Influence of low-level clouds radiative effects on the tropical climate

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$$ACRE = \int_{
ho_{sfc}}^{
ho_{TOA}} [R-R_0] rac{\mathrm{d} p}{g}$$







<CNRM $> \sim 0.1$

$$\textit{ACRE} = \int_{\textit{p}_{sfc}}^{\textit{p}_{TOA}} [\textit{R} - \textit{R}_0] rac{\mathrm{d} \textit{p}}{g}$$







<HadGem> ~ 4.5 <MIROC> ~ 2.1

<IPSL-CM5A> ~ 6.0

$$\textit{ACRE} = \int_{\textit{p}_{sfc}}^{\textit{p}_{TOA}} [\textit{R} - \textit{R}_0] rac{\mathrm{d} \textit{p}}{g}$$







$$\textit{ACRE} = \int_{\textit{p}_{sfc}}^{\textit{p}_{TOA}} [\textit{R} - \textit{R}_0] rac{\mathrm{d}\textit{p}}{g}$$







Atmospheric Cloud Radiative Effects

$$\textit{ACRE} = \int_{\textit{p}_{\textit{sfc}}}^{\textit{p}_{\textit{TOA}}} [\textit{R} - \textit{R}_0] rac{\mathrm{d} \textit{p}}{g}$$

Subs. Tropics (Wm⁻²) Global mean (Wm⁻²) All Tropics (Wm⁻²) <Obs $> \sim -0.3$ $< Obs > \sim 0.5$ $<Obs> \sim 13$ <MPI $> \sim 0.5$ <MPI> ~ 12.4 $\langle MPI \rangle \sim 2.2$ <CNRM $> \sim 0.1$ <CNRM> ~ 13.1 <CNRM $> \sim 4.0$ <HadGem $> \sim 4.5$ <HadGem> ~ 12.3 <HadGem> ~ 0.9 <MIROC> ~ 2.1 <MIROC> ~ 12.6 <MIROC $> \sim 2.1$ <IPSL-CM5A $> \sim 6.0$ <IPSL-CM5A $> \sim 13.1$ <IPSL-CM5A> \sim 2.6





too negative Net ACRE



4/11	Introduction	Results	Interpretation	Summary
	Low	-clouds ACF	RE and tropica	I precipitation
		a) GPCP Precipitation		mm/day
•	304 0 306 1		50W 0 50E 0E 0E 0E 0E	100 100 ⁴
	30N 0 90S	b) IPSL-CM5A-LR Precipitation	on Contraction of the second s	mm/day
	1	0.5 1 2 000 000 000 000 000 000 000 000 000	30W 0 30E 60E 90E	120€ 150€ 16



4/11	Introduction	Results	Interpretation	Summary
	Low	-clouds ACF	RE and tropical	precipitation
ſ	904 905 906 906 906 906 906 906 906 906	a) GPCP Precipitation		mm/day off 100 mm/day
	300 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	VET CRE ATM		

How do low-clouds ACRE influence the tropical climate?





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ts

COOKIE: Clouds ON-OFF Klimate Intercomparison Experiment

Clouds are made transparent to radiation in different configurations.

TABLE 3. CLOUDS-OFF ($\beta = 0$) component of COOKIE. offAMIP simulations may require a climatological run of as long as twenty years to spin-up soil moisture and provide more balanced initial data.

Name	Base Experiment	Modification
offAMIP	AMIP	$\beta = 0$
offAMIP4xCO2	AMIP4xCO2	22
offAMIP4K	AMIP4K	"
offaqua	aqua	**
offaqua4xCO2	aquaxCO2	**
offaqua4K	aqua4K	22

In particular, **offpblamip** experiments consist in rendering PBL clouds transparent to radiation.

TABLE 4. CLOUDS-OFF component of COOKIE

Series	Base Experiment	Modification
offpblAMIP	AMIP	$\beta = 0$ for $p > 680$ hPa
offpblAMIP4K	AMIP4K	**
offpblaqua	aqua	**
offpblaqua4K	aqua4K	**
fixedaqua	aqua	specified mean $R_{\text{atm}}^{\text{cld}}(p, \phi)$

http://www.euclipse.eu/wp4/wp4.html





How robust are these results?















Robust response among physics and models (different amplitude however).







MSE budget:

$$0 = \Delta(LH + SH) + \Delta[ACRE] + \Delta[R_0] + \Delta[\omega \frac{\partial h}{\partial p}] + \Delta[\vec{u}\nabla h]$$

Brient and Bony (2012)

Water budget:

$$\Delta P = \Delta E + \Delta \left[\omega \frac{\partial q}{\partial \rho}\right] + \Delta H_q$$
$$\Delta P = \Delta P_{dyn} + \Delta P_{ther}$$
$$\Delta P_{dyn} = \Delta \bar{\omega} \Gamma_q$$
$$\Delta P_{ther} = \Delta E + \bar{\omega} \Delta \Gamma_q + \Delta V_q^{\alpha} + \Delta H_q$$
Bonv et al (2013)

Aquaplanet ΔP





10/11	Introduction	Results	Interpretation	Summary	
			Summary		
Ξ.	PBL CRE oceans.	enhance pre	ecipitation and ci	culation over trop	oical
	1. Subsi 2. Conv	dence: ΔP ective: ΔP	$\leftrightarrow \Delta E \ \leftrightarrow \Delta ar{\omega}$		
	Robustnes	s among ph	vsics and model	s, but different an	nplitud

- $\Delta P \leftrightarrow \text{present-day ACRE}$?
- □ PBL CRE influence the tropical climate within a few days.



11/11	Introduction	Results	Interpretation	Summary	
In	nalioatione:				
П	nplications.				

- The overestimate of PBL CRE may contribute to the systematic overestimate of (weak) precipitation over subsidence regimes.
- PBL CRE may affect the tropical overturning circulation. PBL clouds-LS circulation feedback in a changing climate?

Perspectives:

- Include more models in the study. Further investigate features non-robust among models.
- Extend the analysis to higher-level clouds (offamip COOKIE runs).



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Im	plications:				
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Cummoru

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Perspectives:

Introduction

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- Extend the analysis to higher-level clouds (offamip COOKIE runs).

Thank you

