Links between Palaeoclimate and Future climate

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Simulations and results from

Paleoclimate Modelling



Past climate changes in brief



→ A range of documented climates, very different from recent climates

Methods



+ sensitivity experiments, + idealised experiments

Must account for uncertainties in forcings/boundary conditions

Polar amplification



ipcc

CLIMATE CHANGE 2013

21st century RCP 8.5

Last Galcial Maximum (21 000 years ago) CO2: 200 ppm Large ice-sheets in NH

Pliocene (3 million years ago) CO2: 350-400 ppm



AR5 WG1 Fig5.5

Last Glacial Maximum (21000 y ago)



Hydrological cycle-precipitation

Normal Conditions



Difference with PI : ensemble means 2xCO2 (6 models, PMIP2)



Tropics PMIP2 / CMIP3 (a) 30 (b) C-C: 7.5% K 20 20 1.5% K 10 (%) b/b⊽ -10 10 ∆P/P (%) 10 . C−C: 7.5% K[−] 2.7% -20 -20 -30⊾ _4 -30 2 3 -2 3 -3 -2 -1 0 4 -3 -1 0 1 2 $-\Lambda$ ΔT_{s} (K) ΔT_{s} (K)

Water wapor follows Clausius Clapeyron Precipitation have smaller rate

Globla PMIP3/CMIP5



Di Nezio et al. 2011

Climate sensitivity and feedbacks



? Cloud feedback
? Use paleo
simulation to
directly assess
climate sensitivity

AR5 WG1 Fig5.5

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Precipitation changes Mid-Holocene

Precipitation / 6k - 0k Annual mean 1000 6k-0k Mean annual precipitation (mm) 0 500 PMIP1 -0.125 0.063 0.250 1.000 -0.500-500-1.000 0.125 0.500 -0.250 -0.063

atitude

Long story of papers / underestimation of African monsoon ŝ - Link with ocean and vegetation feedbacks

- Link with model biases etc... Joussaume et al 1999,... Braconnot et al, 2007,

But : very demanding to be right in the right place for the right reasons



Mid Holocene JA Sahel precipitation

Sahel precipitation : 10°W-20°E; 7°N-25°N



OBS 0ka

+ ITCZ : tendency for southward shift /observation

Framework : decomposition into regimes using ω500hPa as a proxy for convection as in Bony et al. 2004

$$\Pr = \int_{-\infty}^{+\infty} \Pr_{\omega} P_{\omega} d\omega \qquad \int_{-\infty}^{+\infty} P_{\omega} d\omega = 1$$

$$\delta Pr = \int_{-\infty}^{+\infty} Pr_{\omega} \, \delta P_{\omega} \, d\omega + \int_{-\infty}^{+\infty} P_{\omega} \, \delta Pr_{\omega} \, d\omega + \int_{-\infty}^{+\infty} \delta Pr_{\omega} \, \delta P_{\omega} \, d\omega$$

Regime distribution

thermodynamics

- Model underestimate N/S gradients (heating) → location of ITCZ (bias of 0 k simulation impact northward shift at 6ka)
- 6k : changes dominated by shift in regime distribution (robust!!! whatever model do for present day) → Less subsidence ; more deep convection (large scale moisture advection is dominant)

Zheng and Braconnot, J clim 2012





TAS Oka

Extension to other periods



Precipitation in regimes for PI



Braconnot and Zheng, ongoing work

Synthesis of results in 3 regimes (JA)



Robust behaviour across models when looking separately at pdf and precipitation rates within regimes Partitionning between the different effects -→ model spread

Target to define which partitioning is more "realistic"?









- Shift toward deep convection regimes : dominant signal on precipitation
- Deep convection regimes more efficient
- Reduced medium regimes (reverse/CO2) and increased extreme regimes
- Regimes less efficient ; tend to dominate the signal, except for model with large increase in deep convection regimes
- Increase medium regimes, reduce extremes
- o Increase efficiency within regimes
- 4CO2SSTclima → similarities with 6ka
- Sstcllim : role of land/sea → 4CO2 (ESM) show role of ocean warming and water vapor feedbaclk





Conclusion and perspectives

- Paleoclimates offer lots of possibilities to test « climate sensibility » and the response and feedback of the hydrological cycle
- P2F is the group in PMIP addressing the links between past and future
- Need to refine how we better use paleoclimate reconstructions to assess the ability of climate model to properly represent mechanisms and feedbacks at play under anthropogenic forcing.
- Need to figure out how to better use 6k / 4CO2 sstclim to assess the part of the CO2 response resulting from land-sea contrast and monsoon responses.
- More analyses of common/different mechanisms in modelled response to past and future forcings are welcome!