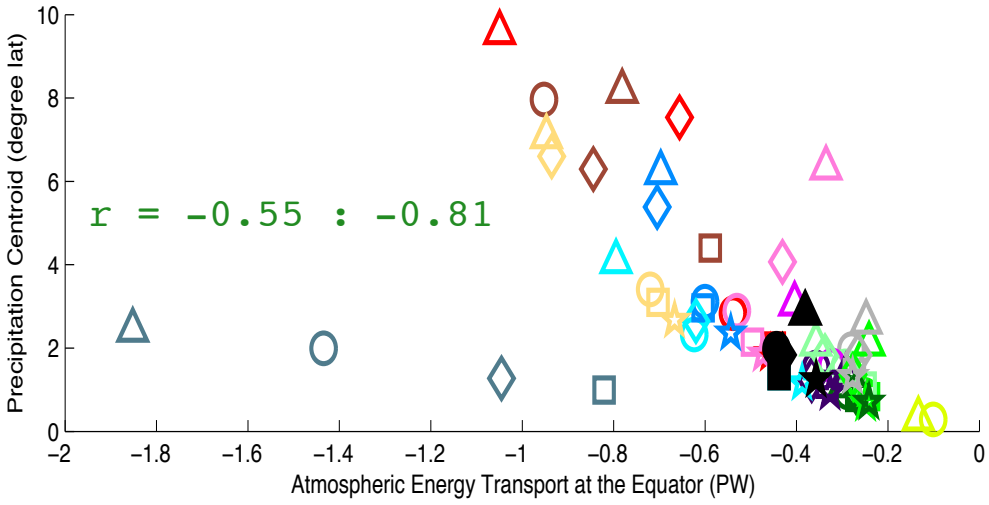


Energy Frameworks (2)

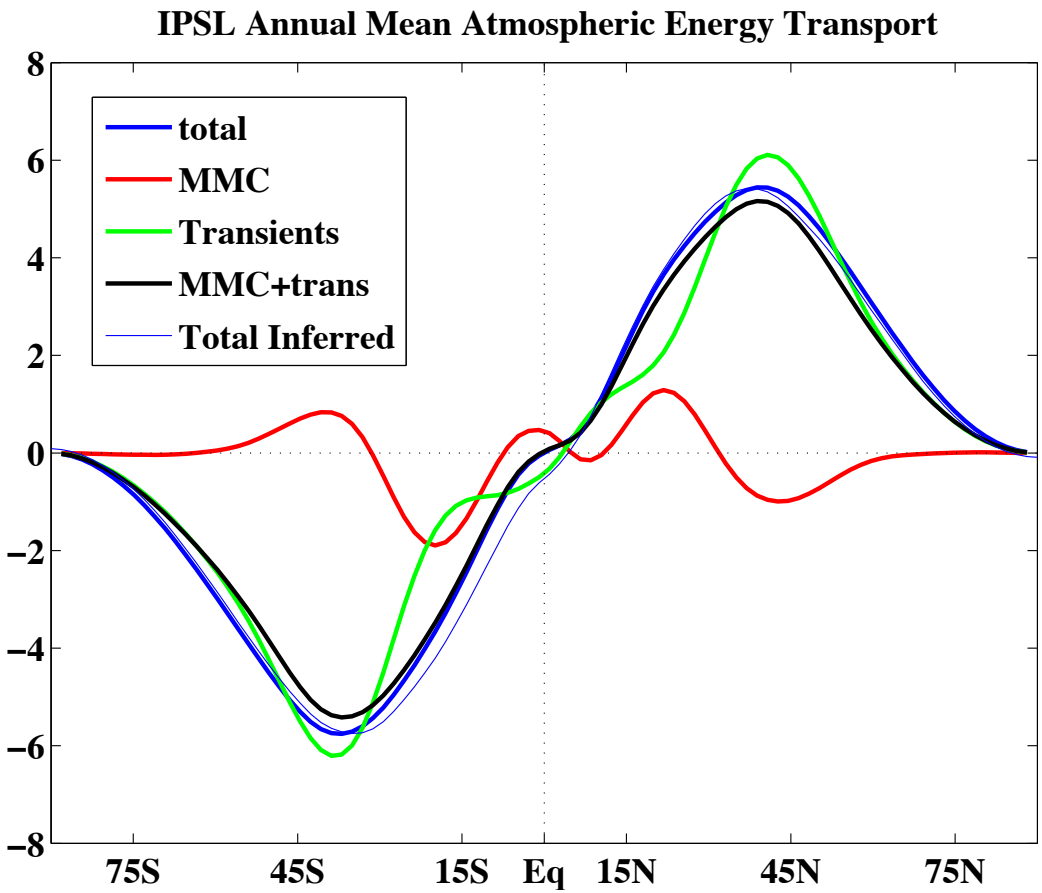


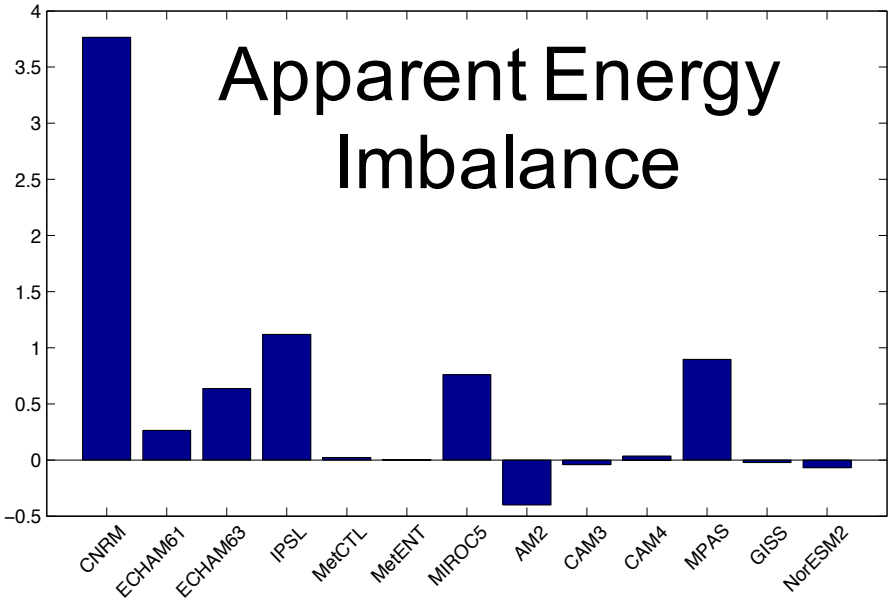
The TRA_0 (energy transport @equator) ITCZ relationship has different slopes for different climates and for the AC and the anomalies.

Its changes explain 30% to 64% of the annual mean climate change signal in the ITCZ position:

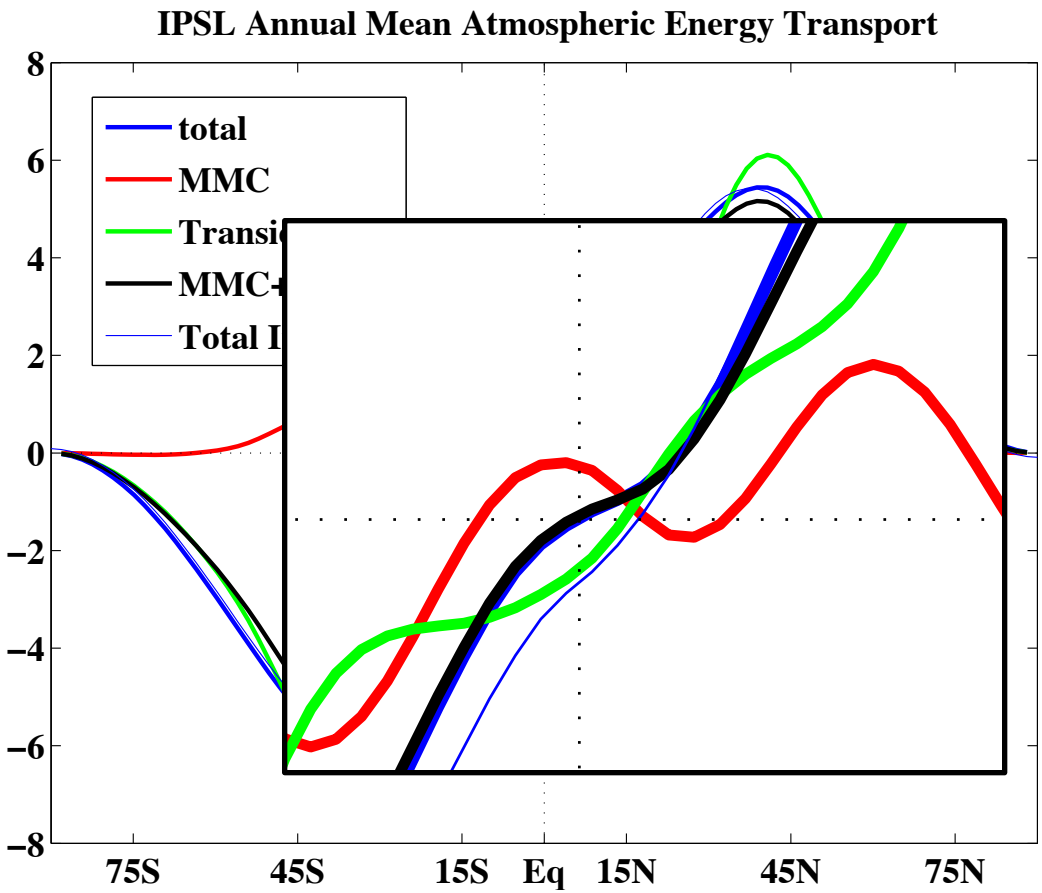


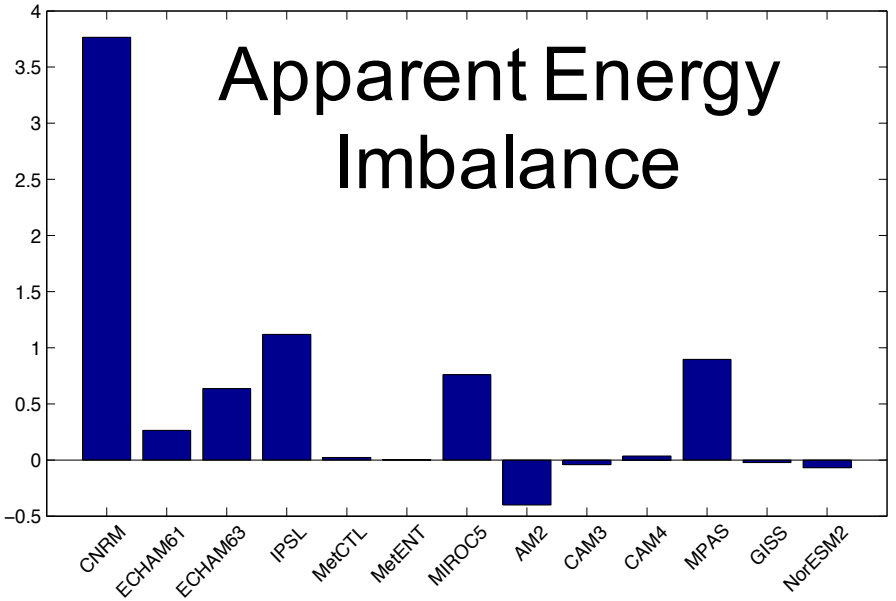
CAVE MINUTIAS!
The devil in the details…



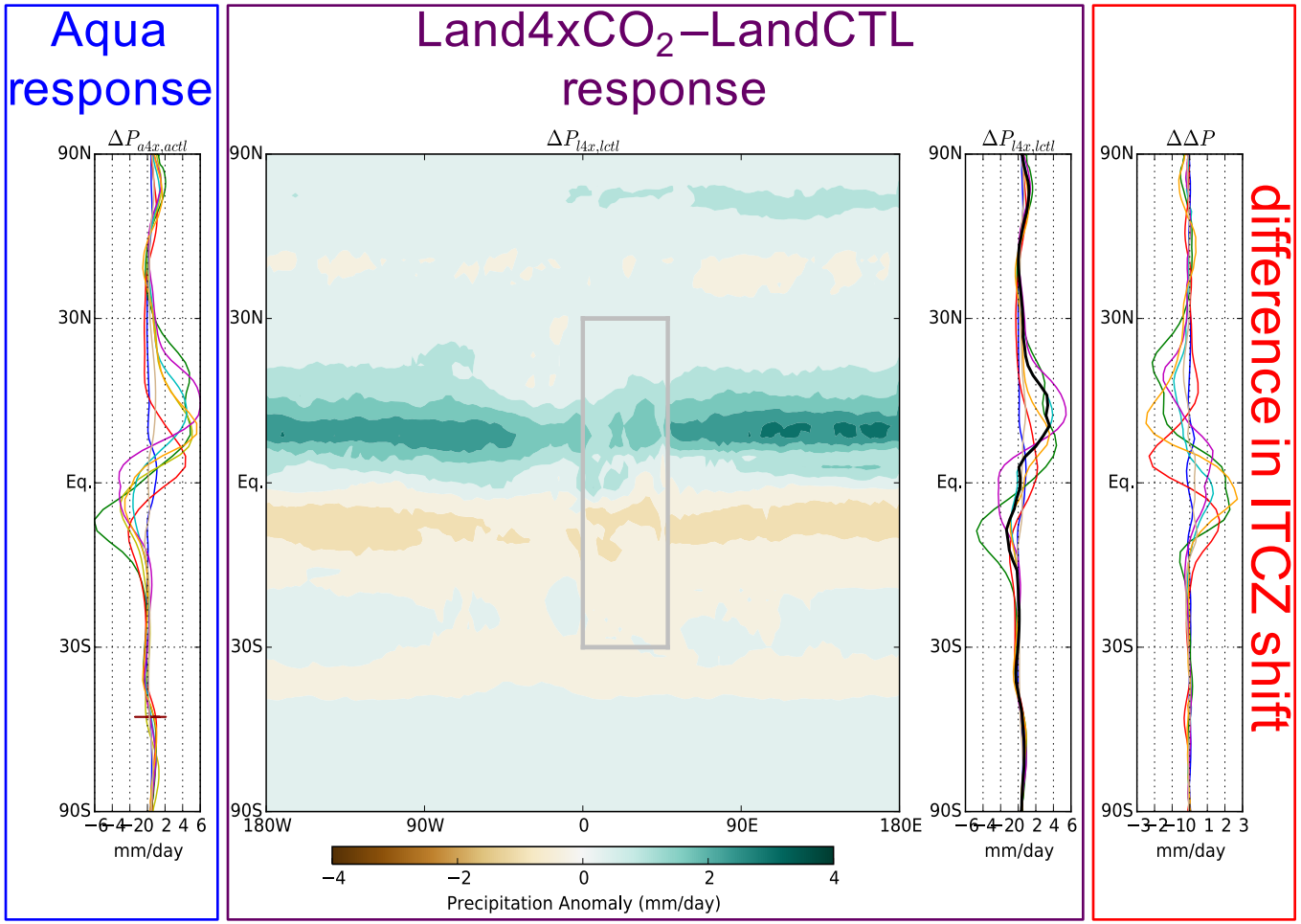


CAVE MINUTIAS!
The devil in the details…

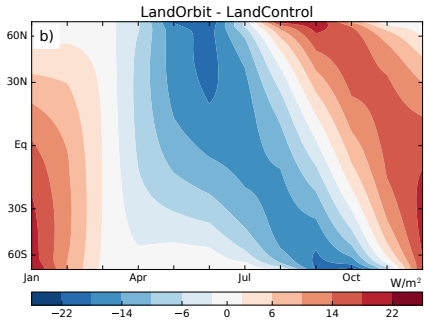




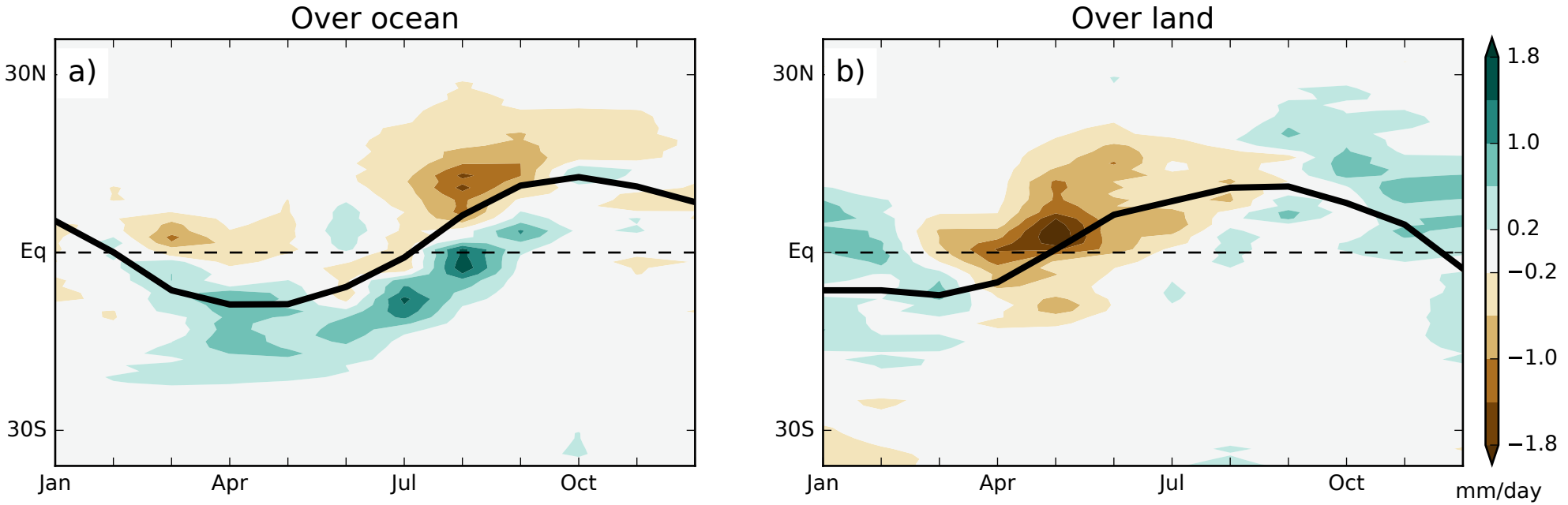
How does the presence of land affect the response of the zonal mean ITCZ to CO_2?



No *qualitative* difference: still a northward shift of the ITCZ in response to warming, but the effect is muted more strongly (1/4) than expected from a small change in land cover (1/16)



LandOrbit: a meridional shift of the ITCZ is robustly realized only over ocean



Land precipitation is reduced when insolation is reduced, and increased when insolation is increased!

Conclusions:

1. TRACMIP is a new community "tool" that targets the essential dynamics of tropical rain belts and the distinction between (zonal mean) ITCZ and monsoons.

2. It is already (Voigt et al. JAMES 2016) providing insights on how
   + warming amplifies inter-hemispheric asymmetries in temperature and precipitation
   + & reduces the seasonal range of the ITCZ
   + "land" affects the sensitivity of the ITCZ to CO_2
   + "land" responds differently than the ITCZ to both CO_2 and orbital forcings.

3. The existence of TRACMIP speaks volumes about the generosity and commitment of the climate community!

4. Much more to explore: contact us at tracmip@gmail.com!