The role of cloud radiative heating in determining the location of the ITCZ in aqua-planet simulations.

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Atmospheric Sciences

Background

Li and Xie (2014)

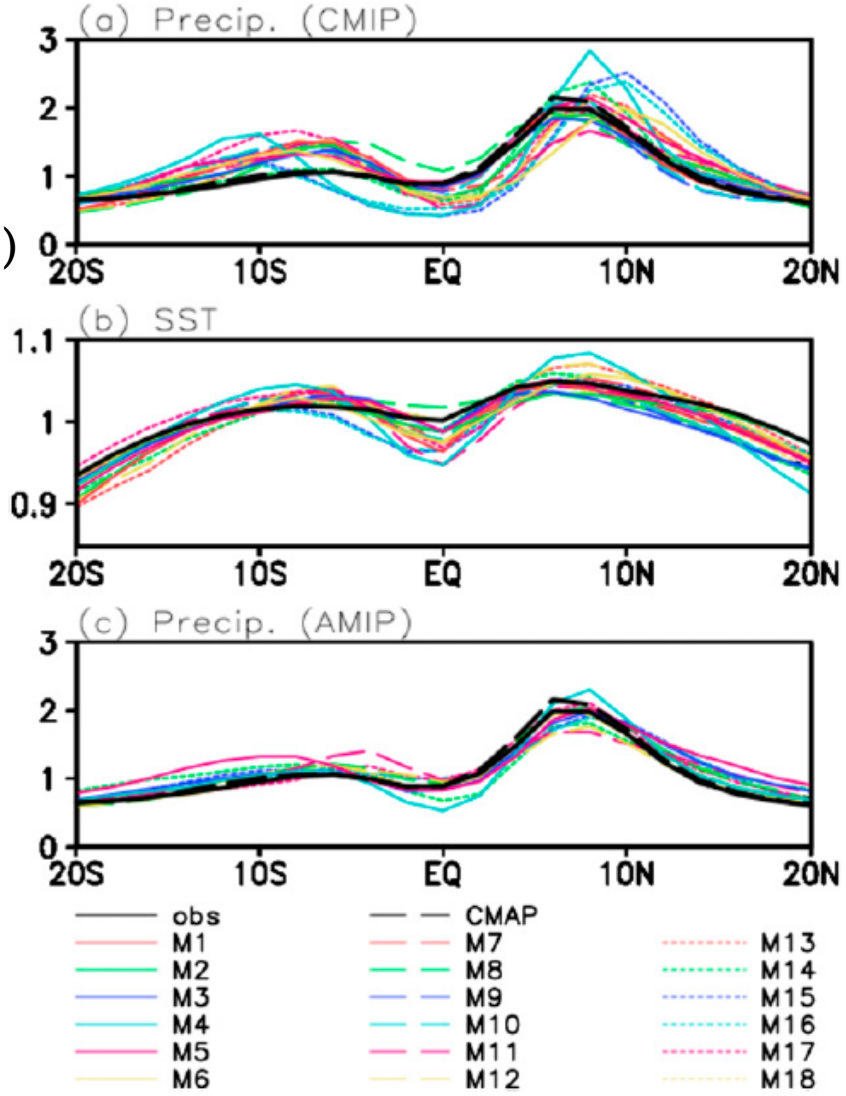


FIG. 1. Zonally and annually averaged (a) precipitation and (b) SST in the tropical Pacific (120°E–80°W) in observations (black lines) and 18 CMIP5 CGCMs (colored lines). (c) As in (a), but for observations and 11 AMIP simulations. Here, the precipitation and SST for observations and each model are normalized by their respective tropical means (20°S–20°N).

Lin (2007)

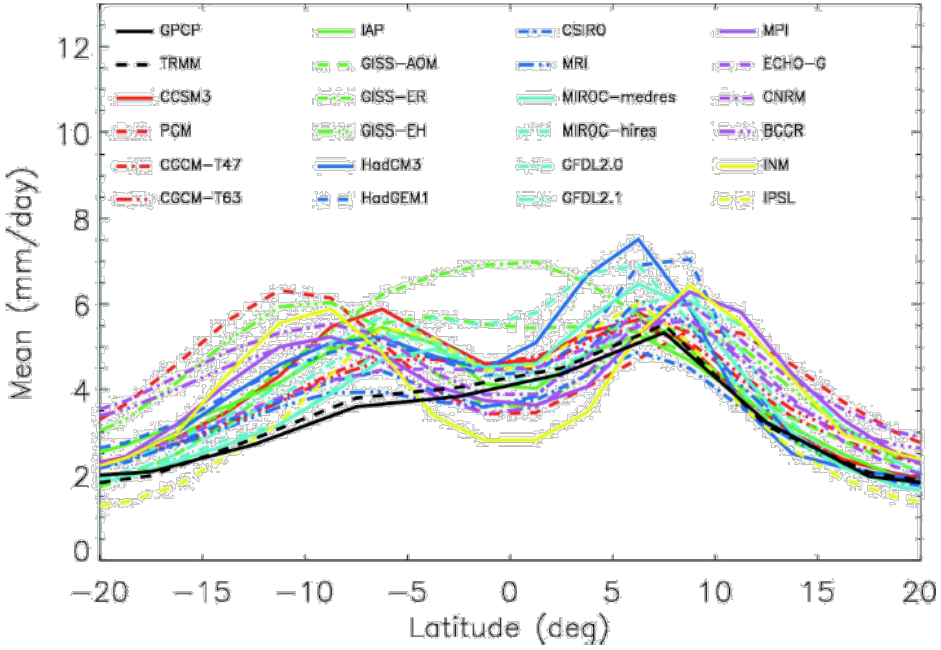


FIG. 5. Meridional profiles of zonal-mean annual mean precipitation.

Background

Landu et al. (2014)

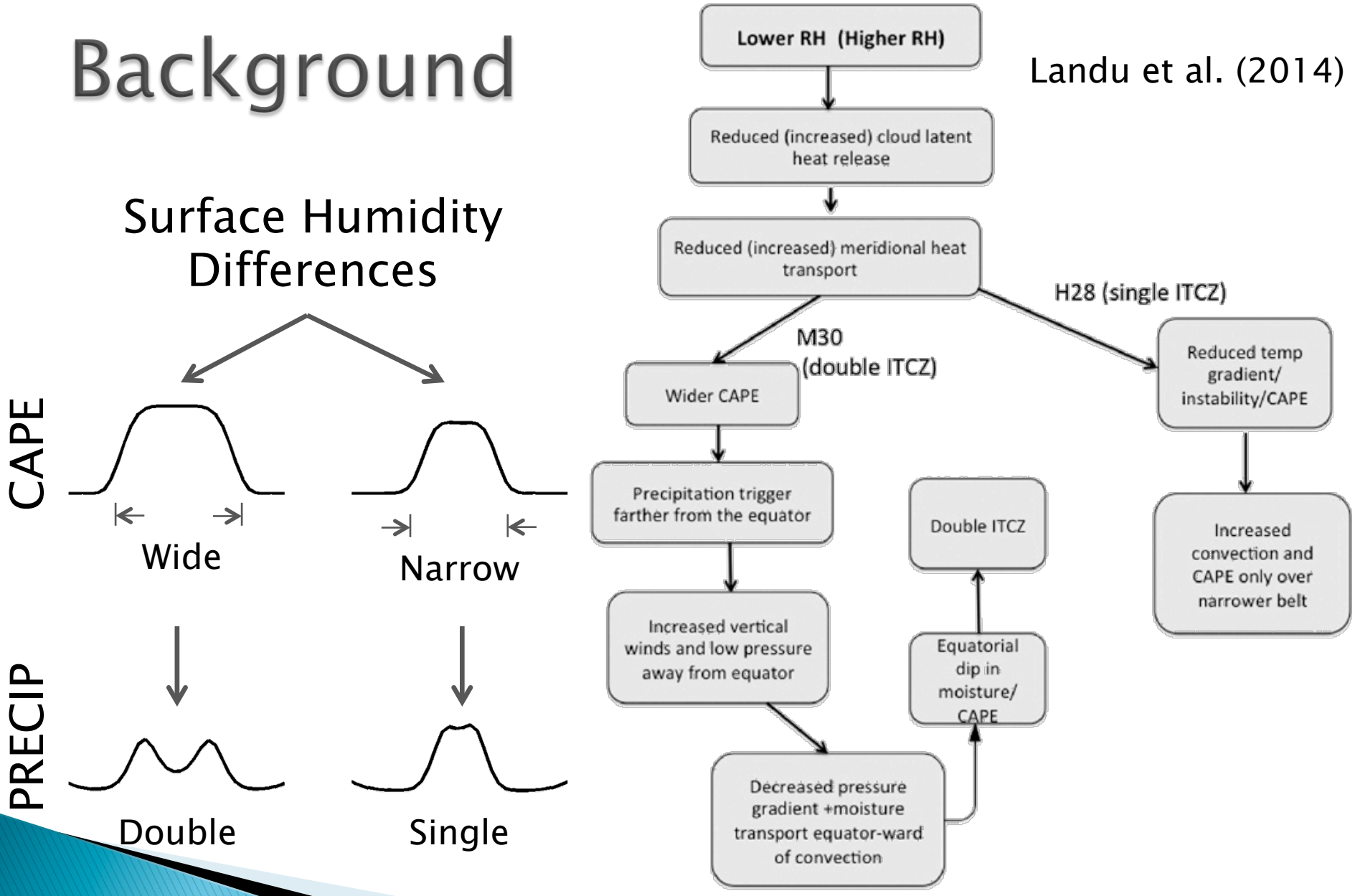


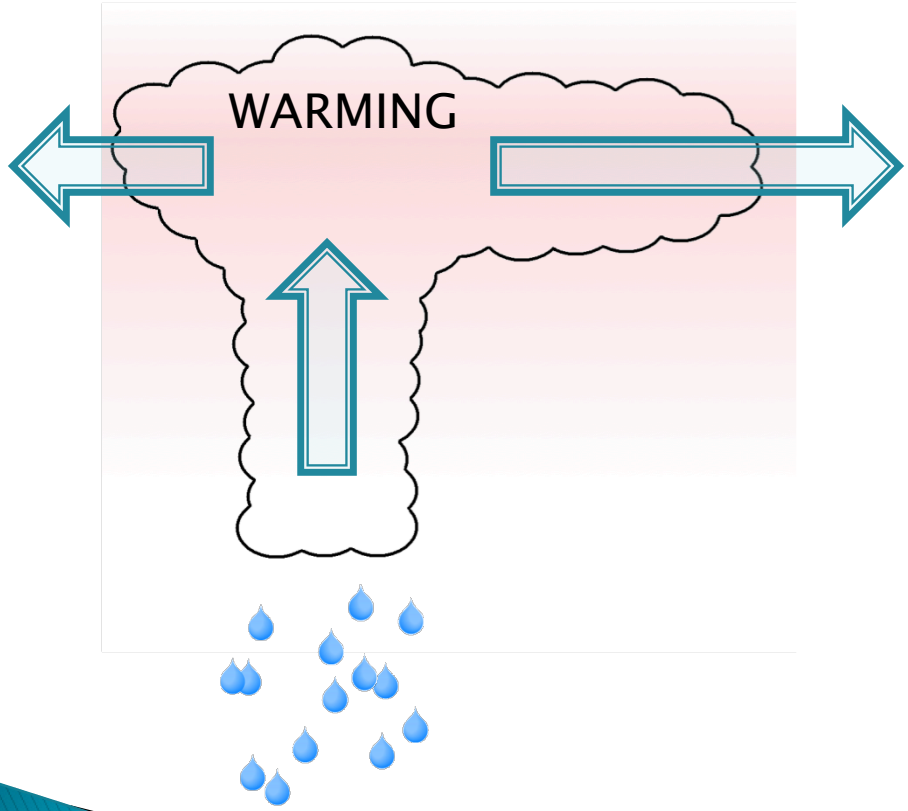
FIG. 9. Schematic of the feedback mechanisms corresponding to double and single ITCZ simulations.

Background

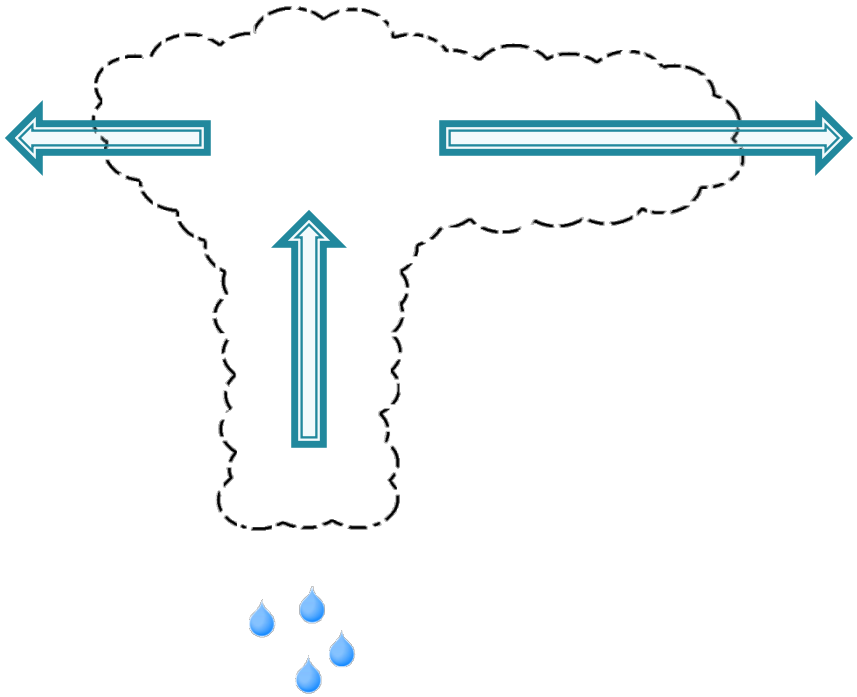
Atmospheric Cloud Radiative Effect

Background

"ACRE-on"

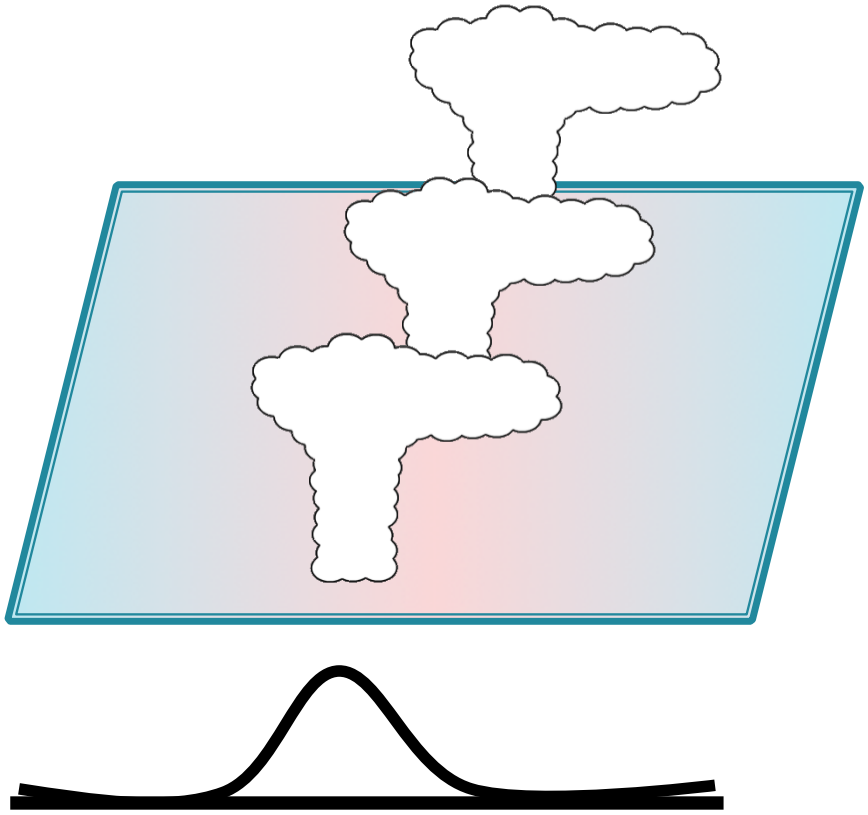


"ACRE-off"



Background

"ACRE-on"



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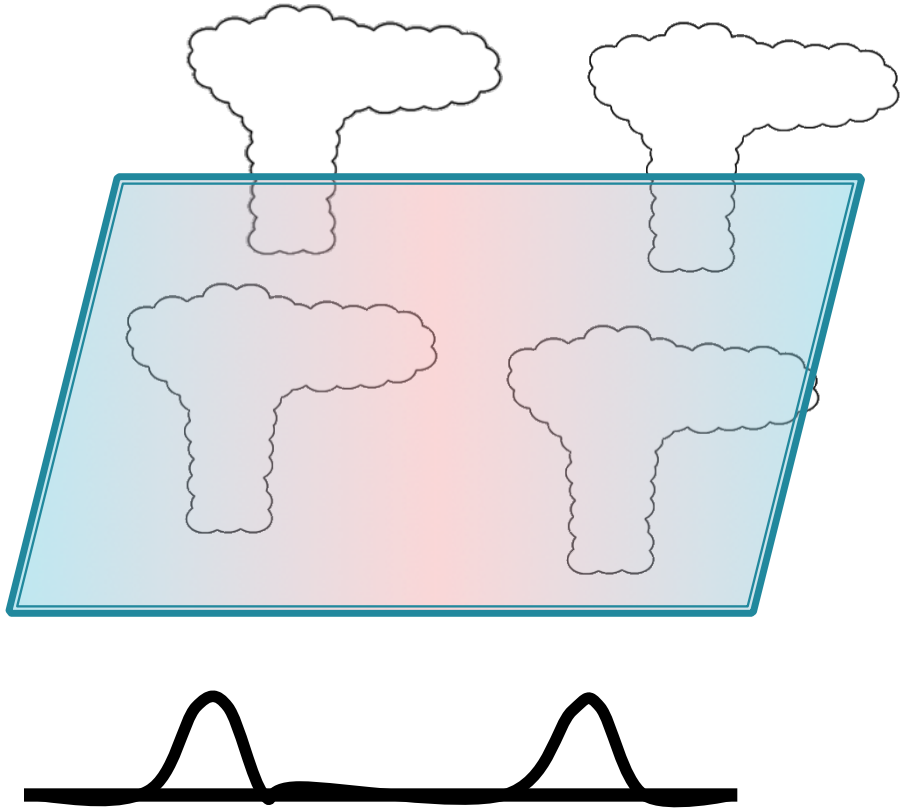
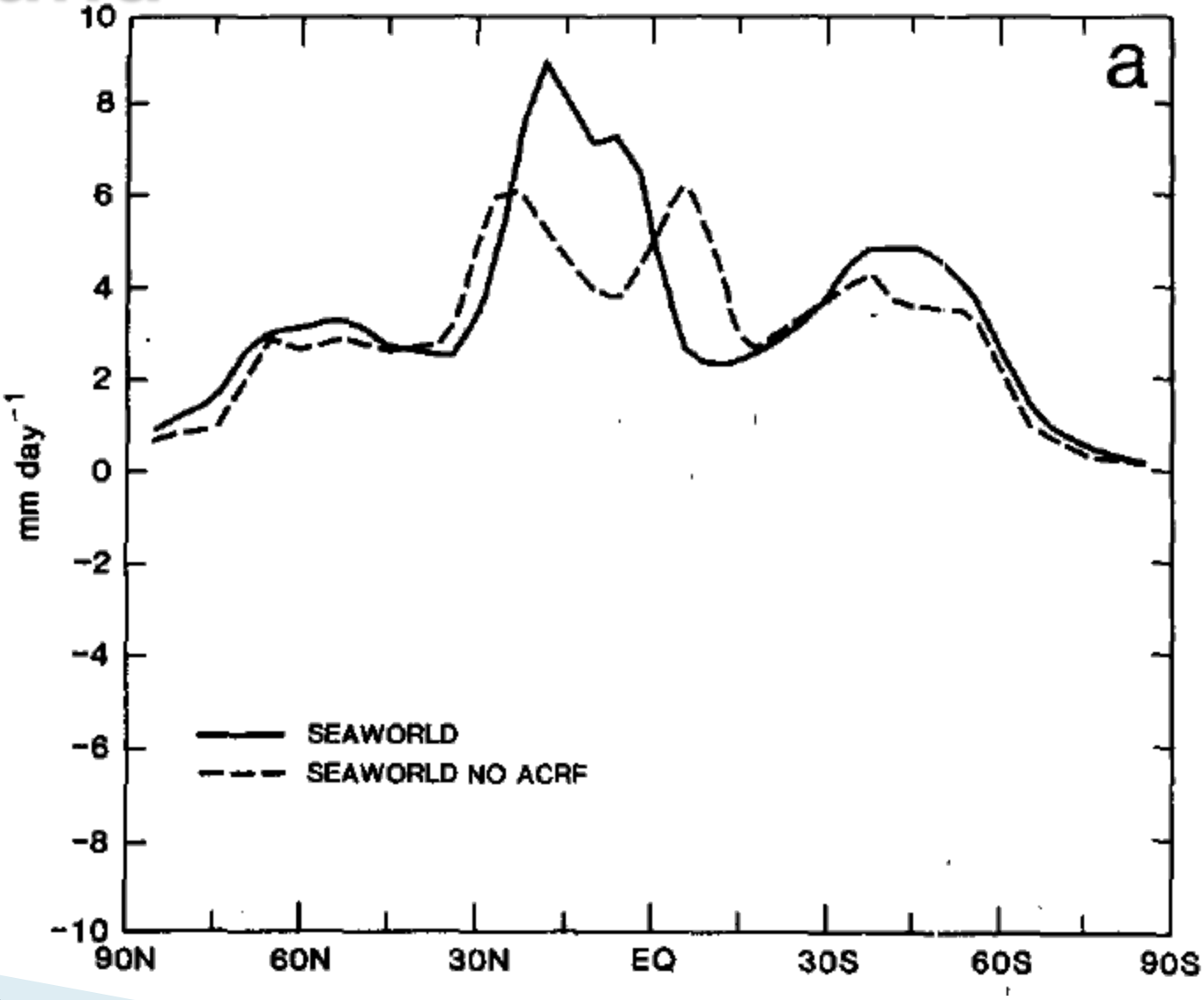


Background

Randall et al. 1989



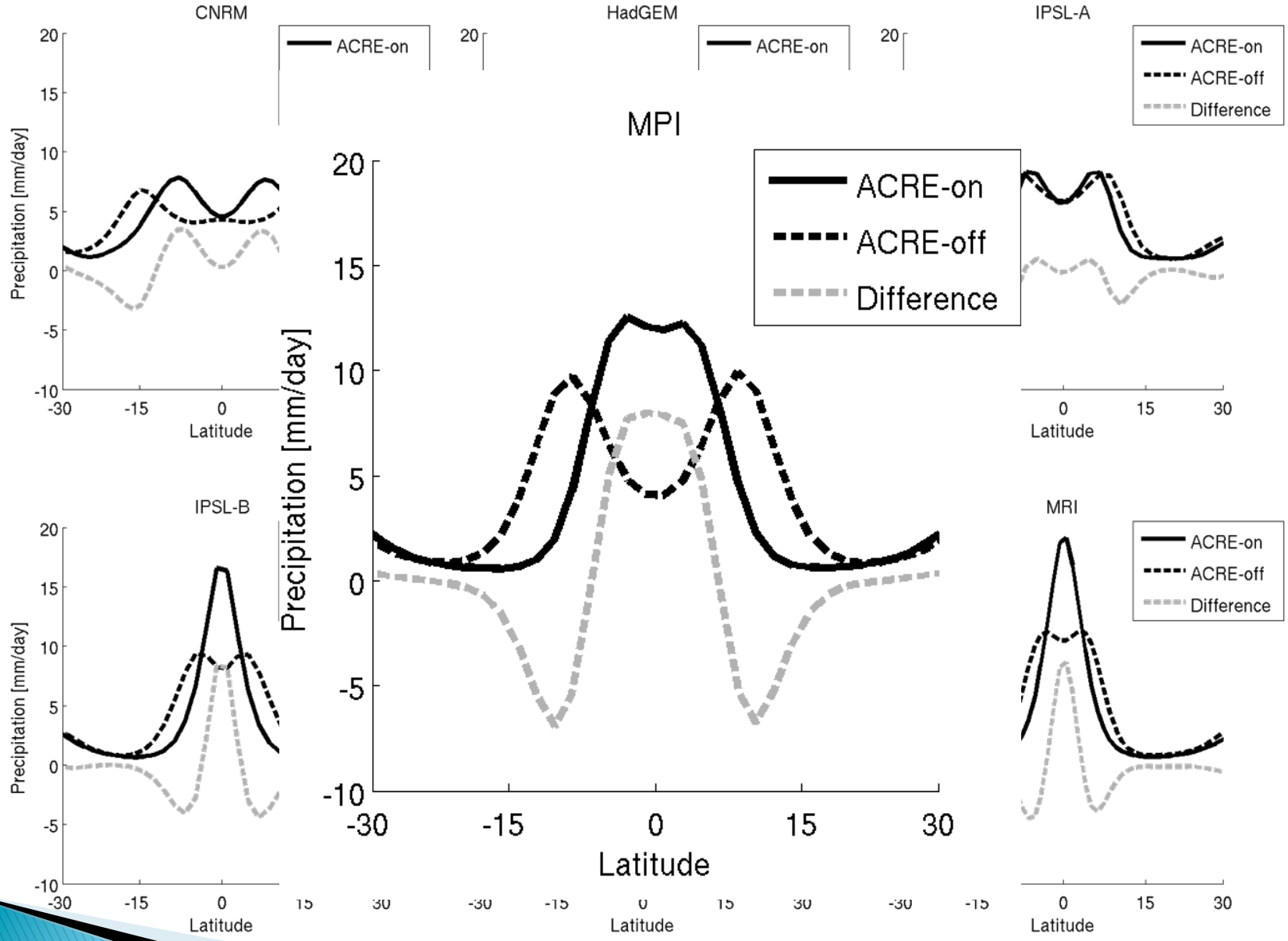
Experiment Description

Clouds On-Off Klimate Intercomparison Experiment (COOKIE)

European Union Cloud Intercomparison, Process Study & Evaluation Project

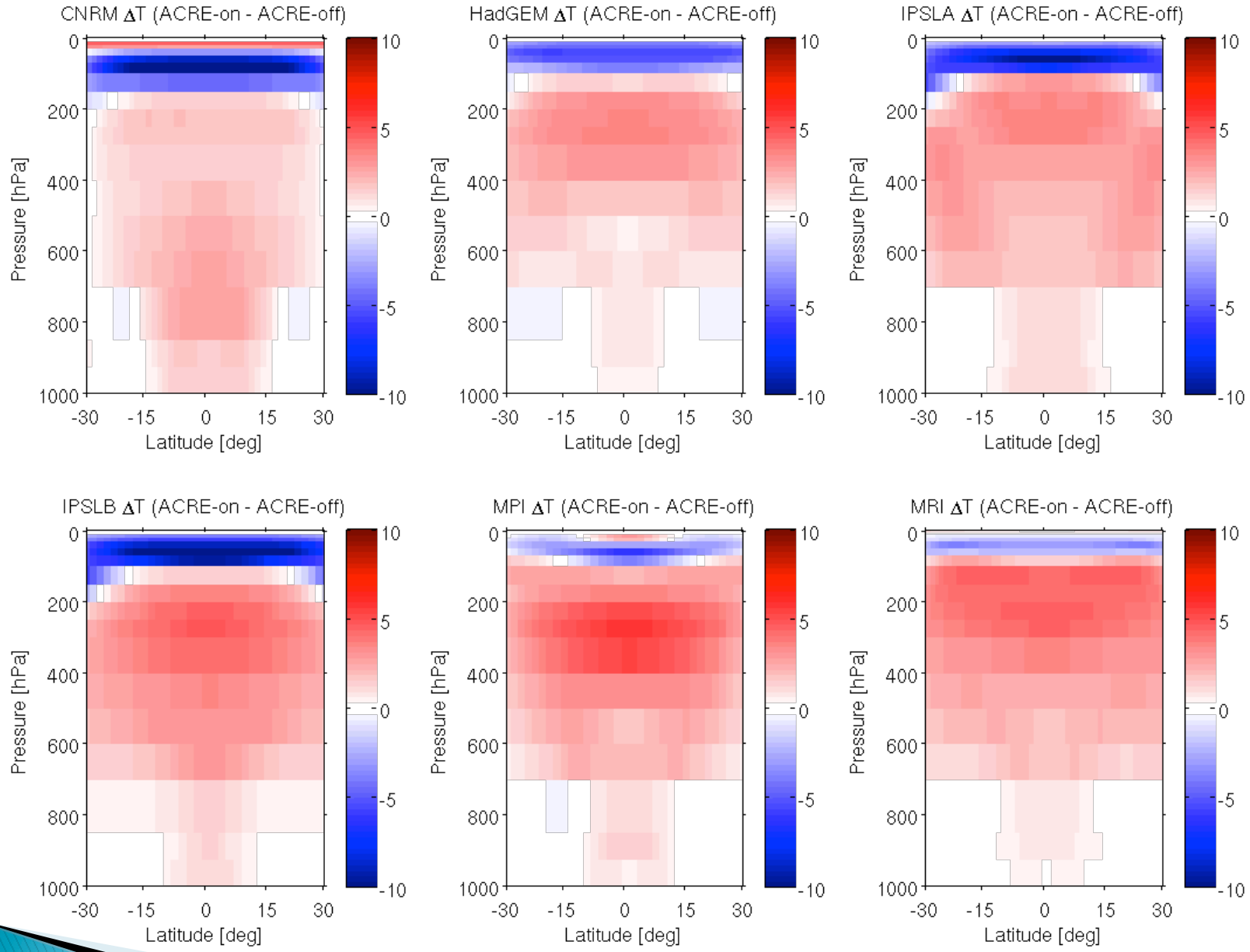
Experiment Description

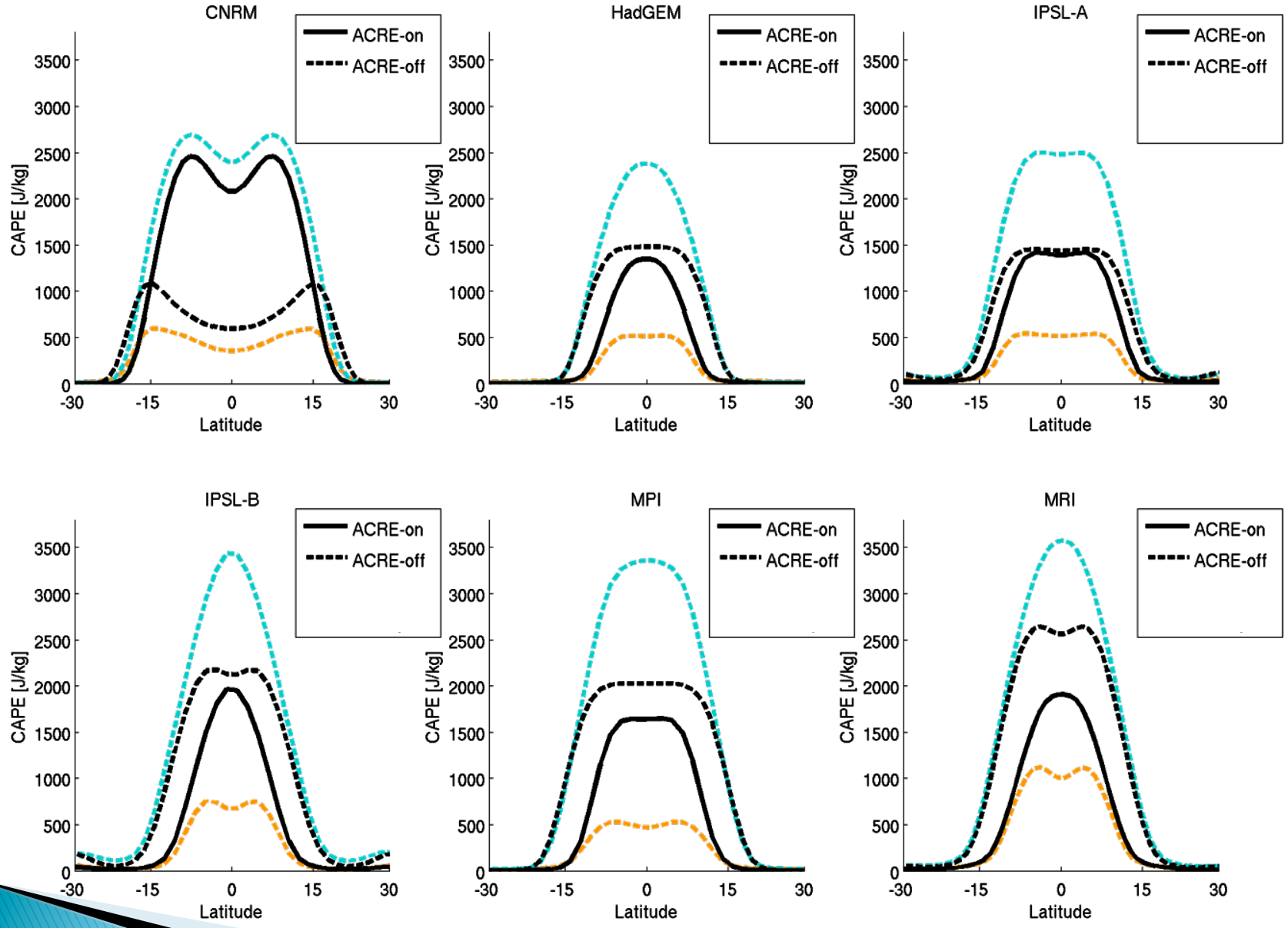
Model	Resolution (lon x lat)	Citations	Comments
CNRM	256 x 128 (1.41° x 1.40°)	Voldoire et al. (2013)	
GFDL	144 x 90 (2.5° x 2°)	The GFDL Global Atmospheric Model Development Team (2004)	Not part of original COOKIE
HadGEM	192 x 145 (1.875° x 1.25°)	Collins et al. (2008)	
IPSL-A	96 x 96 (3.75° x 1.89°)	Dufresne et al. (2013), Hourdin et al. (2013a)	Physics package version A
IPSL-B	96 x 96 (3.75° x 1.89°)	Dufresne et al. (2013), Hourdin et al. (2013b)	Physics package version B
MPI	192 x 96 (1.875° x 1.8653°)	Stevens et al. (2013)	
MRI	320 x 160 (1.125° x 1.12°)	Yukimoto et al. (2012)	

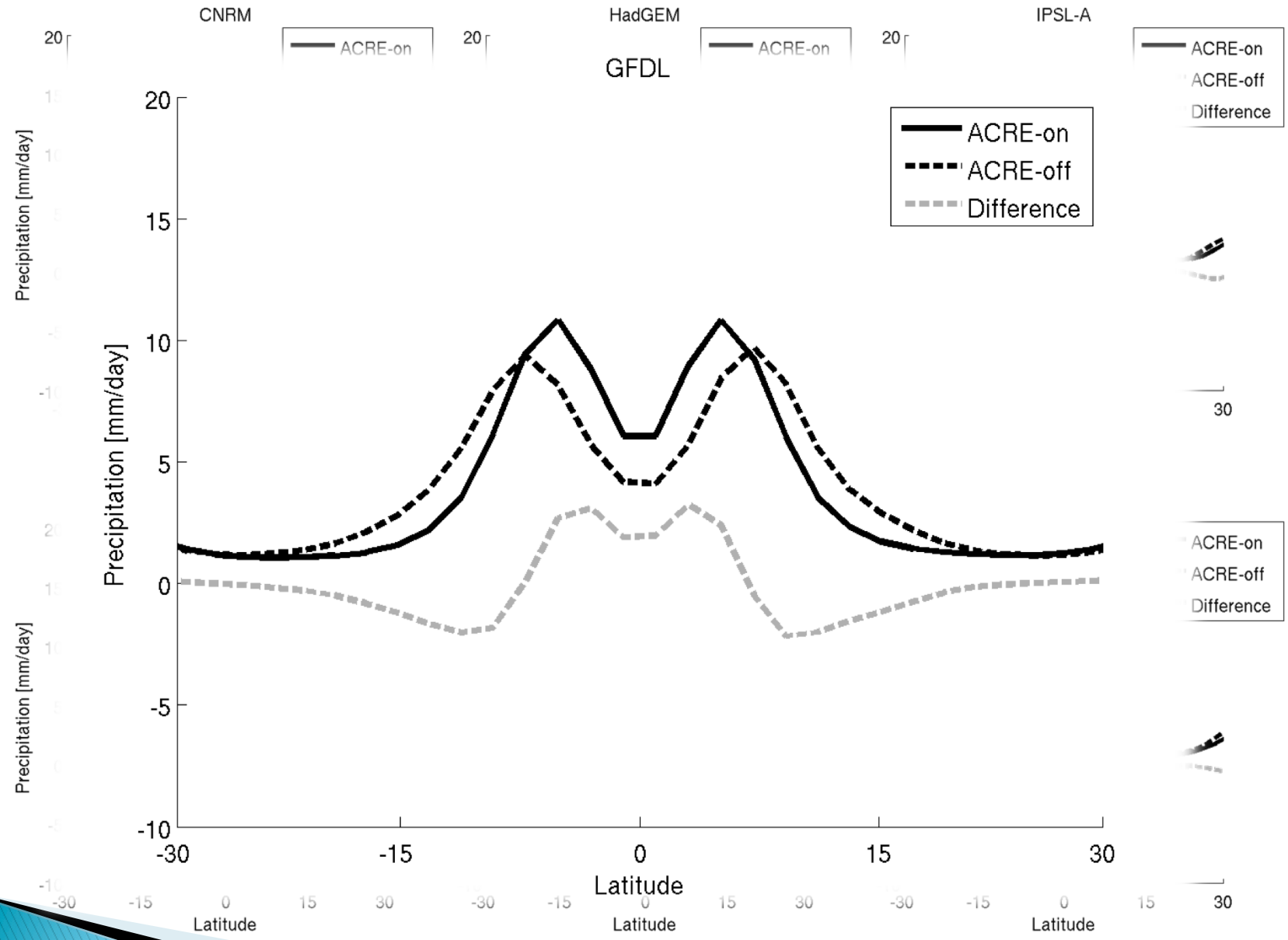

CNRM
HadGEM
IPSL-A
IPSL-B
MRI
MPI
ACRE-on
ACRE-off
Difference
Precipitation [mm/day]
Latitude

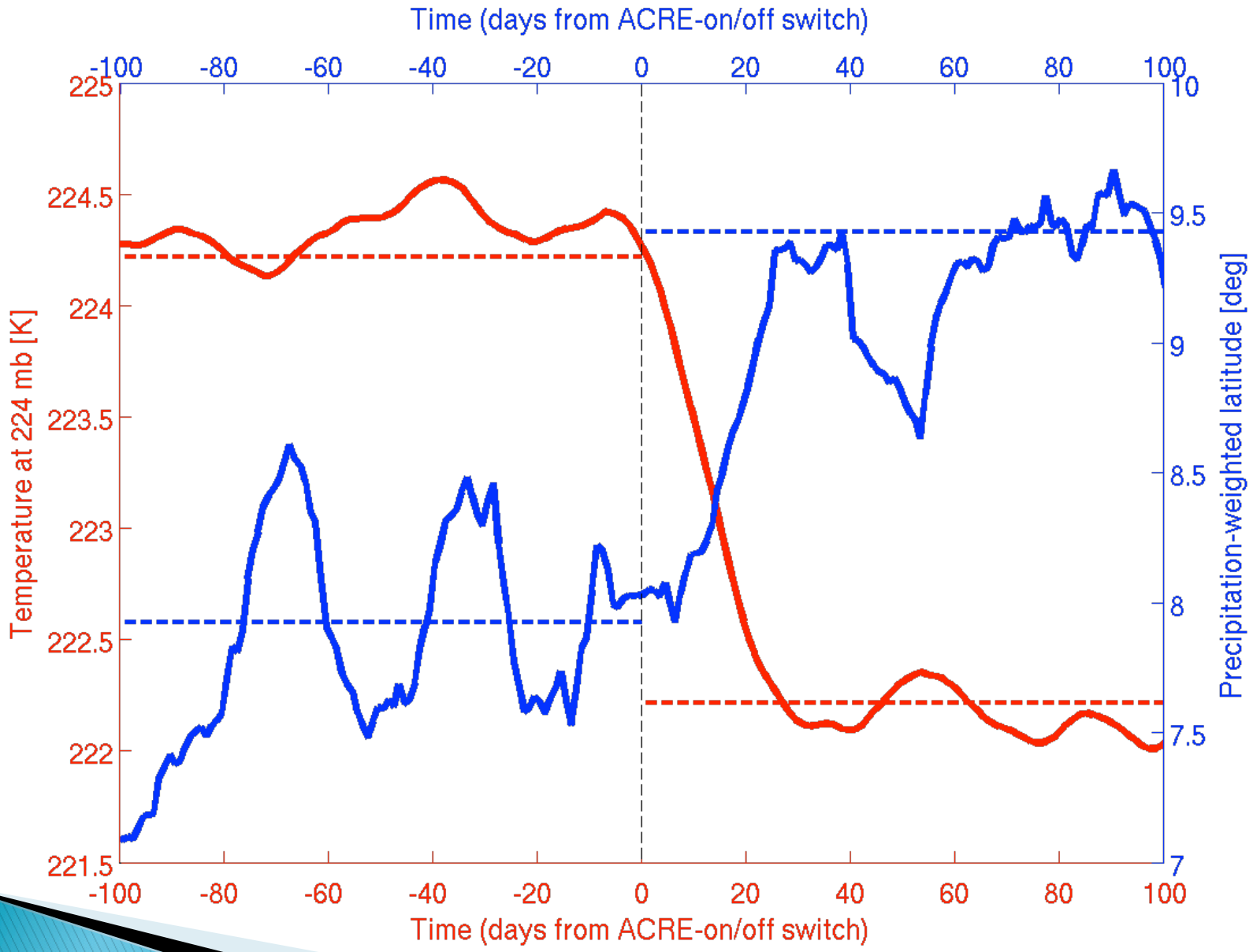
Model	ACRE-on $\phi_{\downarrow P}$	$\Delta_{\phi_{\downarrow P}}$ (on – off)
CNRM	9.58°	–3.29°
HadGEM	4.37°	–1.36°
IPSL–A	7.23°	–0.44°
IPSL–B	4.22°	–2.00°
MPI	5.19°	–3.60°
MRI	3.94°	–1.13°

$$\phi_{\downarrow P} = \int_{0°}^{\uparrow \phi_{\downarrow P}=min} P \times \phi \times \cos\phi \, d\phi \Big/ \int_{0°}^{\uparrow \phi_{\downarrow P}=min} P \times \cos\phi \, d\phi$$


CNRM ΔT (ACRE-on - ACRE-off)
HadGEM ΔT (ACRE-on - ACRE-off)
IPSLA ΔT (ACRE-on - ACRE-off)
IPSLB ΔT (ACRE-on - ACRE-off)
MPI ΔT (ACRE-on - ACRE-off)
MRI ΔT (ACRE-on - ACRE-off)
Pressure [hPa]
Latitude [deg]
0
200
400
600
800
1000
-30
-15
0
15
30
10
5
0
-5
-10

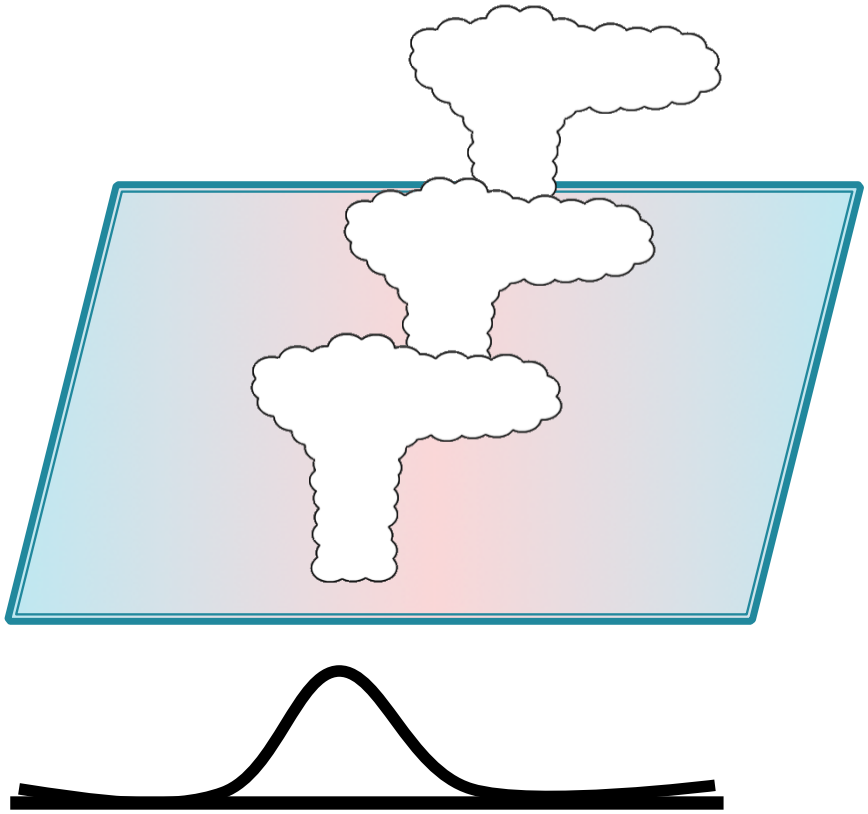

CNRM
HadGEM
IPSL-A
IPSL-B
MPI
MRI
ACRE-on
ACRE-off
CAPE [J/kg]
Latitude
0
500
1000
1500
2000
2500
3000
3500
-30
-15
0
15
30


CNRM
HadGEM
IPSL-A
GFDL
ACRE-on
ACRE-off
Difference
Precipitation [mm/day]
Latitude
20
15
10
5
0
-5
-10
-30
-15
0
15
30

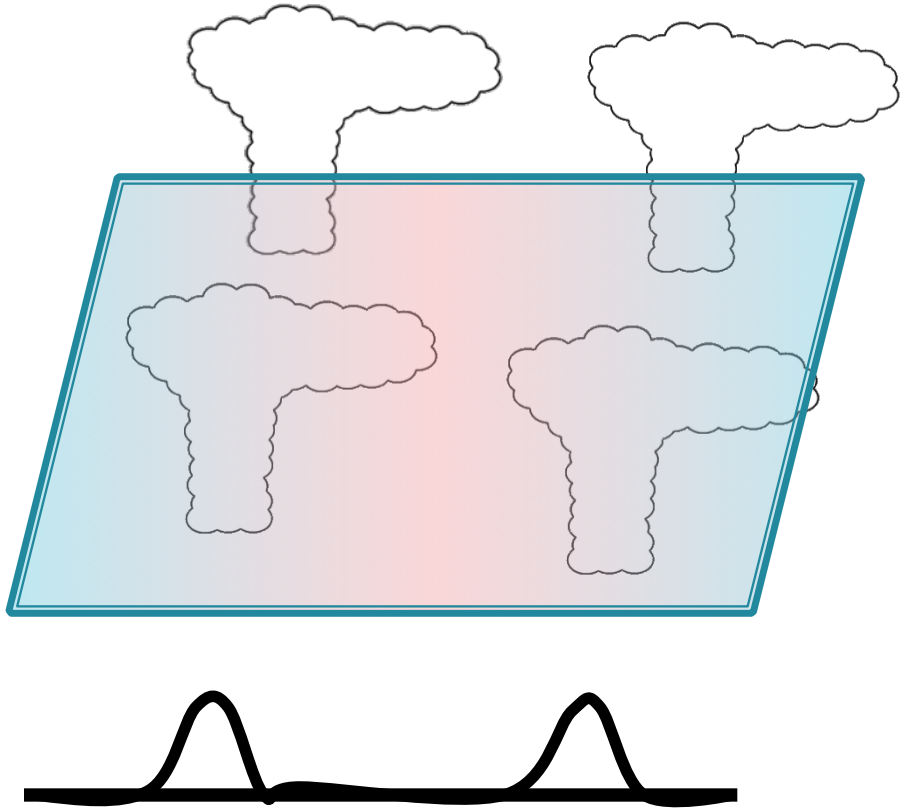

Time (days from ACRE-on/off switch)
-100
-80
-60
-40
-20
0
20
40
60
80
100
225
224.5
224
223.5
223
222.5
222
221.5
Temperature at 224 mb [K]
10
9.5
9
8.5
8
7.5
7
Precipitation-weighted latitude [deg]
Time (days from ACRE-on/off switch)

Summary

"ACRE-on"



"ACRE-off"

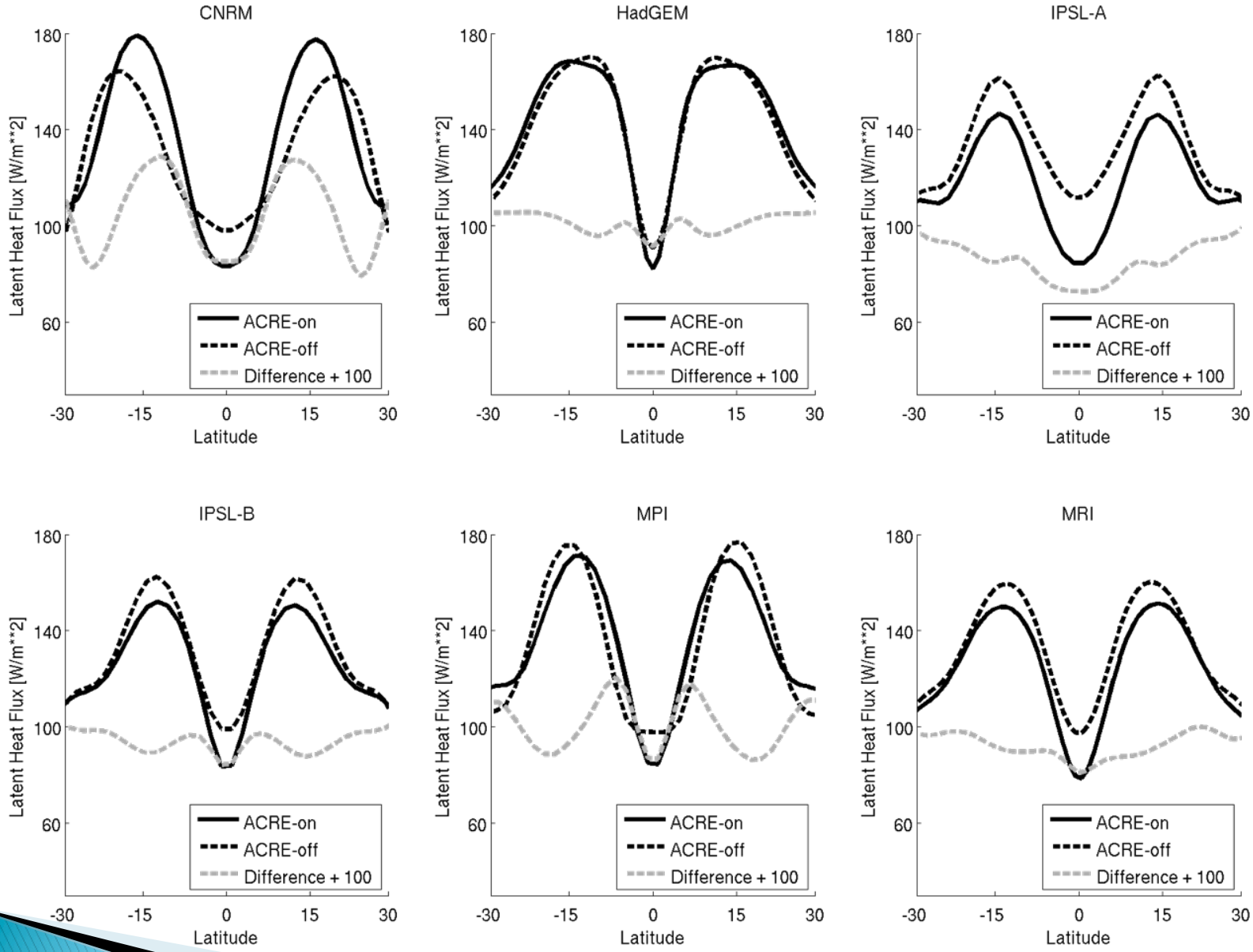


Thank you

- Funding from NSF Grant # AGS-0960497

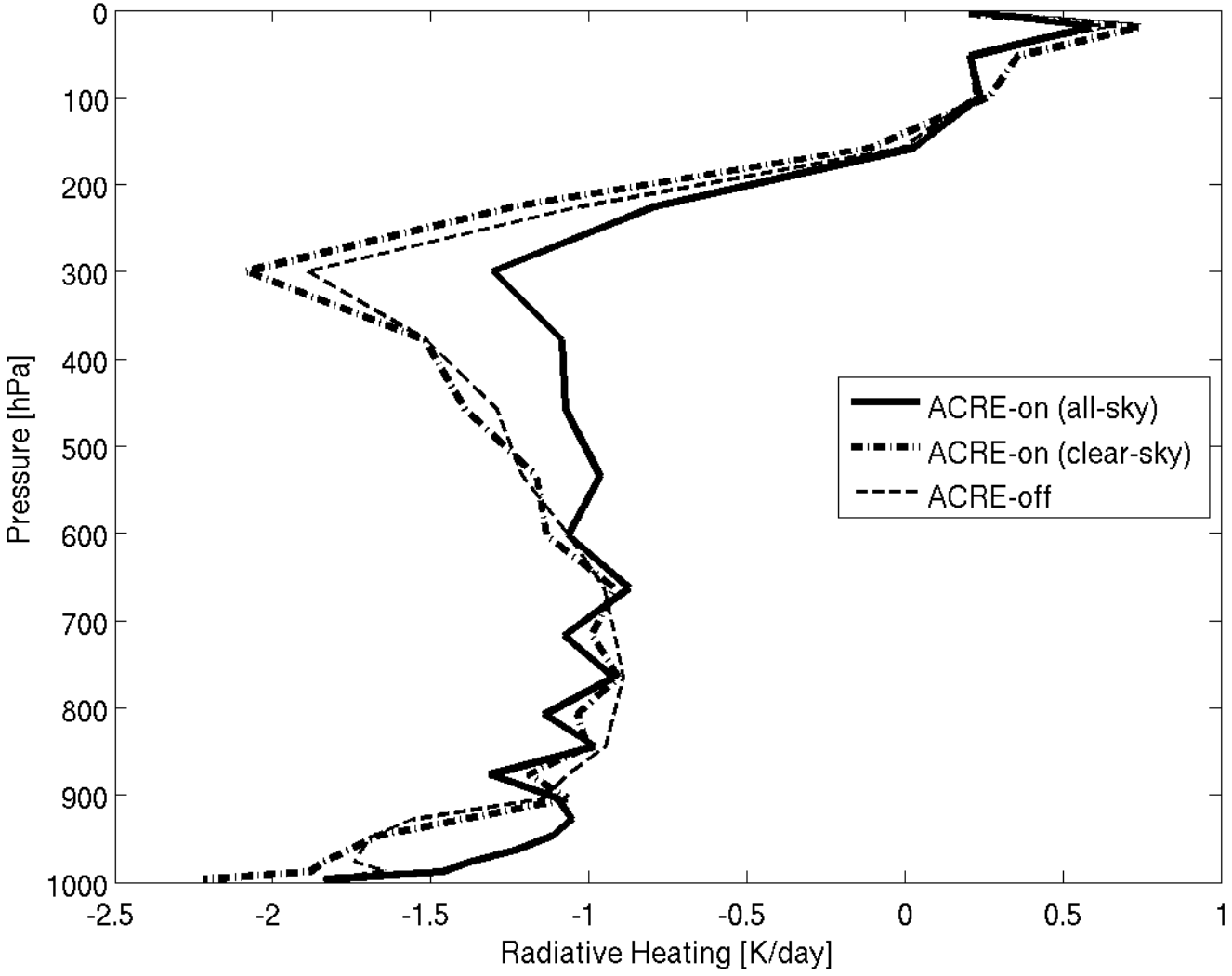
- Thanks to Paulo Ceppi for his help running the GFDL model experiment.

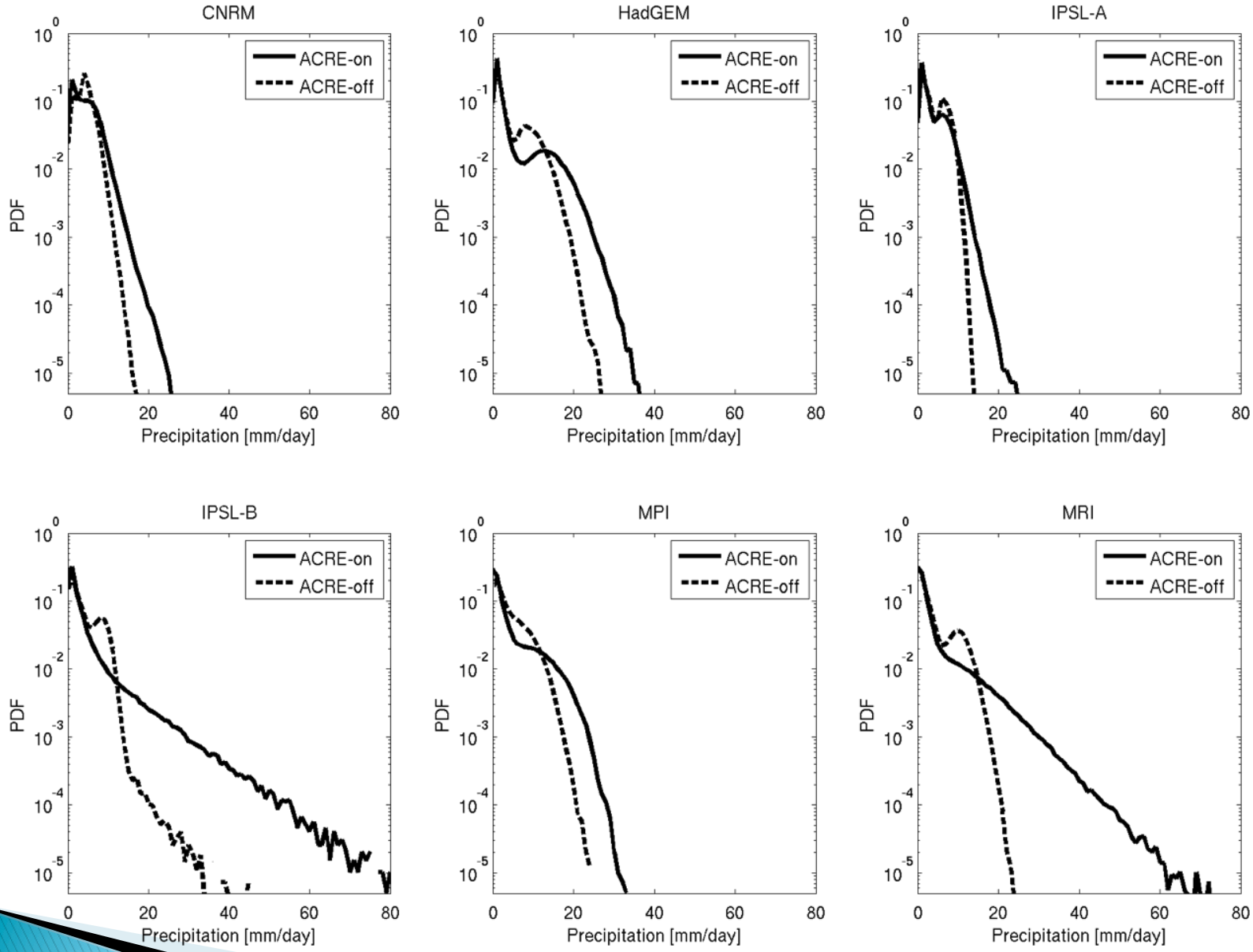
- Thanks to George Bryan for making his CAPE script feely available.

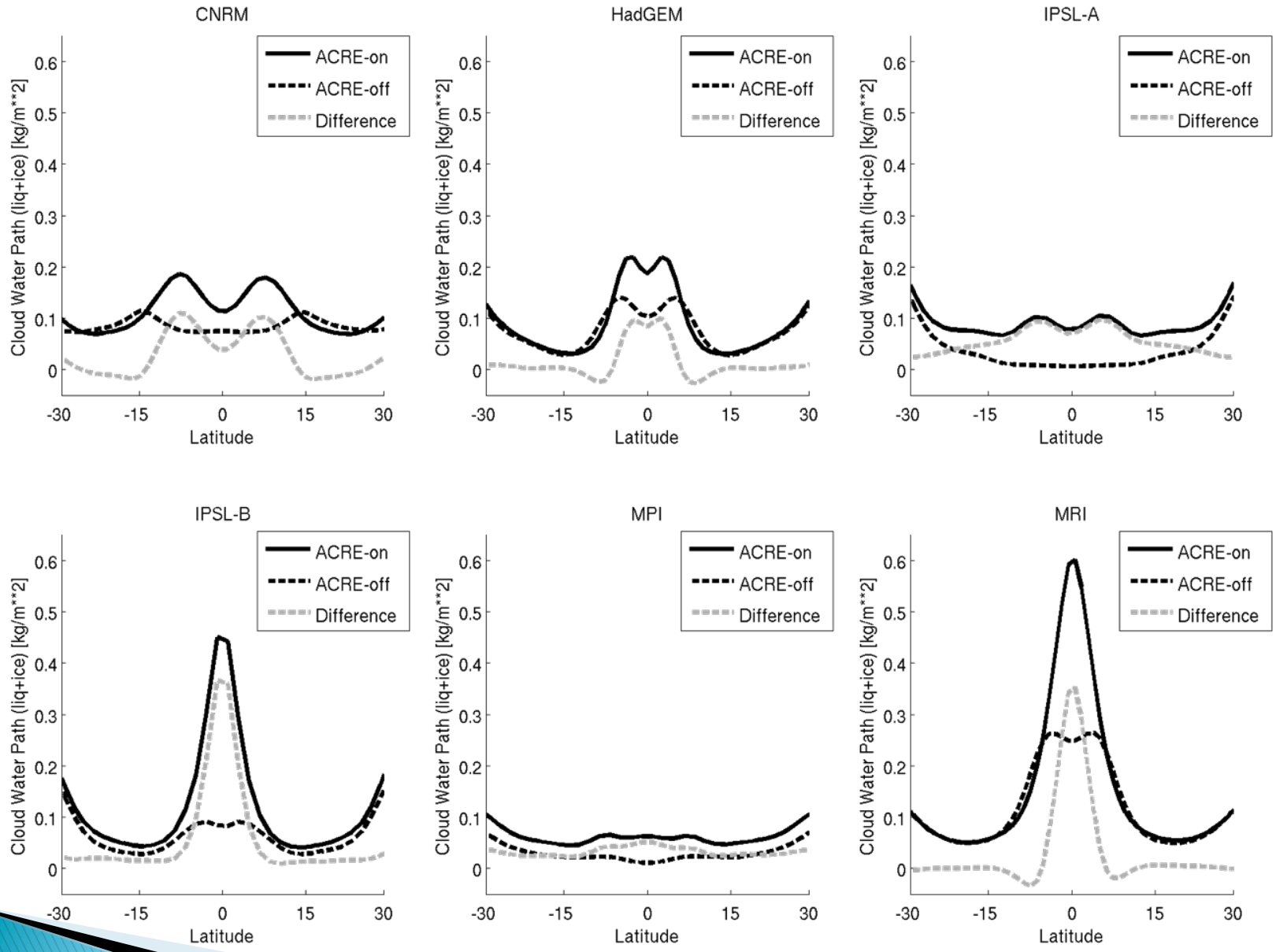

CNRM
HadGEM
IPSL-A
IPSL-B
MPI
MRI
Latent Heat Flux [W/m**2]
Latitude
180
140
100
60
-30
-15
0
15
30
ACRE-on
ACRE-off
Difference + 100

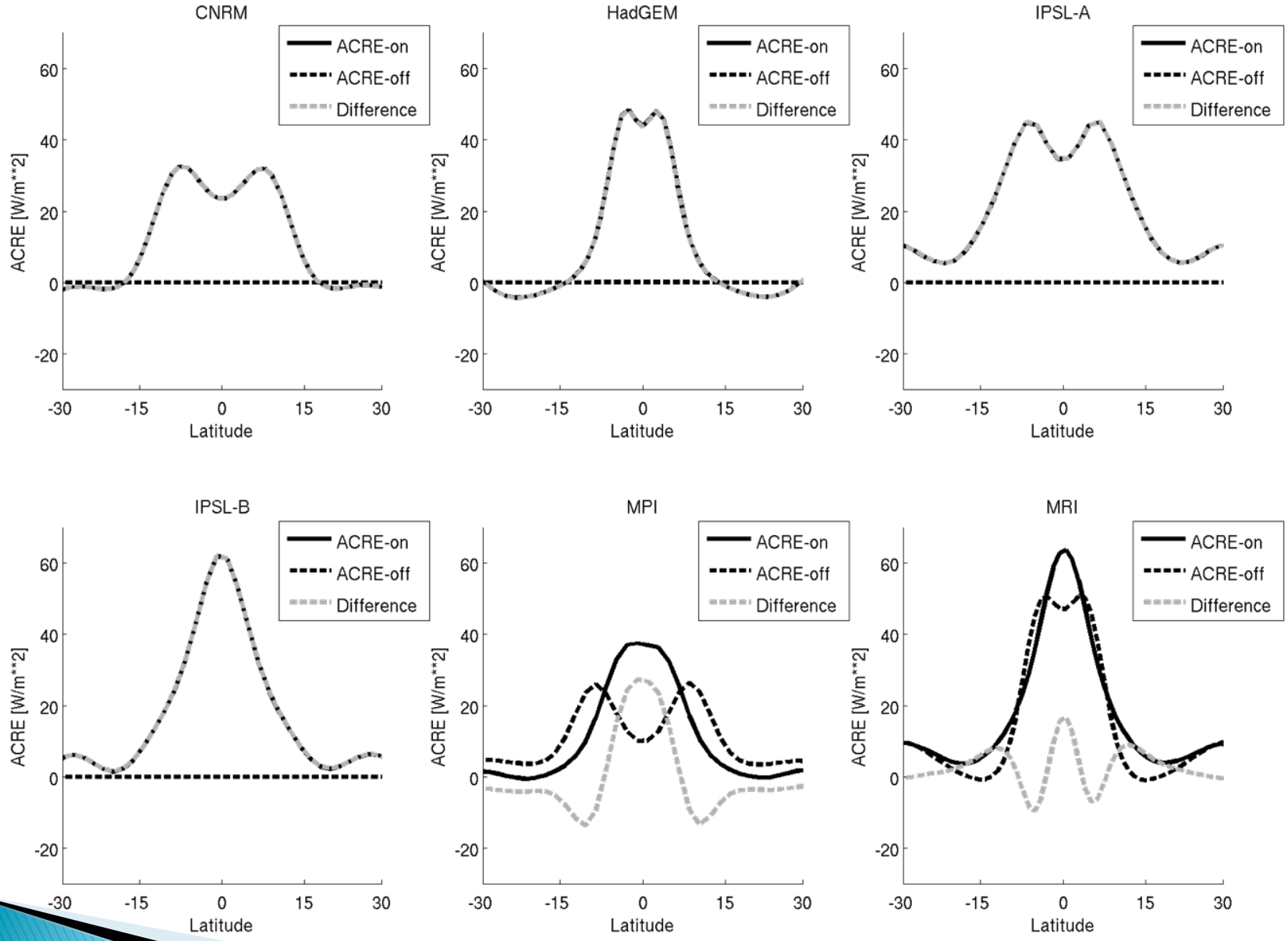
What's next?

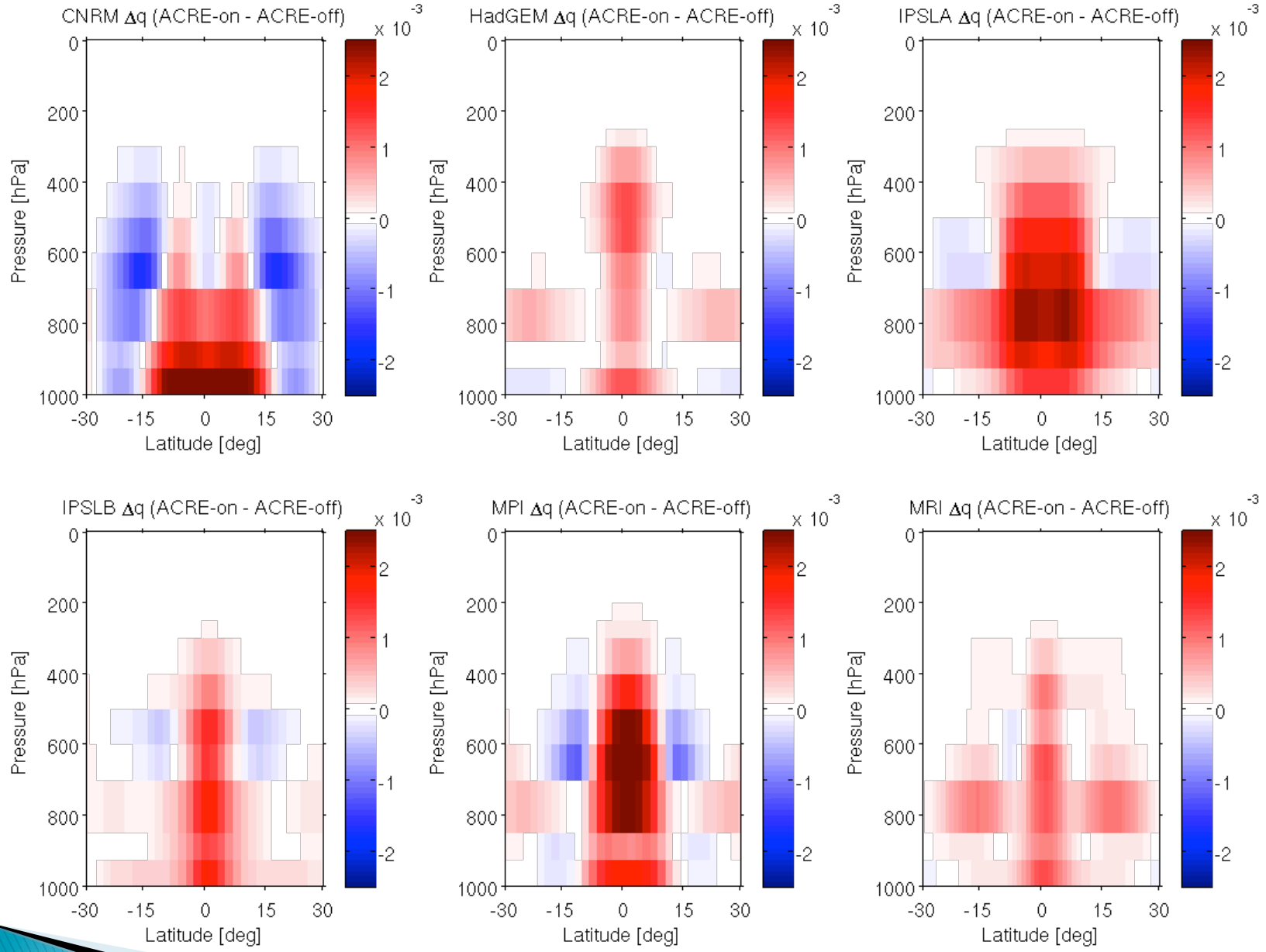
- Cloud macrophysical properties (cloud top temperature, cloud fraction, etc.)
- +4K SST and 4xCO_2 COOKIE experiments

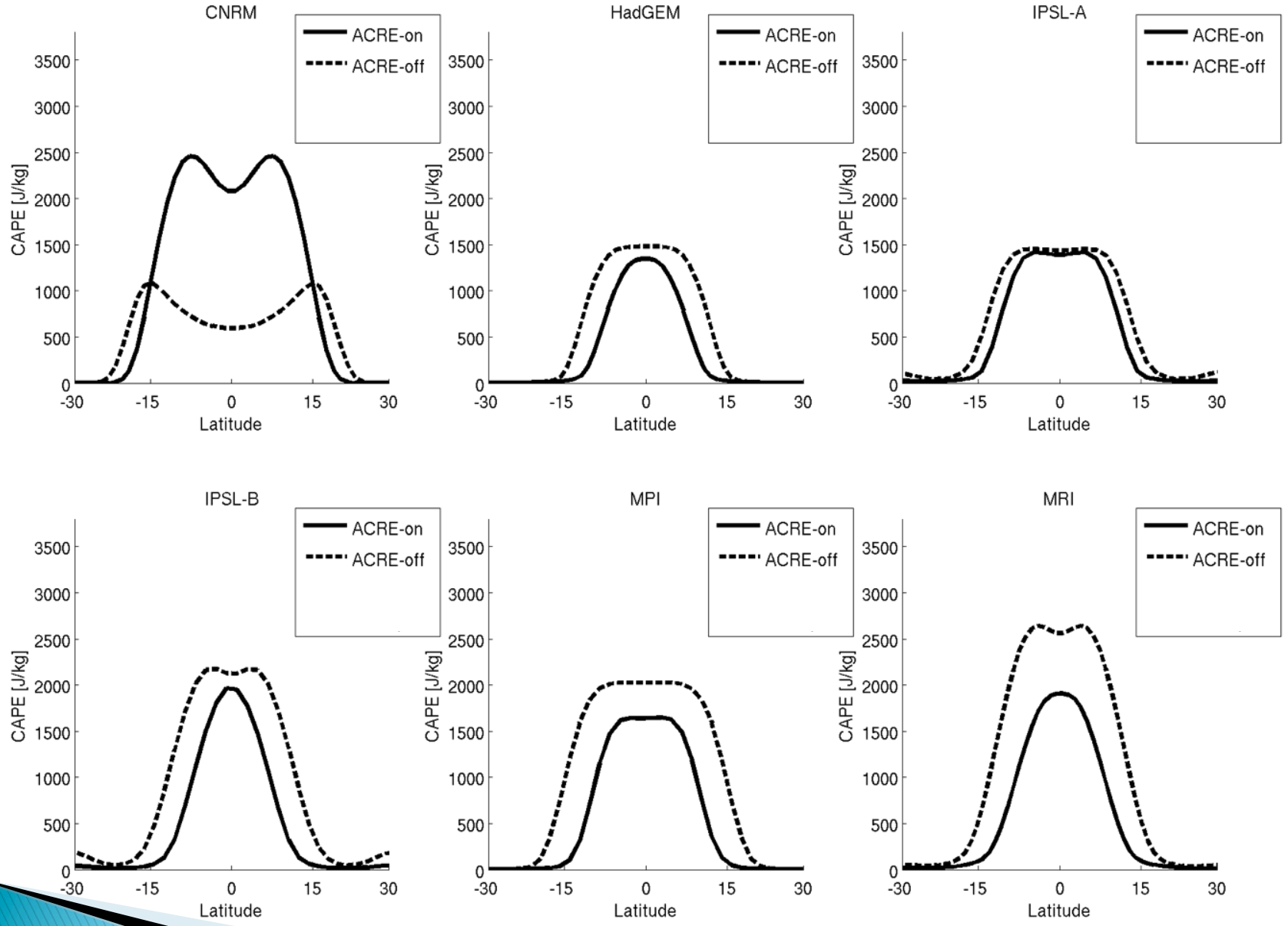

Pressure [hPa]
0
100
200
300
400
500
600
700
800
900
1000
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
Radiative Heating [K/day]
ACRE-on (all-sky)
ACRE-on (clear-sky)
ACRE-off


CNRM
HadGEM
IPSL-A
IPSL-B
MPI
MRI
ACRE-on
ACRE-off
PDF
Precipitation [mm/day]


CNRM
HadGEM
IPSL-A
IPSL-B
MPI
MRI
ACRE-on
ACRE-off
Difference
Cloud Water Path (liq+ice) [kg/m**2]
Latitude
0
0.1
0.2
0.3
0.4
0.5
0.6
-30
-15
0
15
30

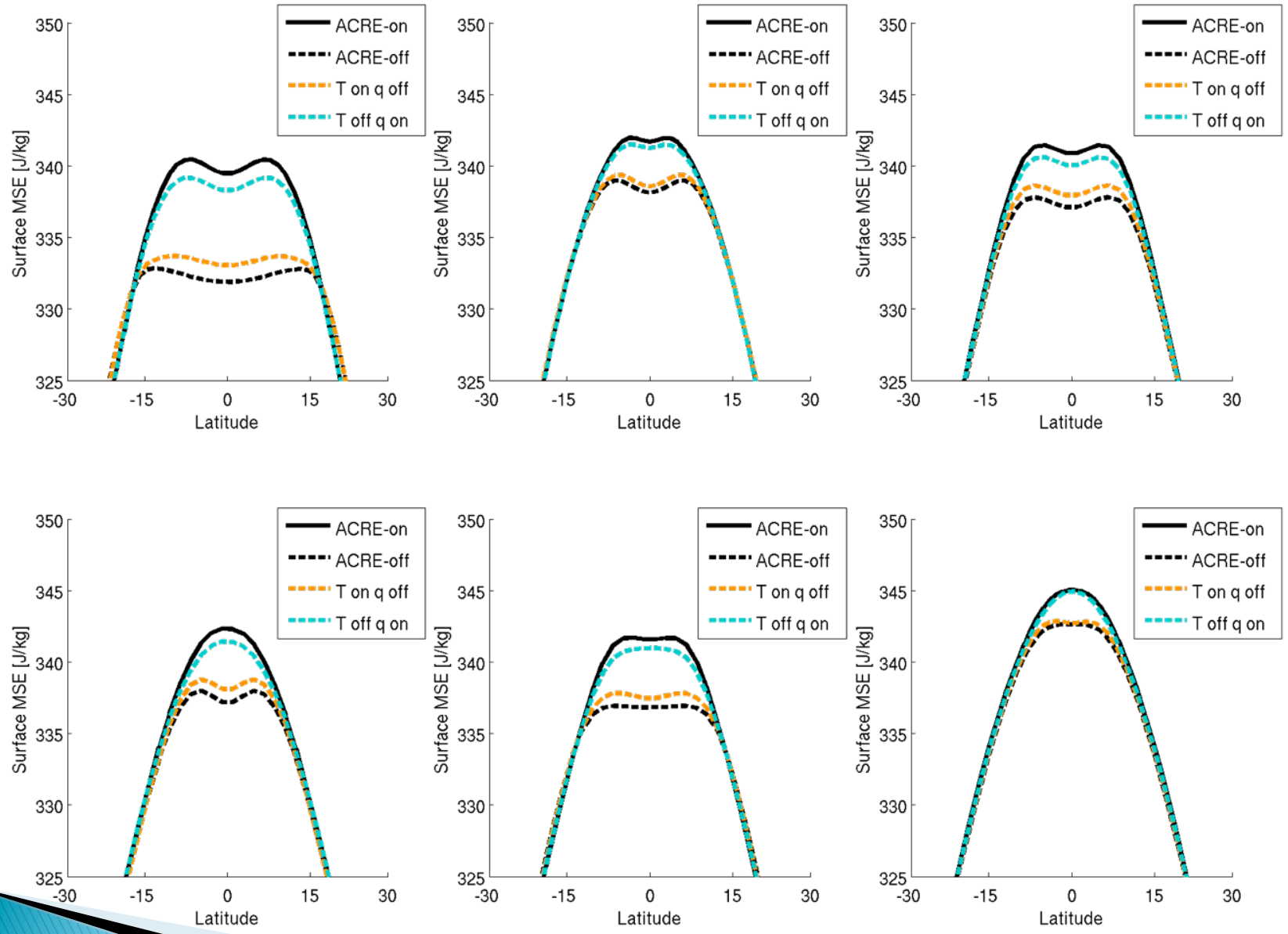

CNRM
HadGEM
IPSL-A
IPSL-B
MPI
MRI
ACRE-on
ACRE-off
Difference
ACRE [W/m**2]
Latitude
60
40
20
0
-20
-30
-15
0
15
30

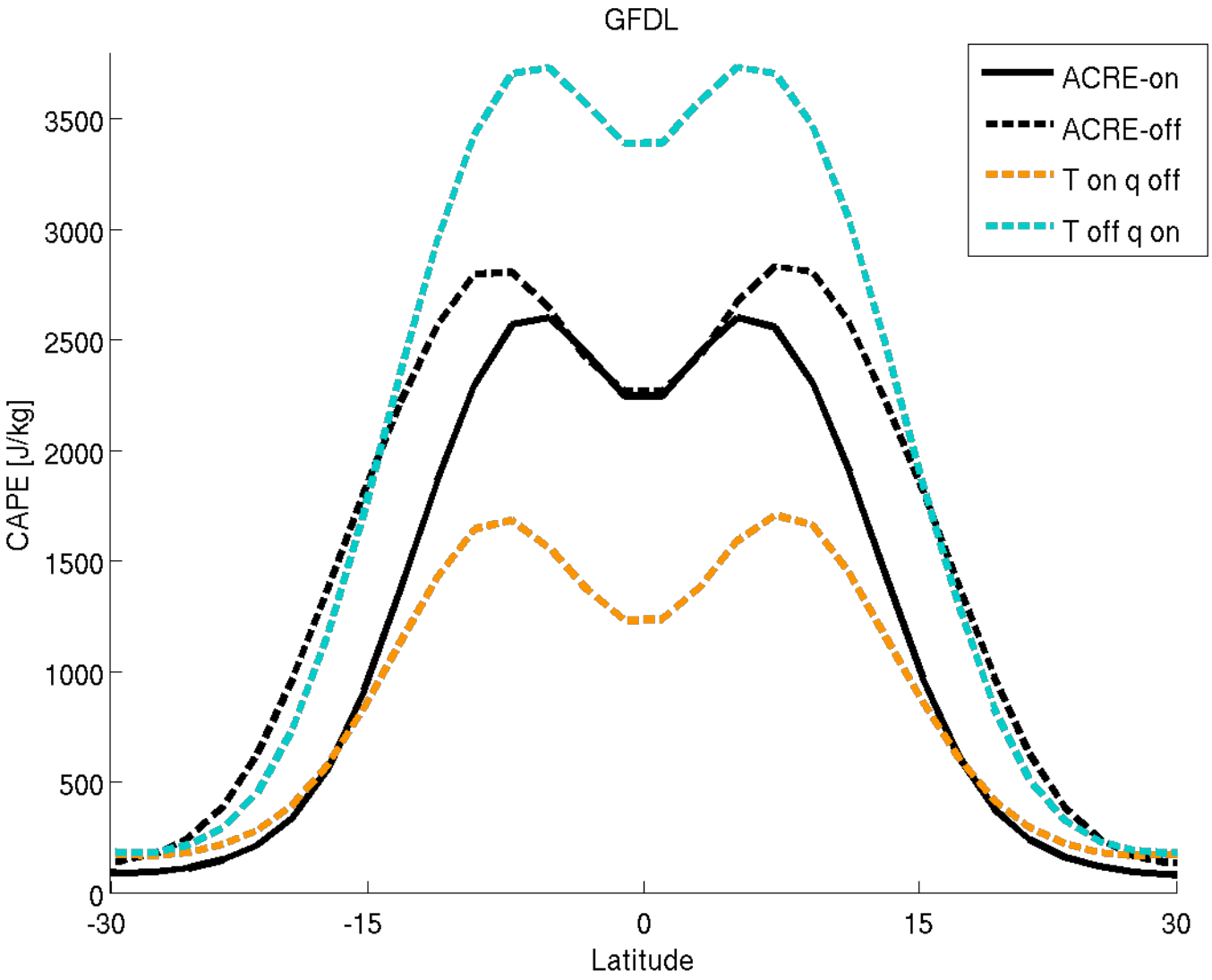

CNRM Δq (ACRE-on - ACRE-off)
HadGEM Δq (ACRE-on - ACRE-off)
IPSLA Δq (ACRE-on - ACRE-off)
IPSLB Δq (ACRE-on - ACRE-off)
MPI Δq (ACRE-on - ACRE-off)
MRI Δq (ACRE-on - ACRE-off)
x 10^-3
Pressure [hPa]
Latitude [deg]
0
200
400
600
800
1000
-30
-15
0
15
30
2
1
0
-1
-2


CNRM
HadGEM
IPSL-A
IPSL-B
MPI
MRI
ACRE-on
ACRE-off
CAPE [J/kg]
Latitude
0
500
1000
1500
2000
2500
3000
3500
-30
-15
0
15
30

Model	ΔP (tropics)	Clouds on $\phi_{\downarrow P}$	$\Delta_{\phi_{\downarrow P}}$
CNRM	-7.4×10^{10} kg/s	9.58°	-3.29°
HadGEM	-5.6×10^{9} kg/s	4.37°	-1.36°
IPSL-A	-13×10^{10} kg/s	7.23°	-0.44°
IPSL-B	-10×10^{10} kg/s	4.22°	-2.00°
MPI	-8.1×10^{10} kg/s	5.19°	-3.60°
MRI	-5.0×10^{10} kg/s	3.94°	-1.13°

$$\phi_{\downarrow P} = \int_{0°\uparrow\phi_{\downarrow P}=min} P \times \phi \times \cos\phi \, d\phi \Big/ \int_{0°\uparrow\phi_{\downarrow P}=min} P \times \cos\phi \, d\phi$$


ACRE-on
ACRE-off
T on q off
T off q on
Surface MSE [J/kg]
Latitude
350
345
340
335
330
325
-30
-15
0
15
30


GFDL
ACRE-on
ACRE-off
T on q off
T off q on
CAPE [J/kg]
0
500
1000
1500
2000
2500
3000
3500
-30
-15
0
15
30
Latitude