Cloud-radiative effects on the Madden-Julian Oscillation

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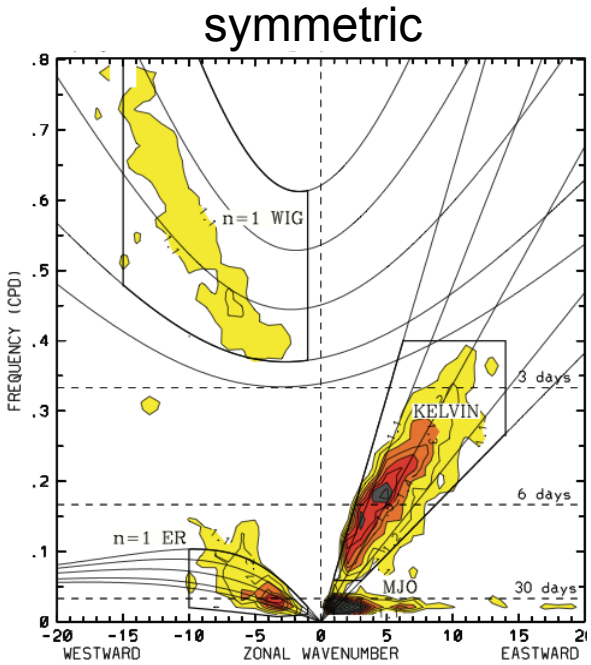
clisap

Max-Planck-Institut für Meteorologie

Wave number frequency spectra (Brightness temperature)



(Wheeler & Kiladis, 1999)

MJO signal no solution of theory

COOKIE

(**C**louds **O**n/**O**ff **K**limate **I**ntercomparison **E**xperiments)

“clouds-on” - AMIP experiments:

- observed monthly mean SST and SIC, 1979-2008

“clouds-off”

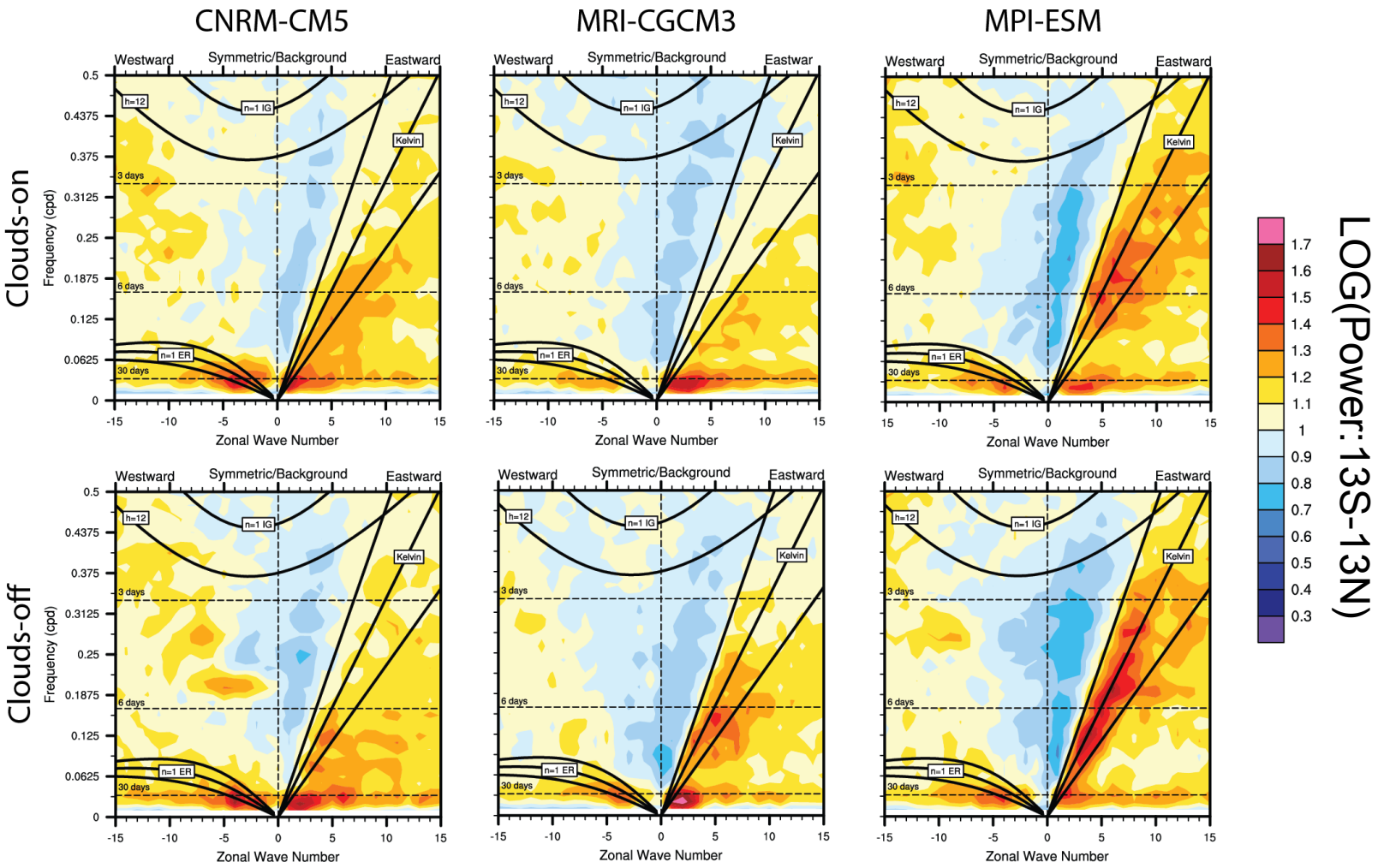
- no cloud radiation feedbacks,
  cloud cover zero in radiation code

Models:

- CNRM-CM5, MRI-CGCM3 and MPI-ESM

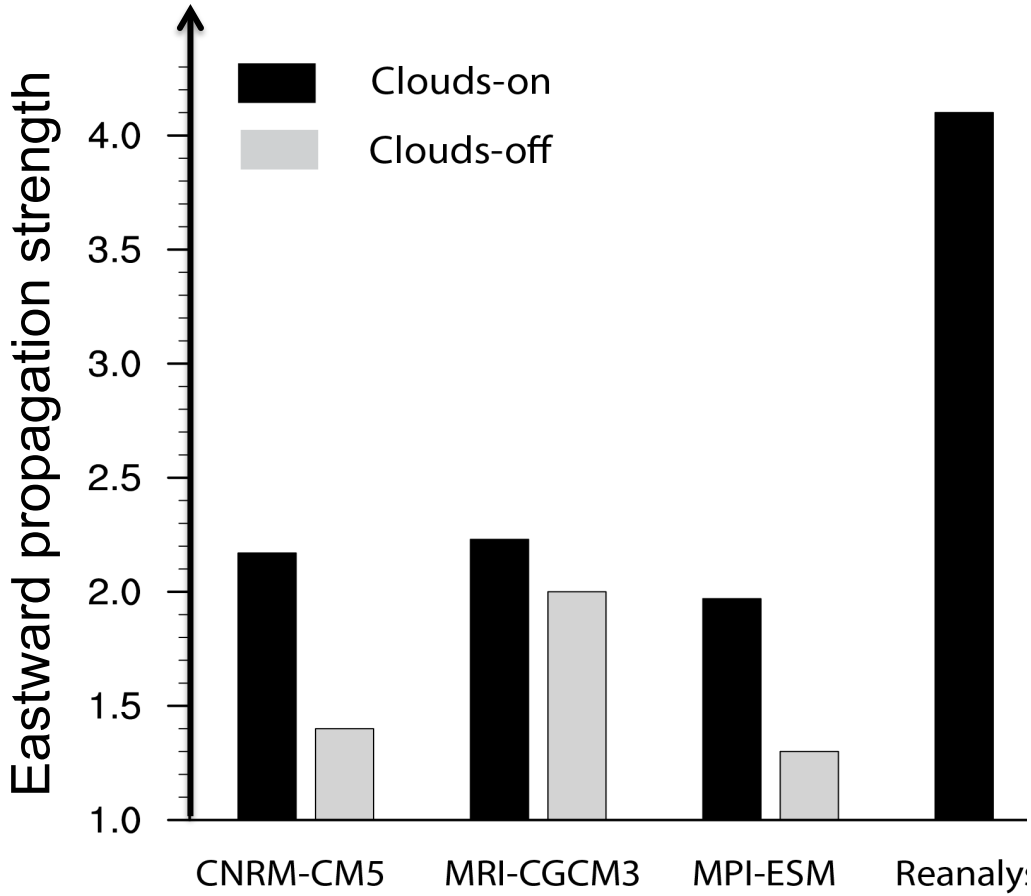
Analysis in T63 resolution (1.9°/1.9°)

Wave number-frequency spectra (precipitation)



➔CR-feedbacks affect MJO & Kelvin waves

MJO performance



- Generally too weak MJO
- strong decay when eliminating CR-feedbacks

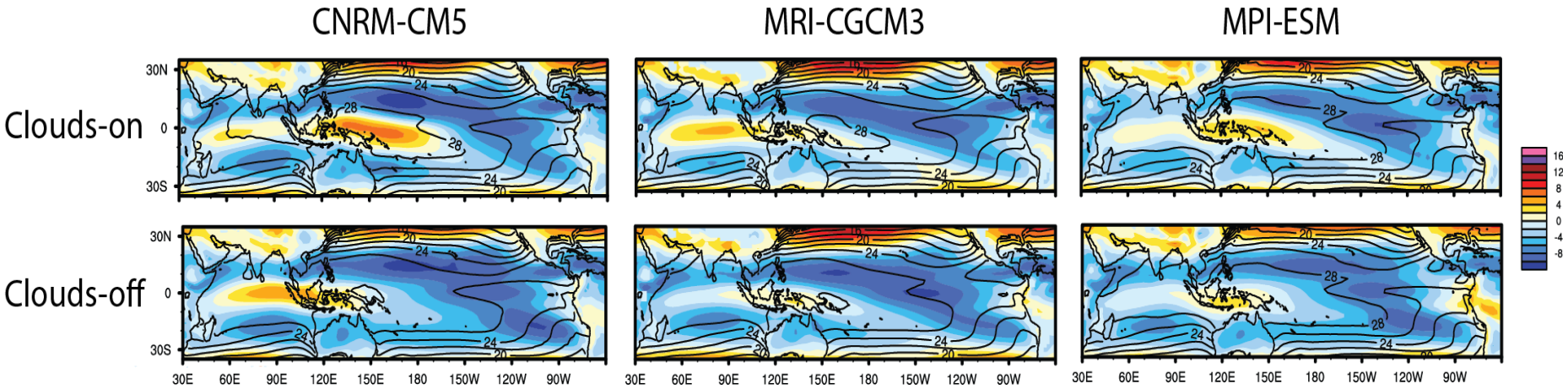
No CR-feedback ➔ No/weaker MJO

Reasons?

- Mean state changes (zonal wind, precipitation)?
- Heating rate changes?

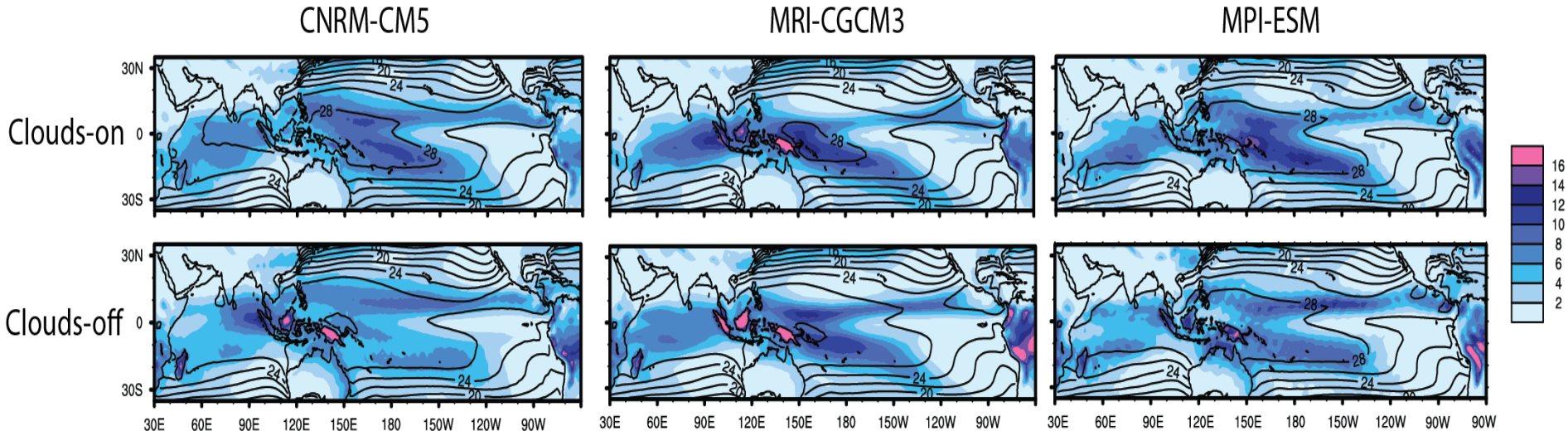
Mean 850 hPa zonal wind

(Nov.-April)

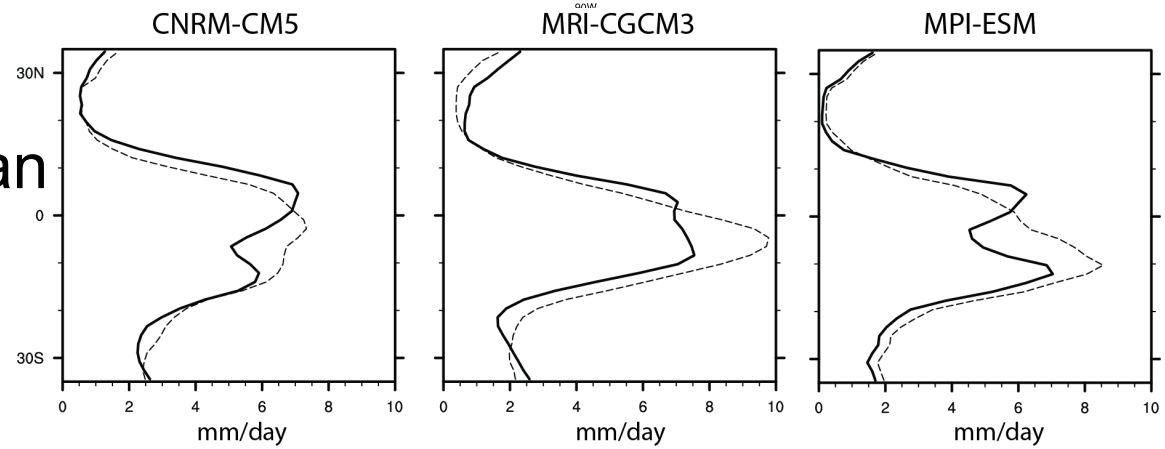


No CR-effects ➔Weaker/shifted equatorial westerlies

Mean Precipitation (Nov.-April)



Indian Ocean



Solid: Clouds-off

Dash: Clouds-on

No CR-effects ➔Tendency to double ITCZ

Conclusions (1)

Eliminating cloud-radiative effects …
… change mean state:

- weaker equatorial westerlies,
- double ITCZ.

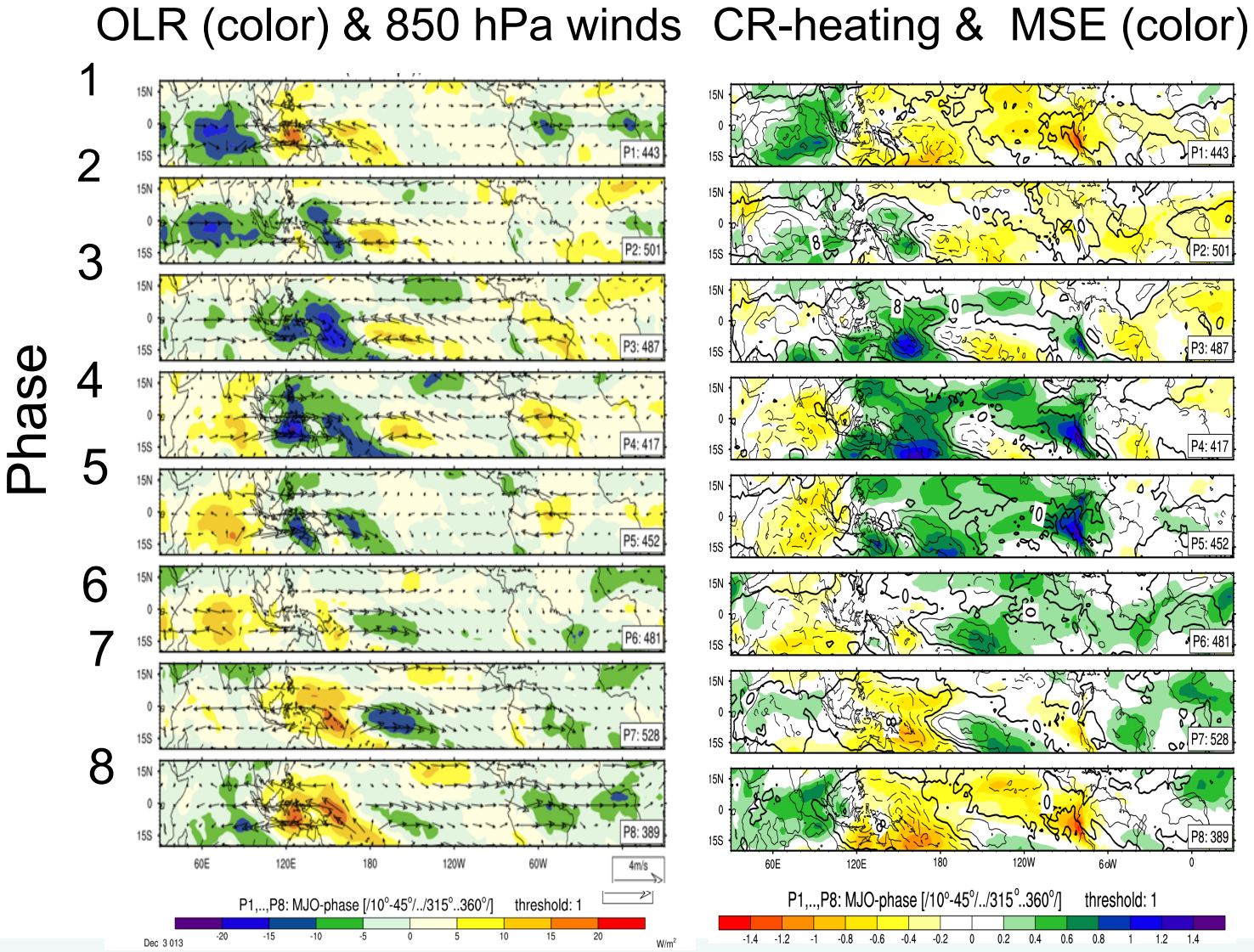
… weaken MJO

Relationship

- westerlies/double ITCZ & MJO

Heating rates (MPI-ESM only)

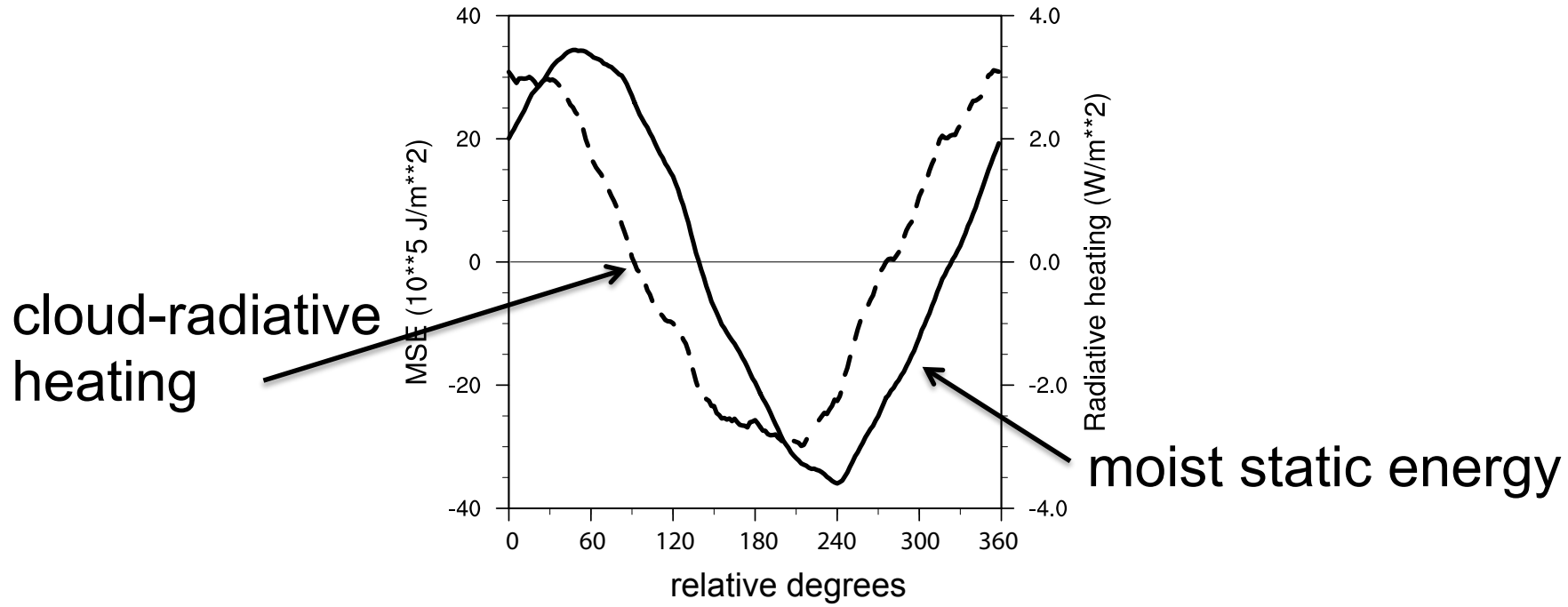
MJO lifecycle composites (MPI-ESM clouds-on)



Vertically integrated cloud radiative heating in “Clouds-on”
-> contributes to changes of moist static energy

MSE & LW cloud-radiative heating

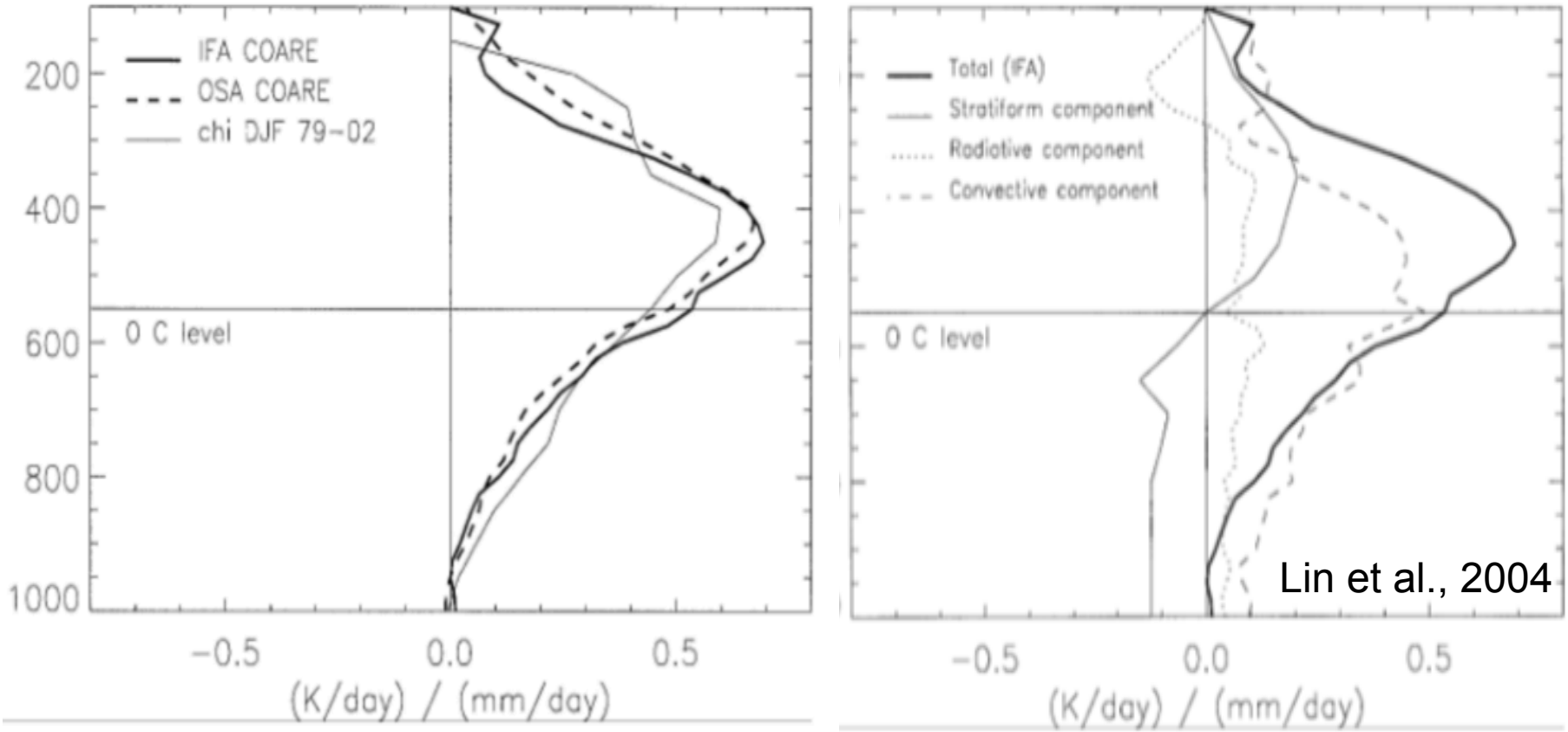
Zonal structure of composite analysis “clouds-on”
(mean over all lifecycle phases)



CR-heating lags MSE by 40-60 deg. (6-10 days)
➔ slows down phase speed

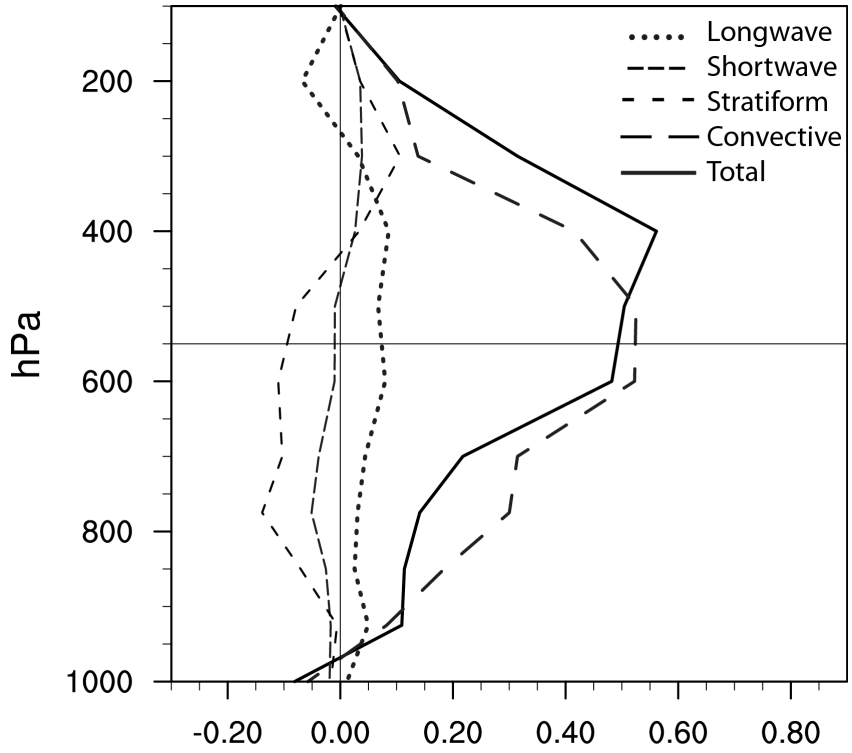
Heating profiles

Observed MJO anomalous DJF heating profile
(5S-5N,145E-155E)



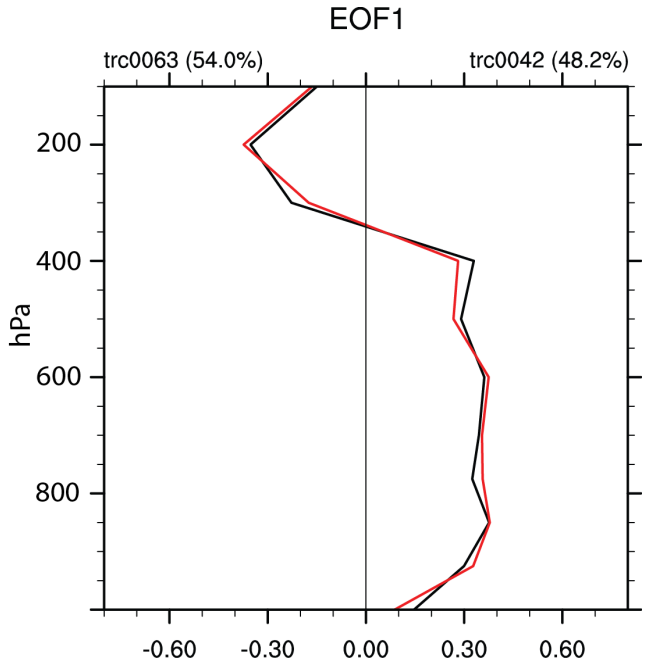
Obs: Top-heaviness due to convective & stratiform heating

Heating rates (clouds-on) composited to MJO deep convection over IO



MPI-ESM: Top-heaviness due to convective & stratiform heating

LW- heating rates
intraseasonal deep convection



Clouds-on
Clouds-off

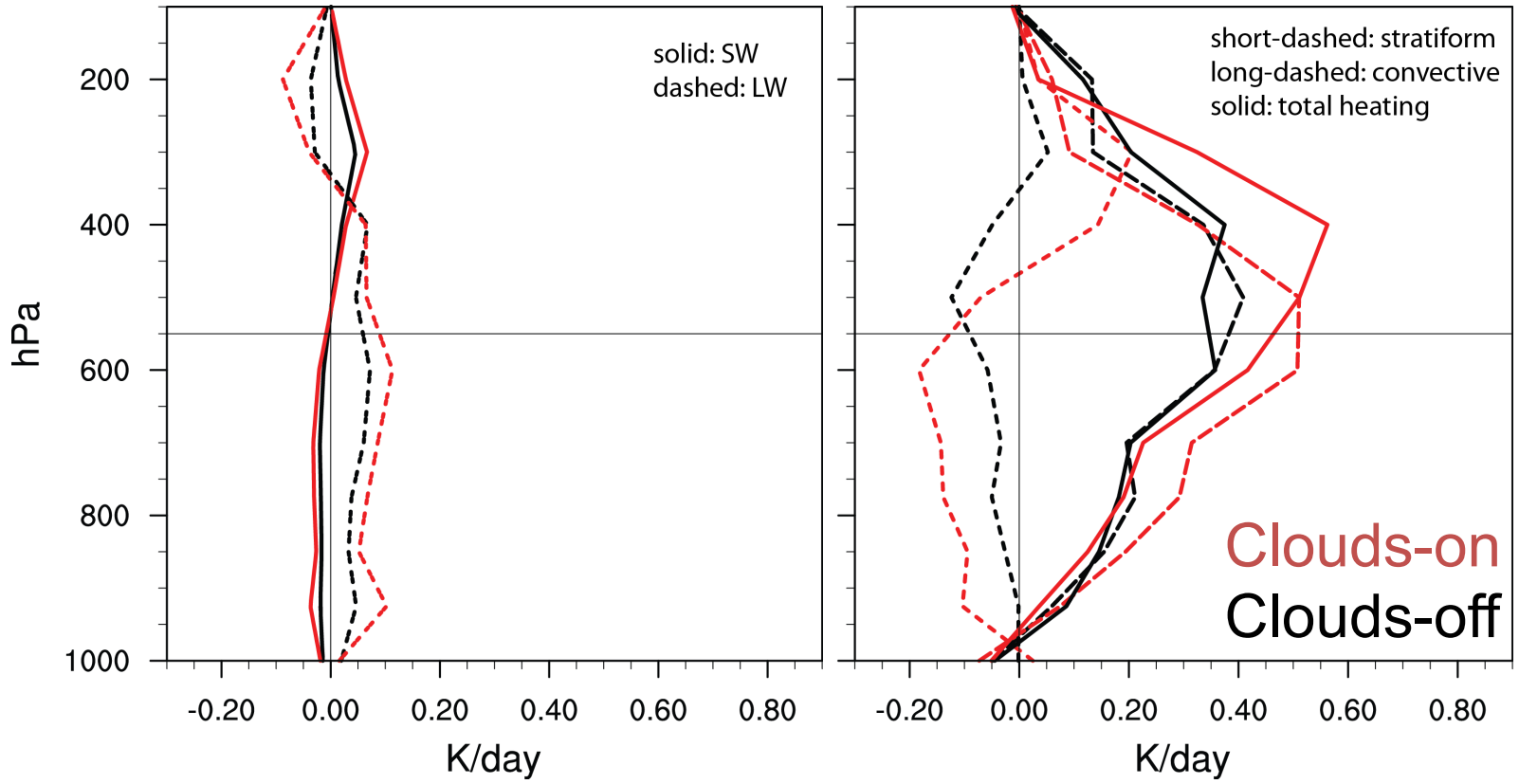
EOF1 of longwave heating rate profile (20-100 day filtered)

➔ intraseasonal deep convection

➔ basis for regression analysis

➔ eastward & not-eastward propagation

Heating profiles of intraseasonal deep convection (IO)



Clouds-on ➔ top-heavy

Clouds-off ➔ mid-heavy

Conclusions

Cloud-radiation feedbacks …
… modify convectively coupled equatorial waves:

- enhance MJO and weaken Kelvin waves.

... change mean state:

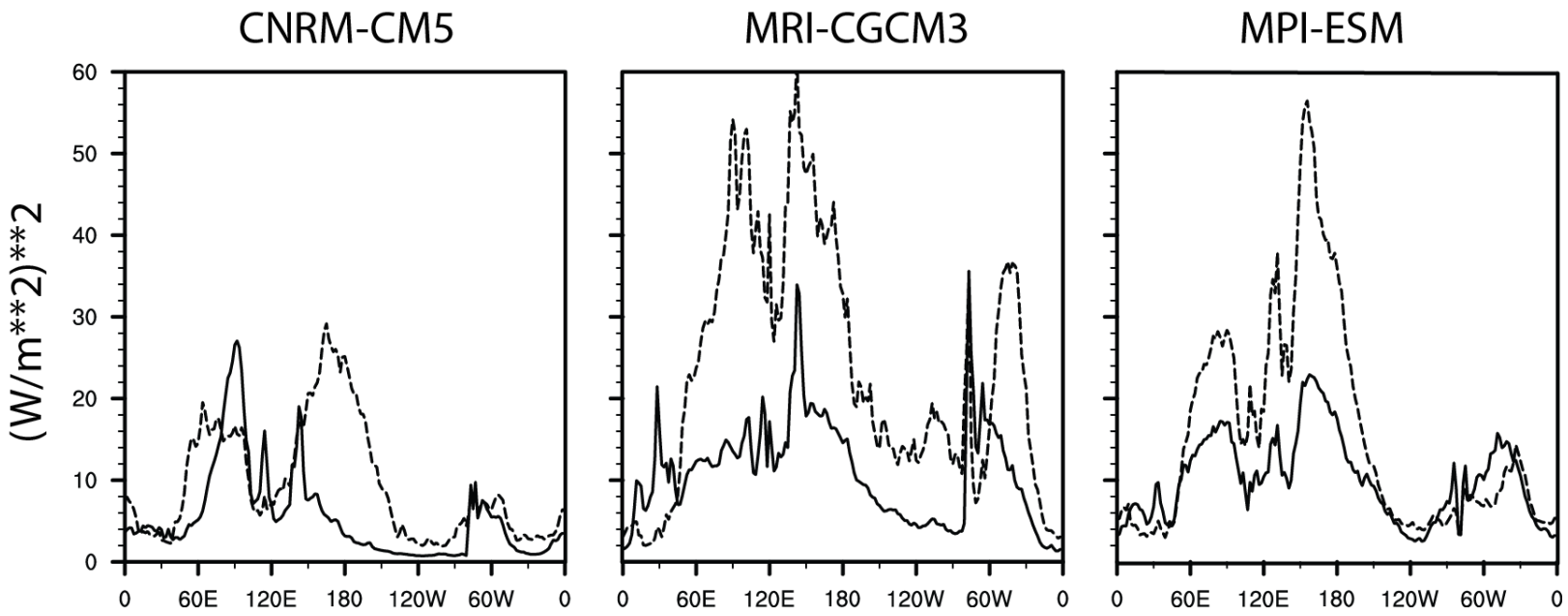
- lead to single ITCZ & strengthen equatorial westerlies

… change heating rates:

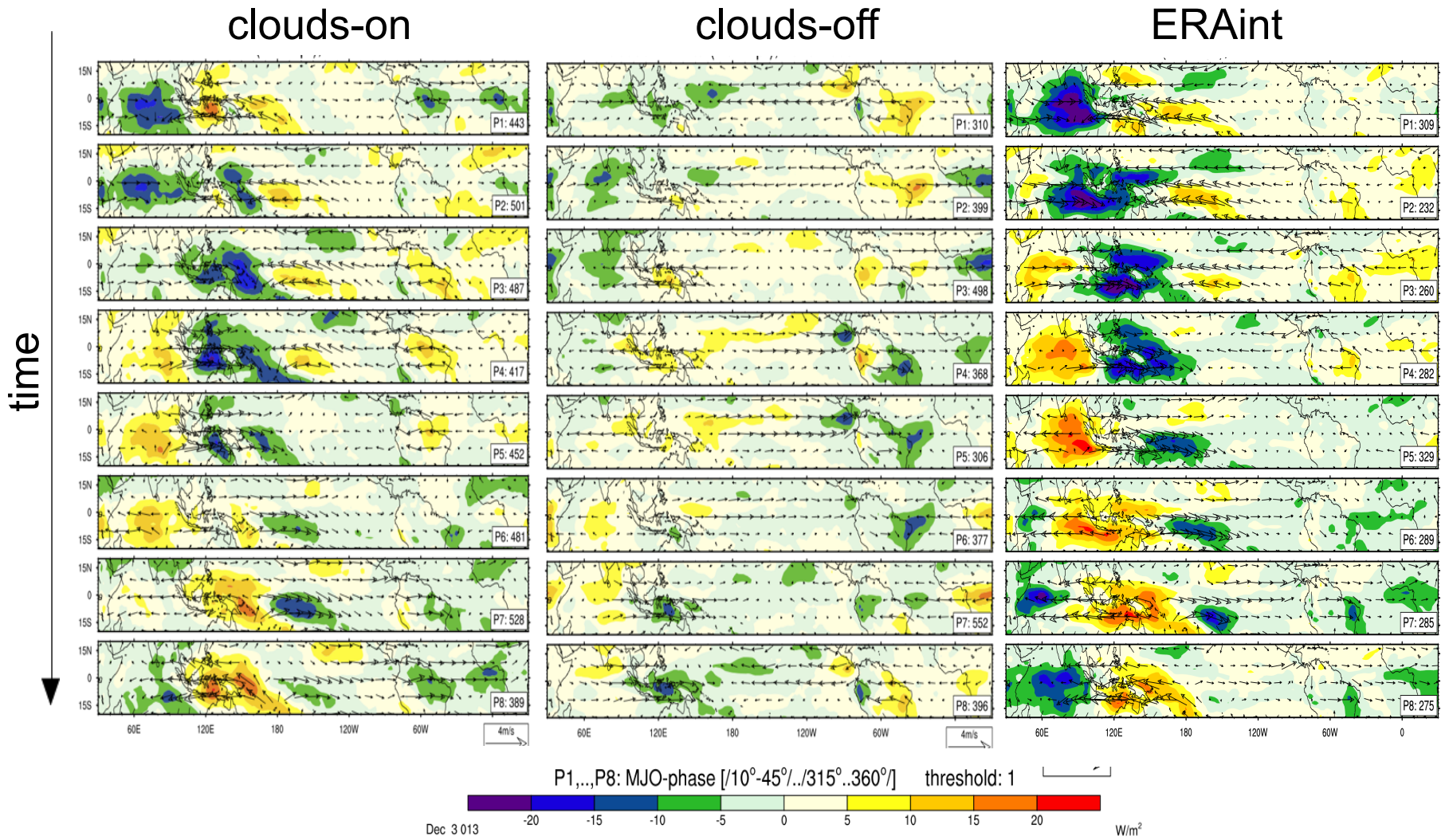
- slow-down MJO phase speed
- strengthen top-heavy heating profile (convective & stratiform).

Does MJO respond to mean state changes or to heating changes?

Thank you!


CNRM-CM5
MRI-CGCM3
MPI-ESM
(W/m**2)**2
60
50
40
30
20
10
0
0
60E
120E
180
120W
60W
0

MJO lifecycle composites (OLR and 850 hPa winds)



➔ CR-effects necessary for MJO in ECHAM6