# Process-oriented assessment of CMIP5 simulations in the present climate along the AMMA transect.

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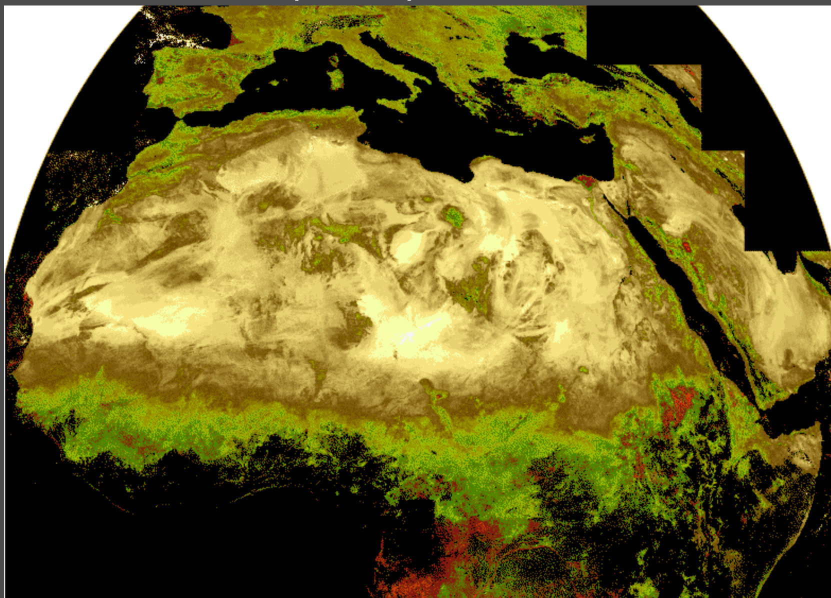
CFMIP-EUCLIPSE meeting, 10-14 June 2013, Hamburg, Germany

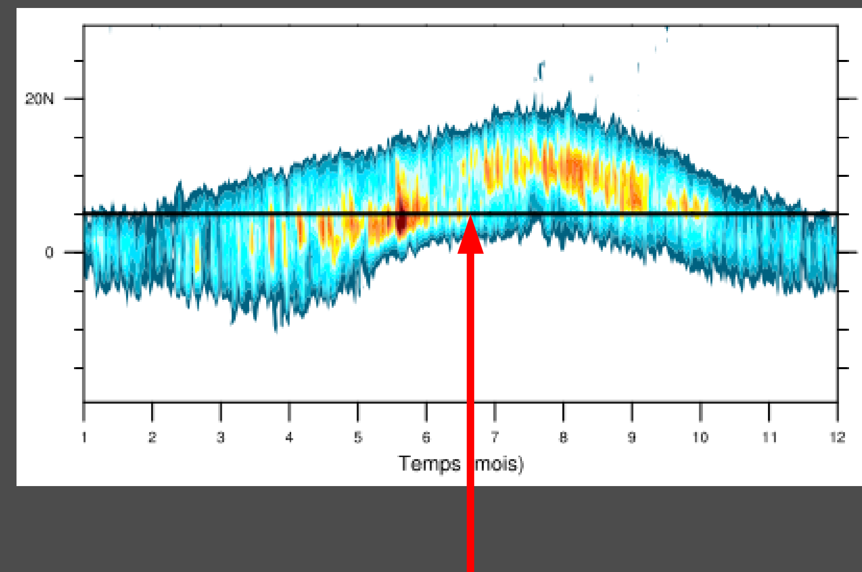
# West African Monsoon (WAM)

*Albedo June (1996)*



Well defined meridional gradient
At the surface : albedo, vegetation...

*Rain Hovmüller diagram*




Climatological WAM onset
Sultan & Janicot (2006)

Major interest and difficulty of WAM :
- involves about every type of moist convective phenomena occurring over land
- MCS => interactions of processes up to synoptic scales (Gong & Eltahir 1996)
- role of cloud radiative feedbacks ?

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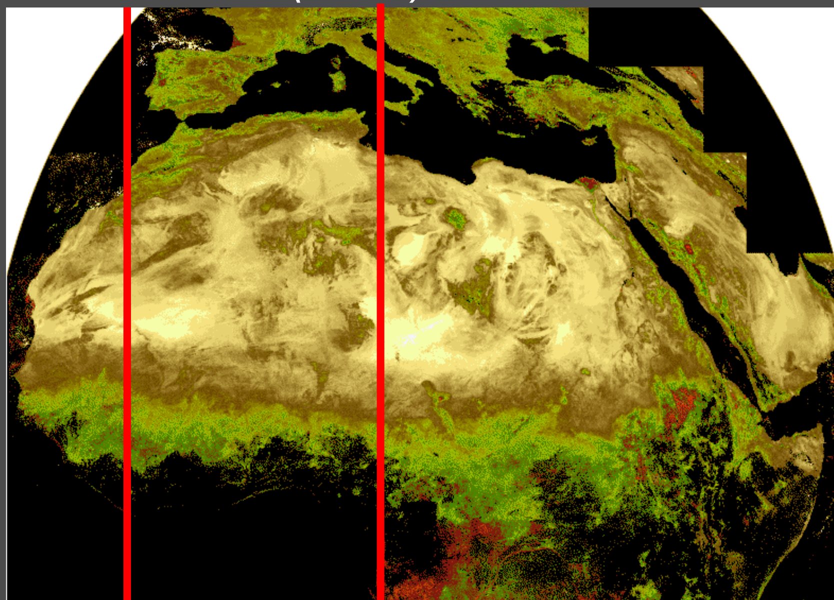
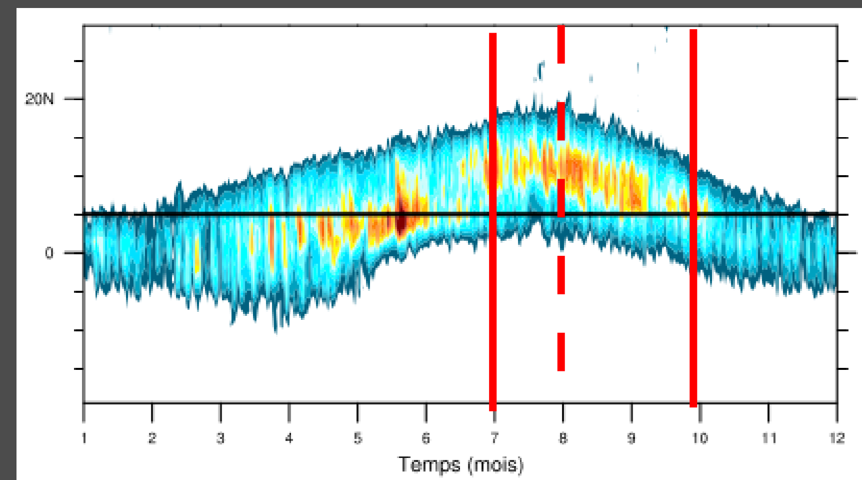
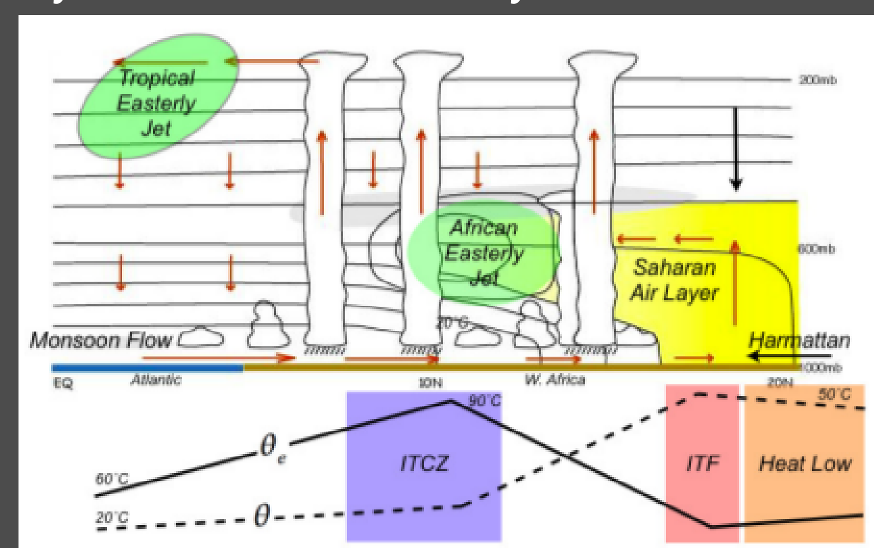


*Rain Hovmüller diagram*




*Dynamics and thermodynamics*




Simplification of the system :

2D hypotheses => zonal average between 10W/10E

Focus to the full monsoon period JAS or J

Inspired several studies Zheng & Eltahir (1998), Peyrillé et al (2007), Hourdin et al. (2008)

Hall & Peyrillé 2006

# Outline

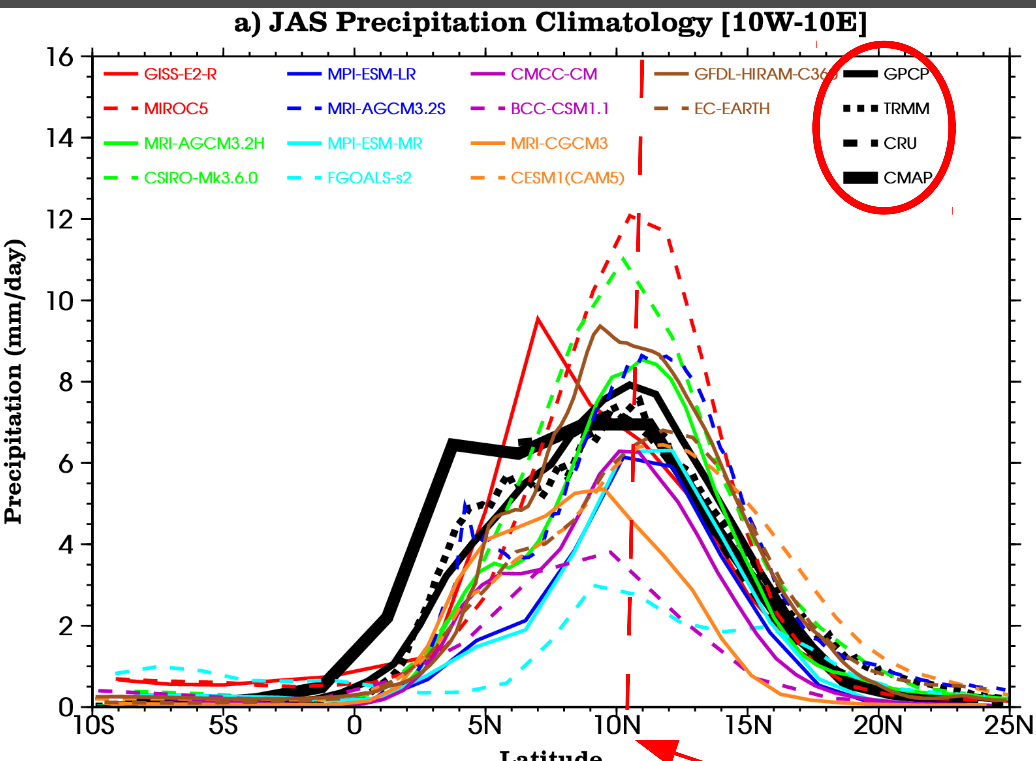
- Skills of CMIP5 models for simulating the present day WAM ?
    -> data = reference data sets
    -> results enclosed in Roehrig et al. (*J. Climate*, 2013)

- Cloud feedbacks on WAM dynamical and thermodynamical organization ?
    -> 2D idealized model
    -> CMIP5 models

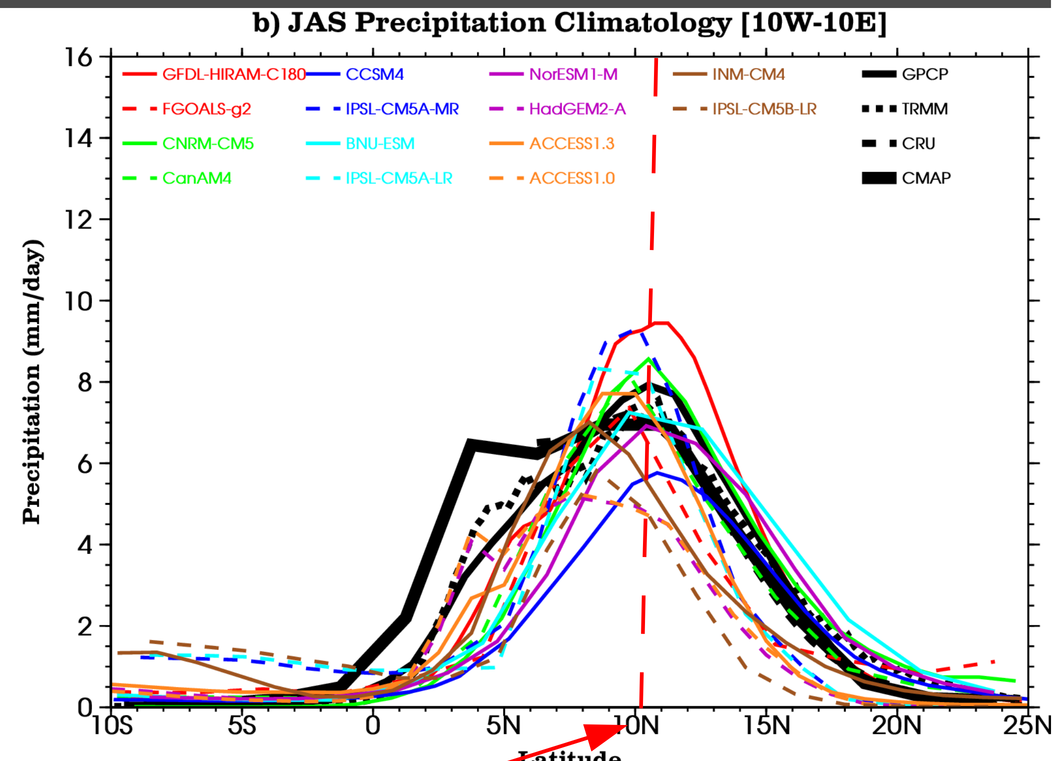
# WAM features in CMIP5 models (AMIP) : Rain

30 year average for JAS of AMIP simulation in the 10E/10W domain
Models are separated according to their mean temperature over Sahara

*« Warm » models*




*« Cold » models*

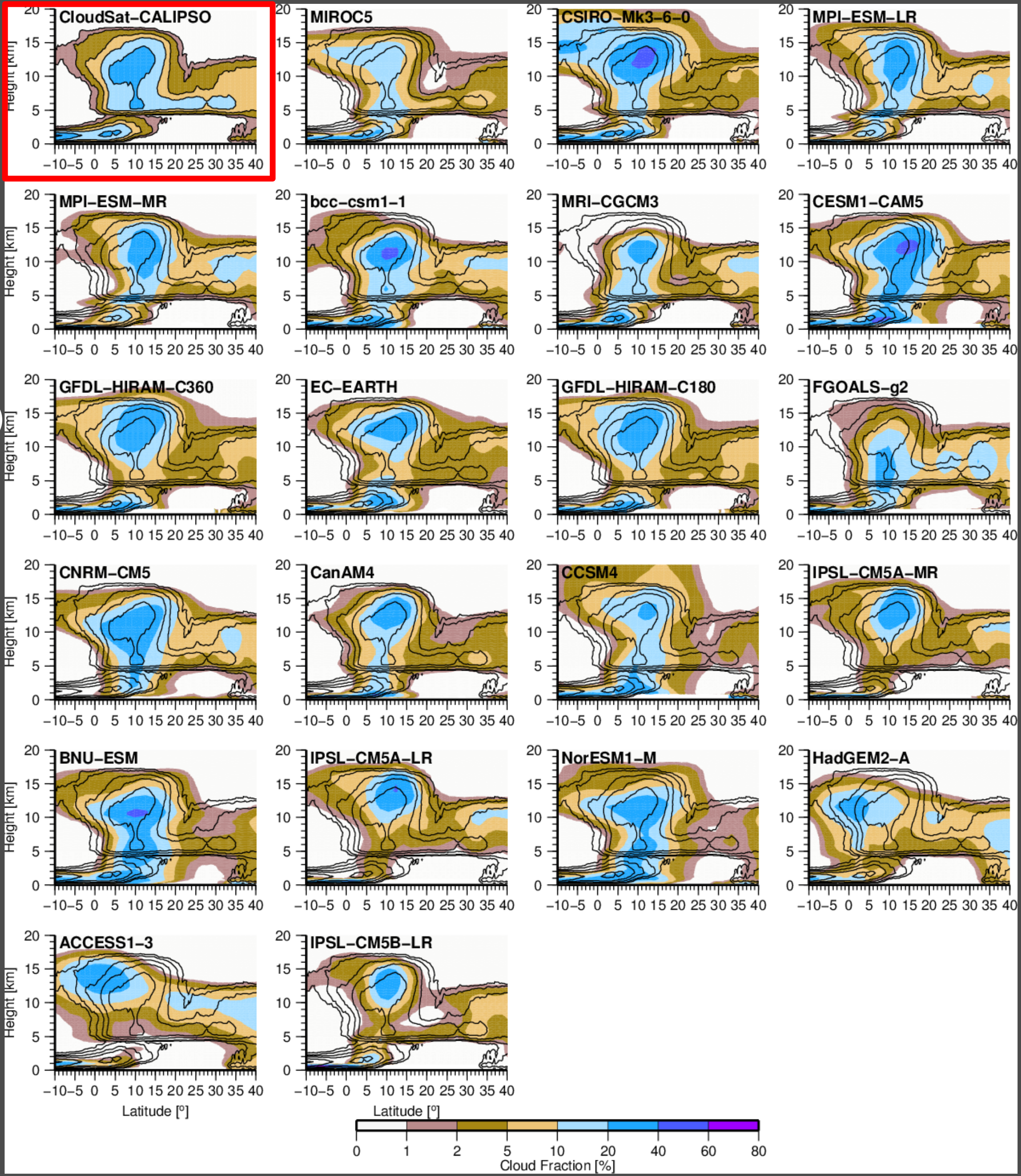



All model : Large scale max over the continent 10-11° N

One third of the model => too south ITCZ (7-8°N)
Overestimation / underestimation of the max of precipitation

# WAM features in CMIP5 models (AMIP) : Cloud fraction

- Sc on the gulf of Guinea
- low level clouds at the coast (5°N) and norther
- deep convection in the ITCZ
- mid level clouds in the ITCZ + Sahara
- deck of high level clouds




Deep cv in the ITCZ
Miss mid-level
Miss Sc or at least their vertical extend

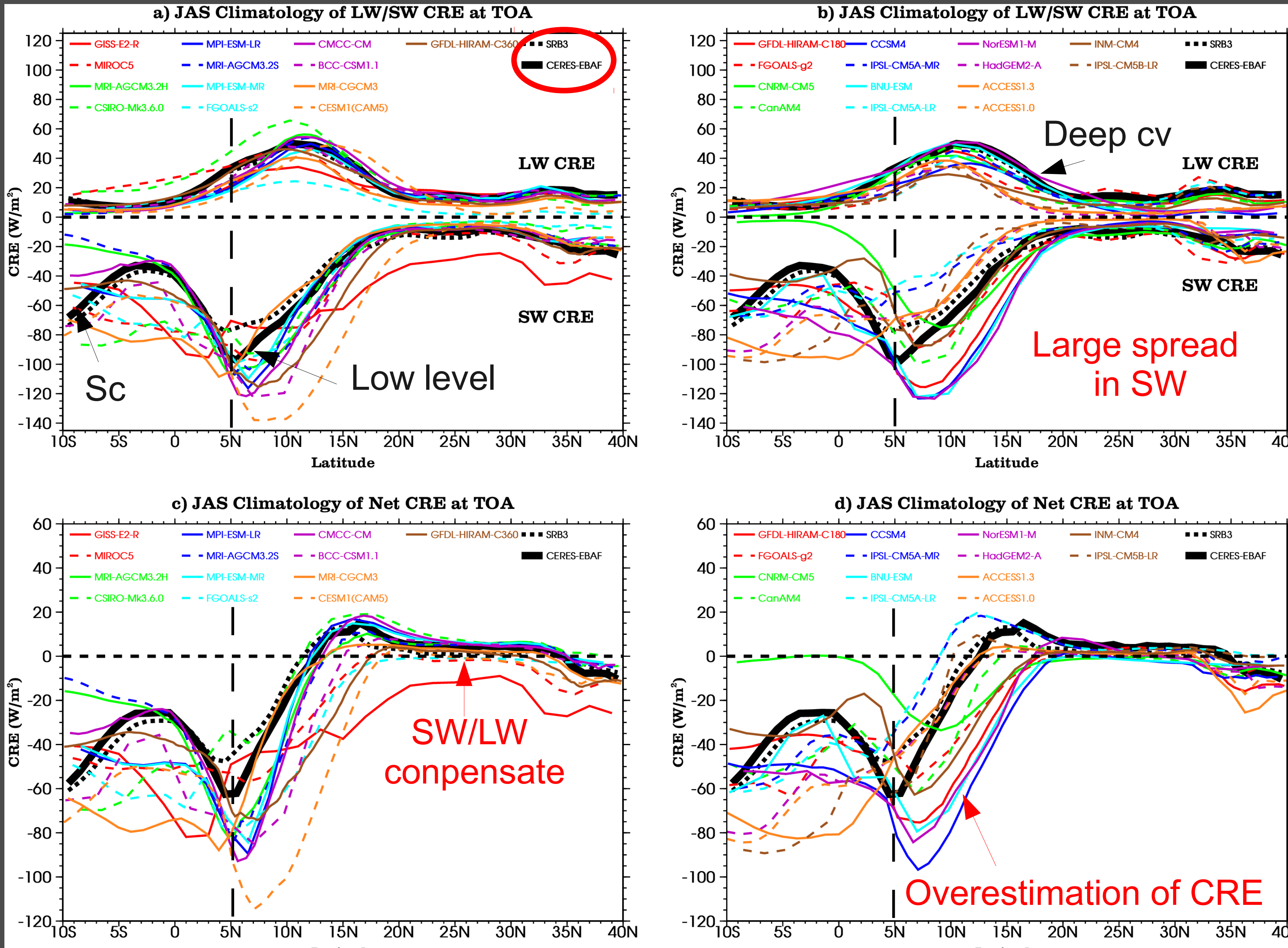
# WAM features in CMIP5 models (AMIP) : CRE at TOA

*« Warm » models* *« Warm » models*

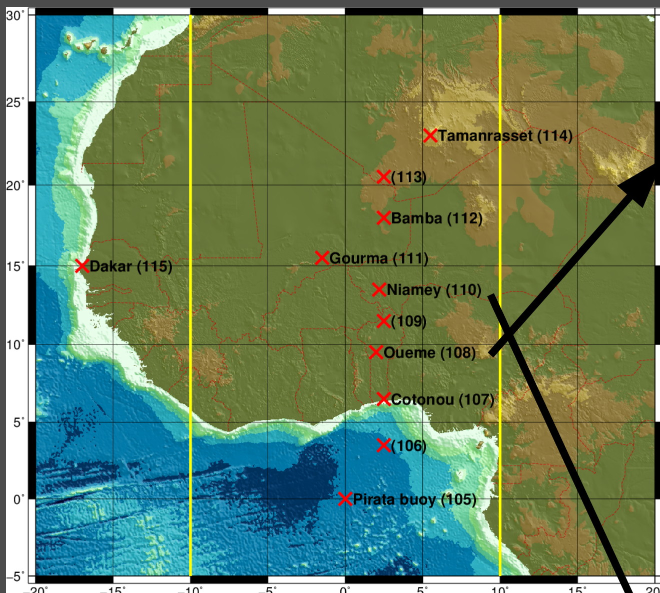
LW

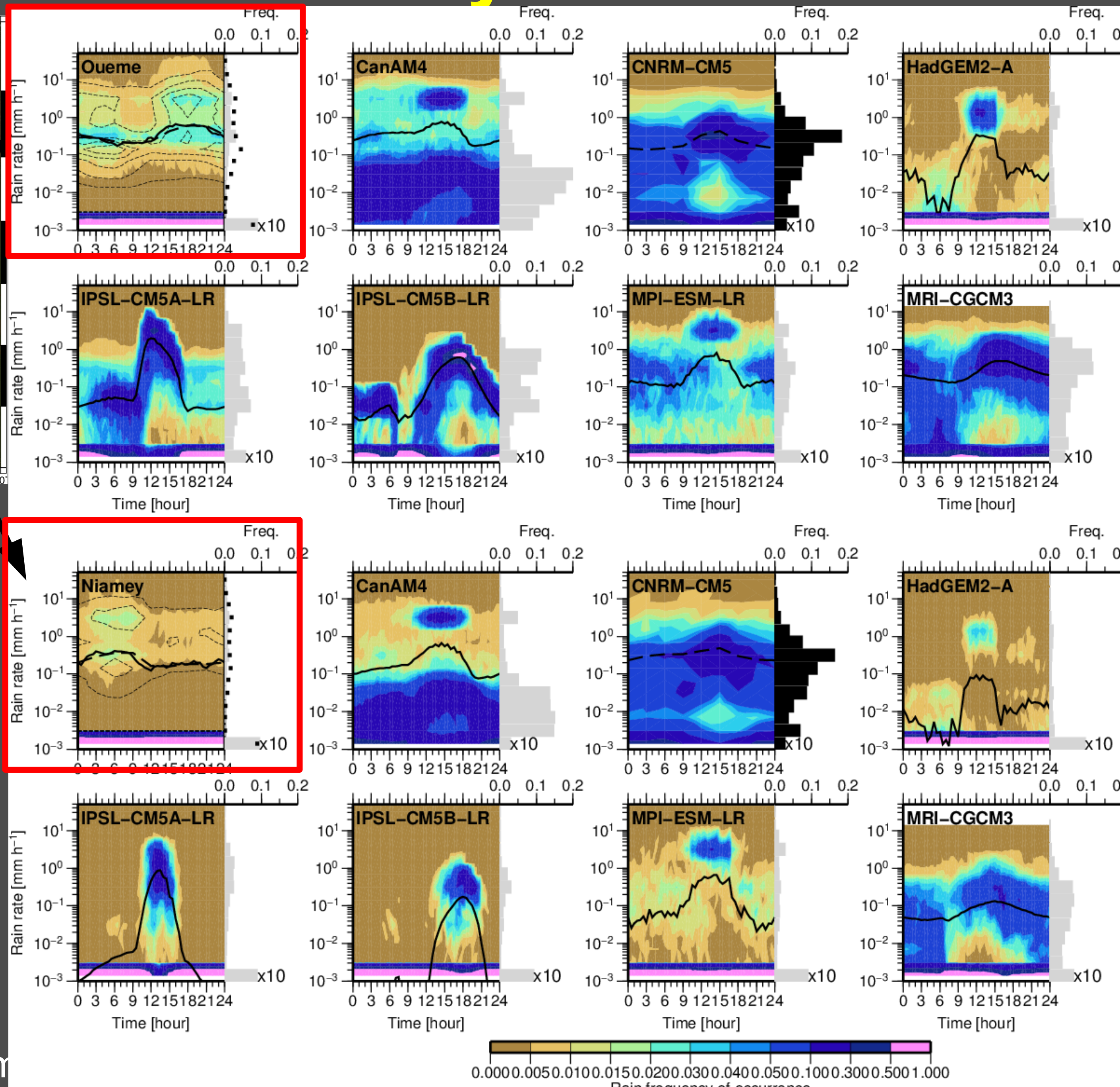
SW

Net



# WAM features in CMIP5 models (AMIP) : rain diurnal cycle



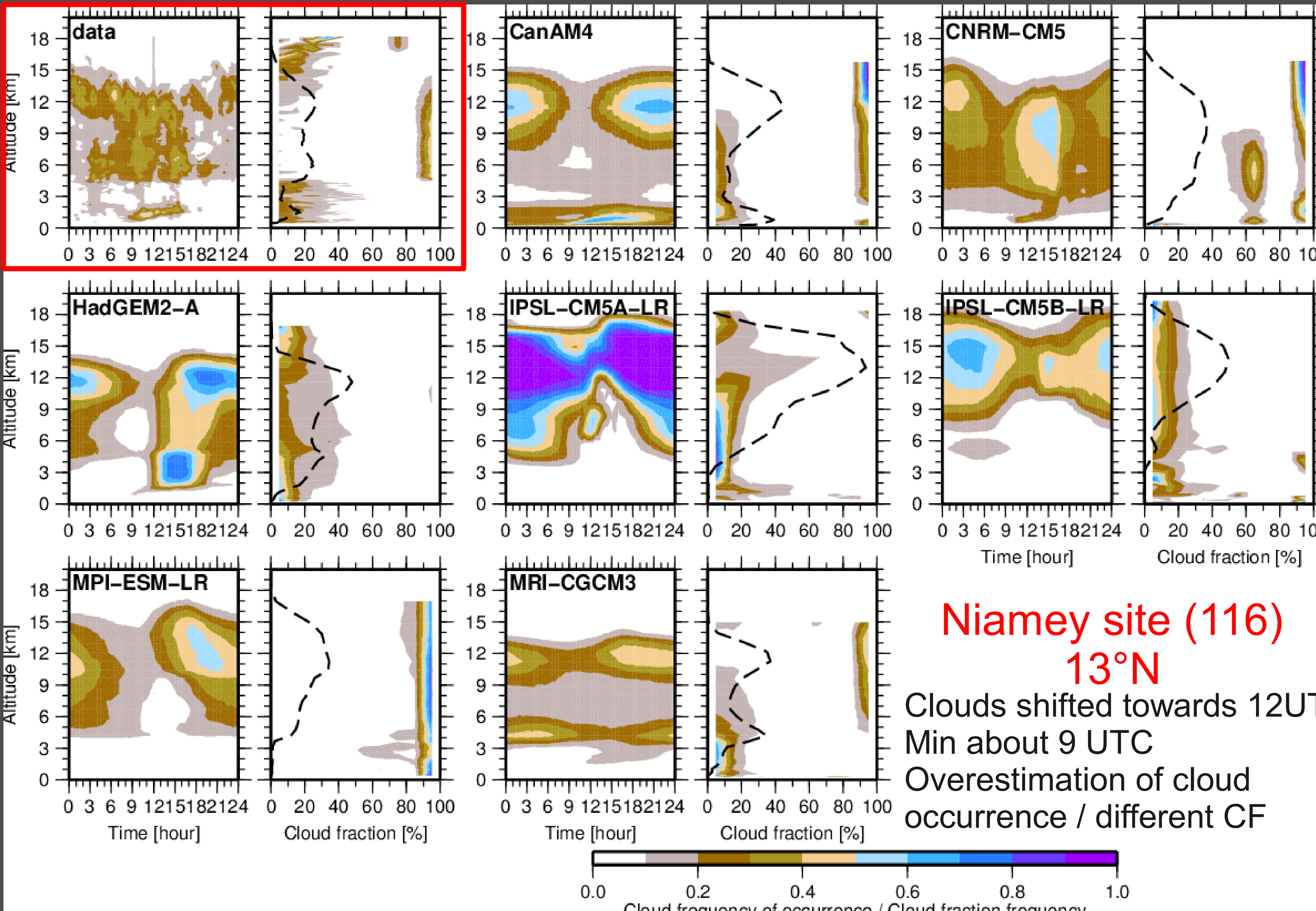




North (Niamey): propagating system in the morning
=> Major rain source (Mathon et al. 2002)
South (Oueme): propagating + afternoon peak

Model: No change with latitude
Less occurrence norther
Too early peak in precipitation in phase with max insolation except for IPSL-CM5B and MRI
Some model rain most of the tim

# WAM features in CMIP5 models (AMIP) : cloud diurnal cycle – occurrence + CF

NIAMEY (cfSite 116)




Niamey site (116)
13°N

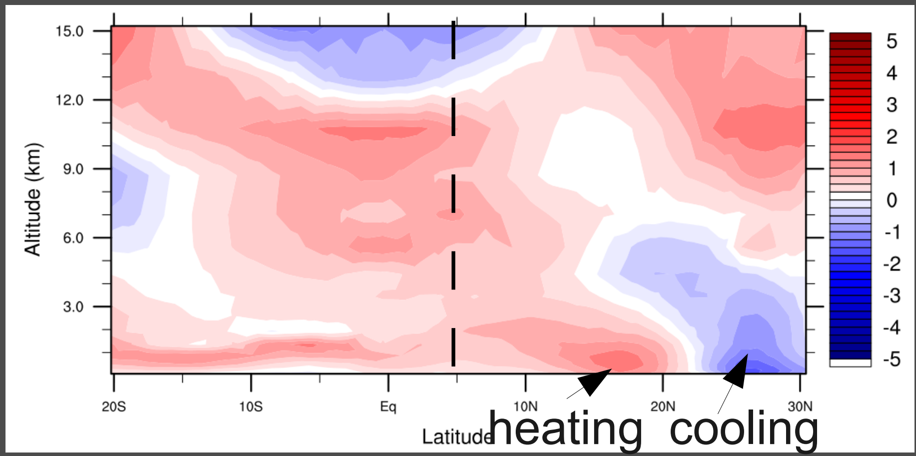
Clouds shifted towards 12UTC
Min about 9 UTC
Overestimation of cloud occurrence / different CF

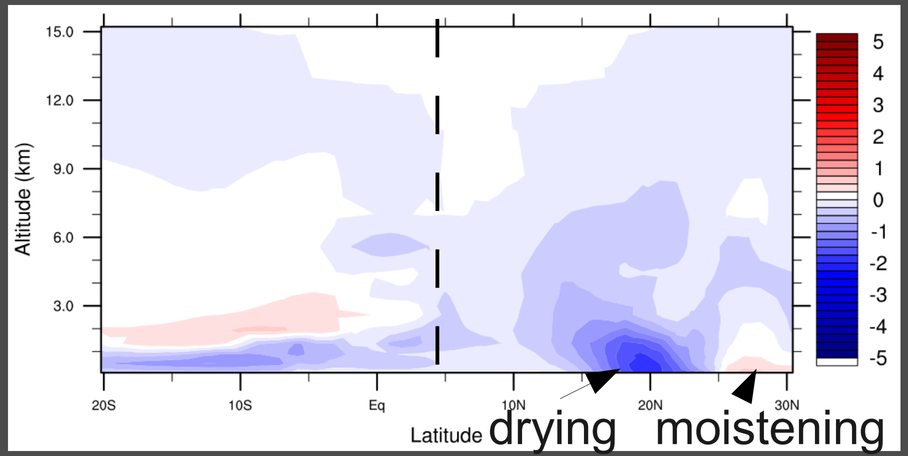
# 2D idealized WAM model Peyrillé et al. (2007)

2D version of MESO-NH (Lafore et al. 1998)

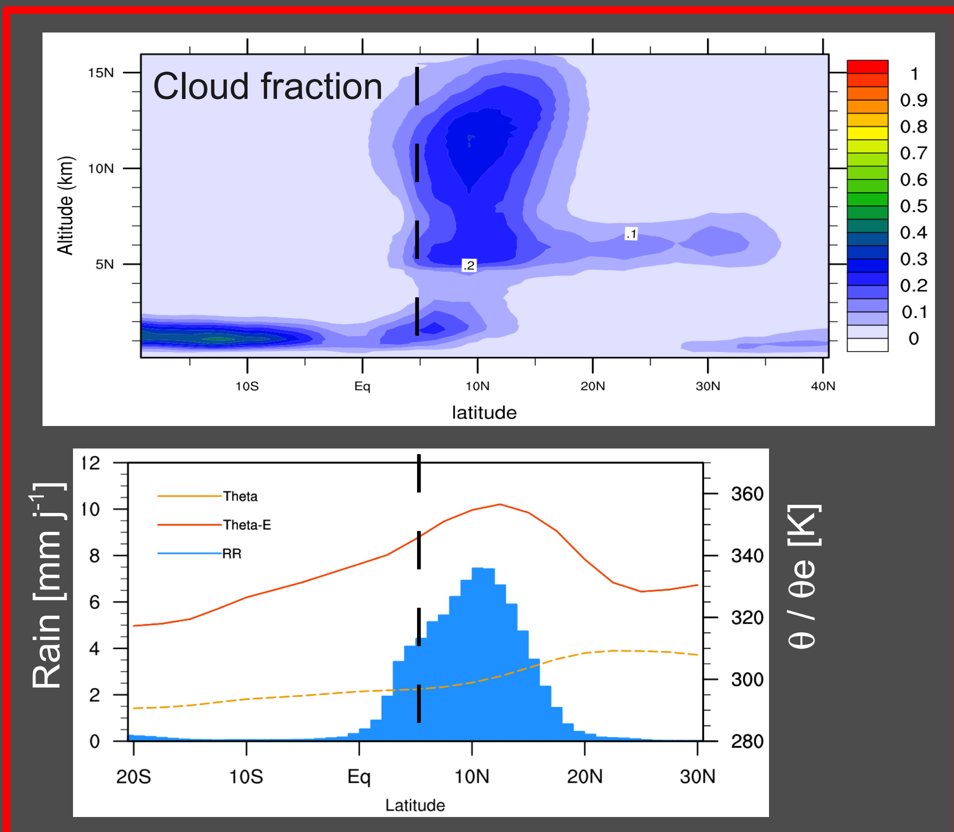
- Horizontal resolution = 150 km / 20 levels
- Convection : Bechtold et al. (2001)
- Turbulence : Cuxart et al. (2000)
- Radiation : RRTM
- 5 specied microphysics
- surface model : ISBA
- Aerosol climatology : Tegen
- imposed diurnal cycle + SST : Reynolds & Smith (1995)

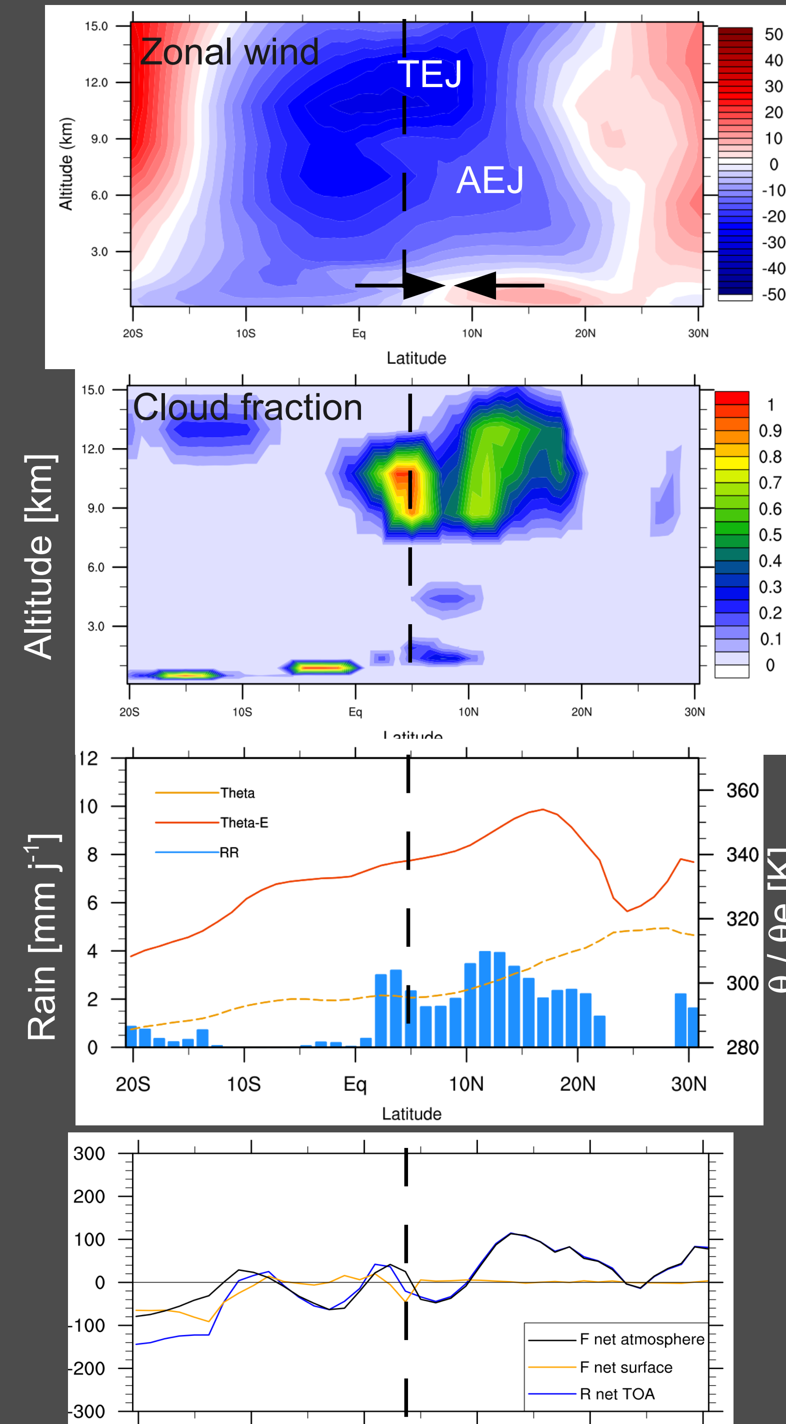
+ Heat flux parameterization (Zou and Gal-Chen,99), (Stone,Yao, 90)
+ Momentum meridian flux
+ need to impose advective forcing of heat and humidity (ERAI)



# Simulation of a constant July



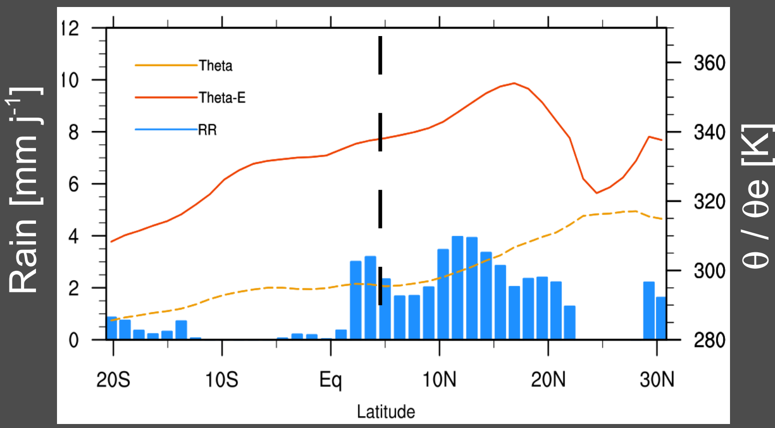




$$\left\langle \frac{\partial MSE}{\partial t} \right\rangle = -\langle \vec{\nabla} .(MSE\,\vec{V})\rangle + Rnet_{TOA} + \cancel{Rnet_{BOA} + H + LE}$$

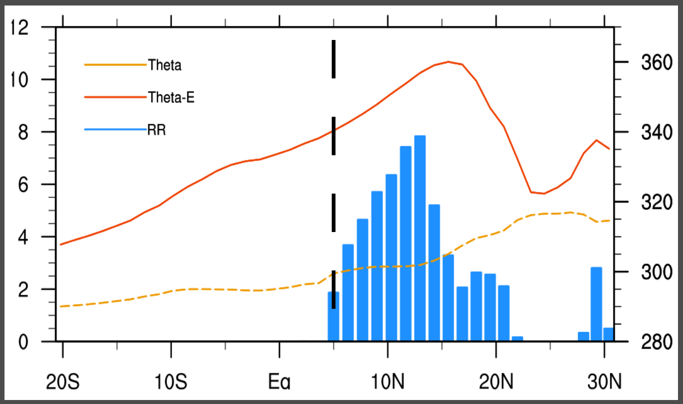
Over continental surface

# Simulation of a constant July – COOKIE mode

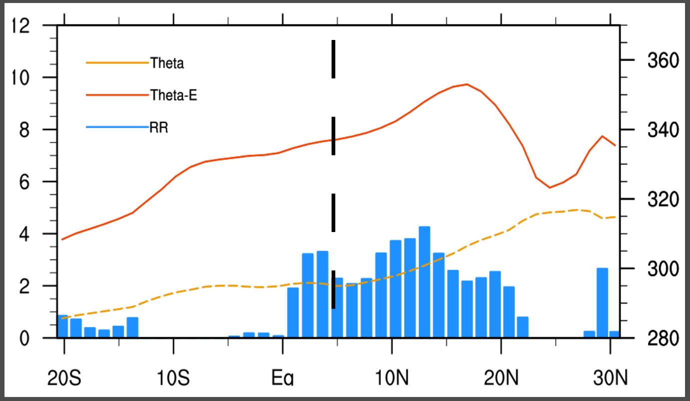
REF



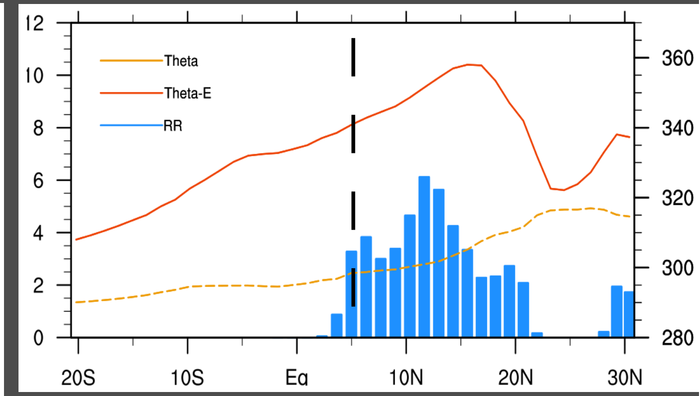

COOKIE

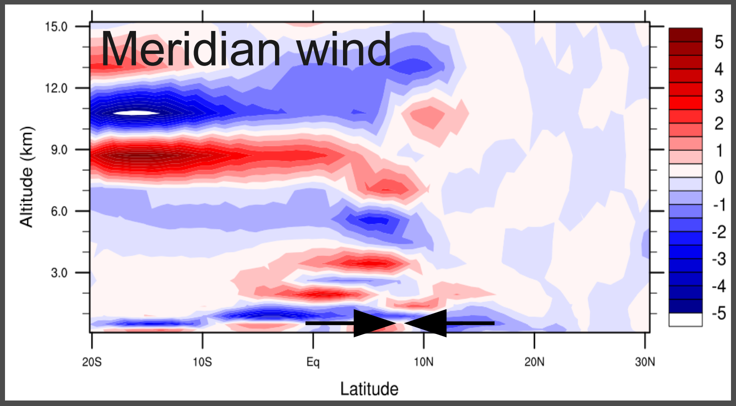



COOKIE – No LW but SW




COOKIE – No SW but LW




COOKIE => more intense rain / more narrow precipitation band

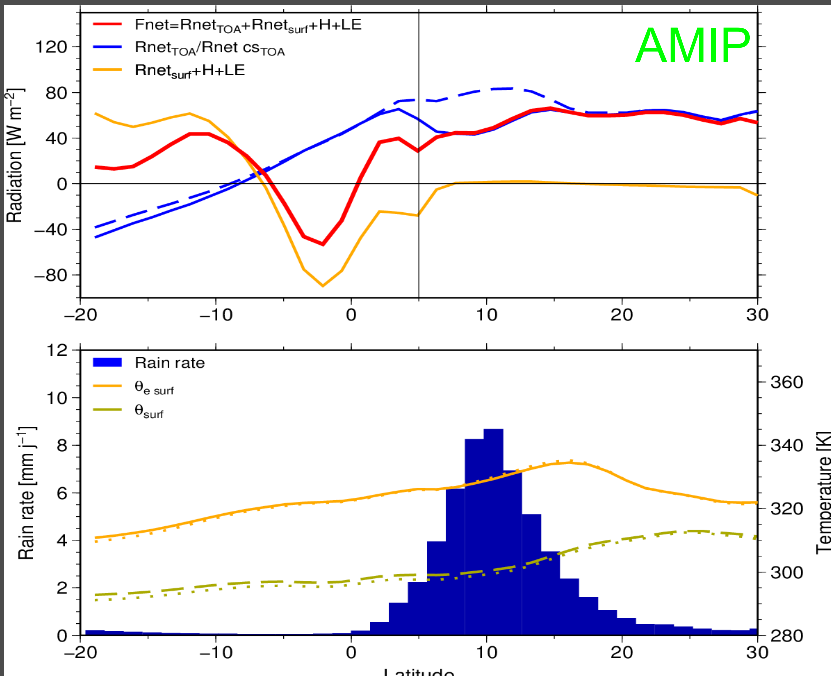
Because of more heating at the surface + less low cloud over the ocean and about the coast

Rain results of surface/atm interactions

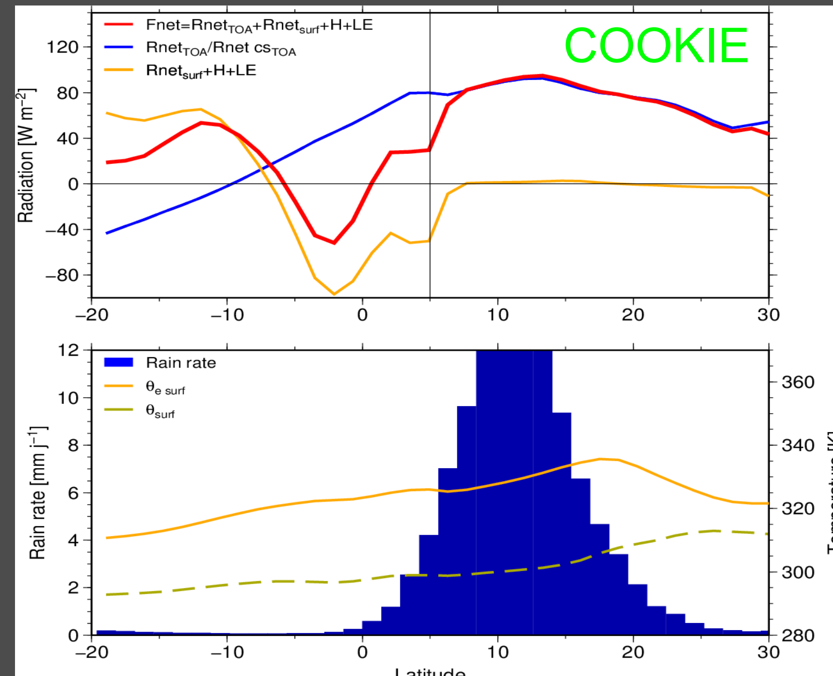
Stronger impact of no SW effect : more energy in the system (less loss at TOA)

# CMIP5 models – preliminary results

CNRM-CM5

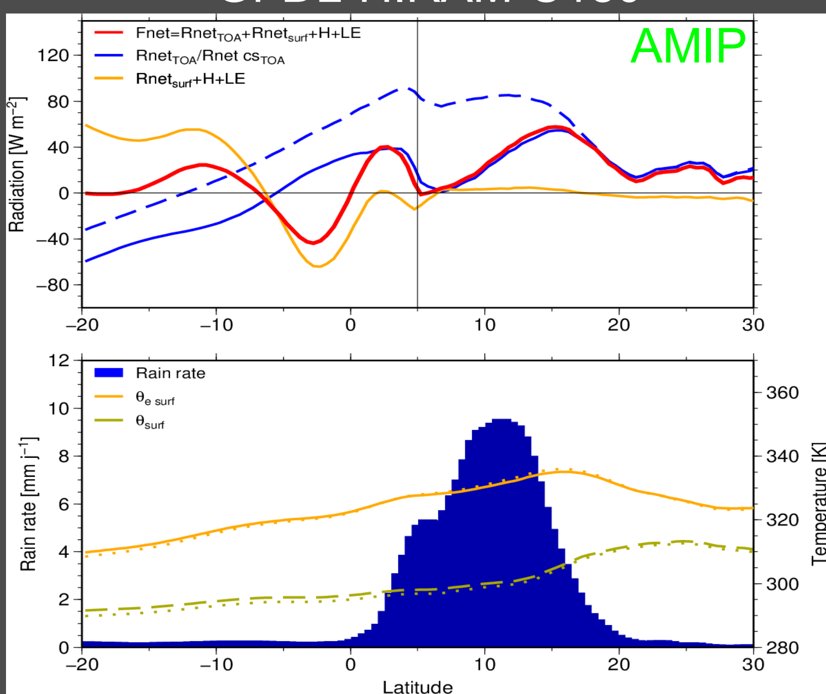



CNRM-CM5

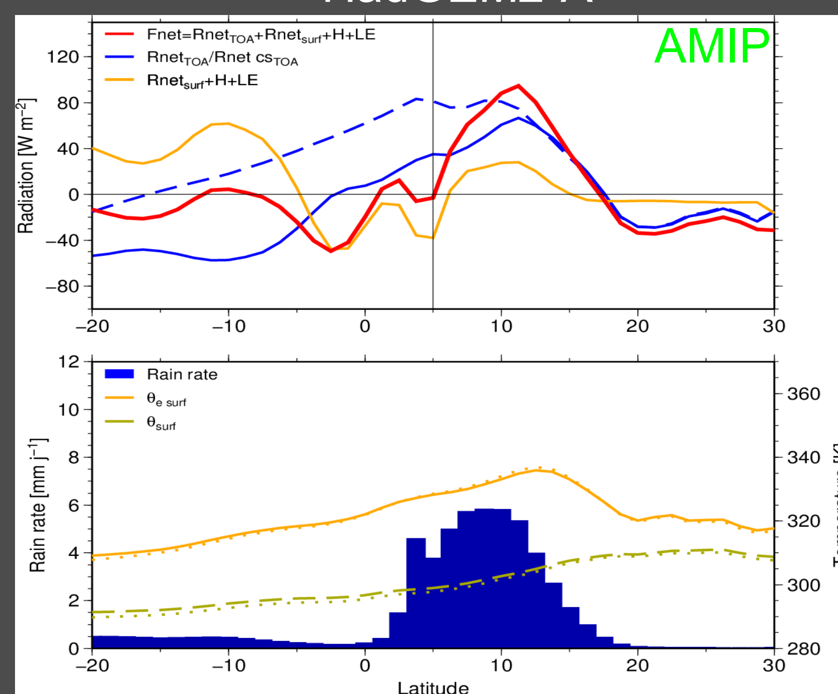



Strong increase
In precipitation
Mainly because
less SWup from
clouds

GFDL-HIRAM-C180




HadGEM2-A



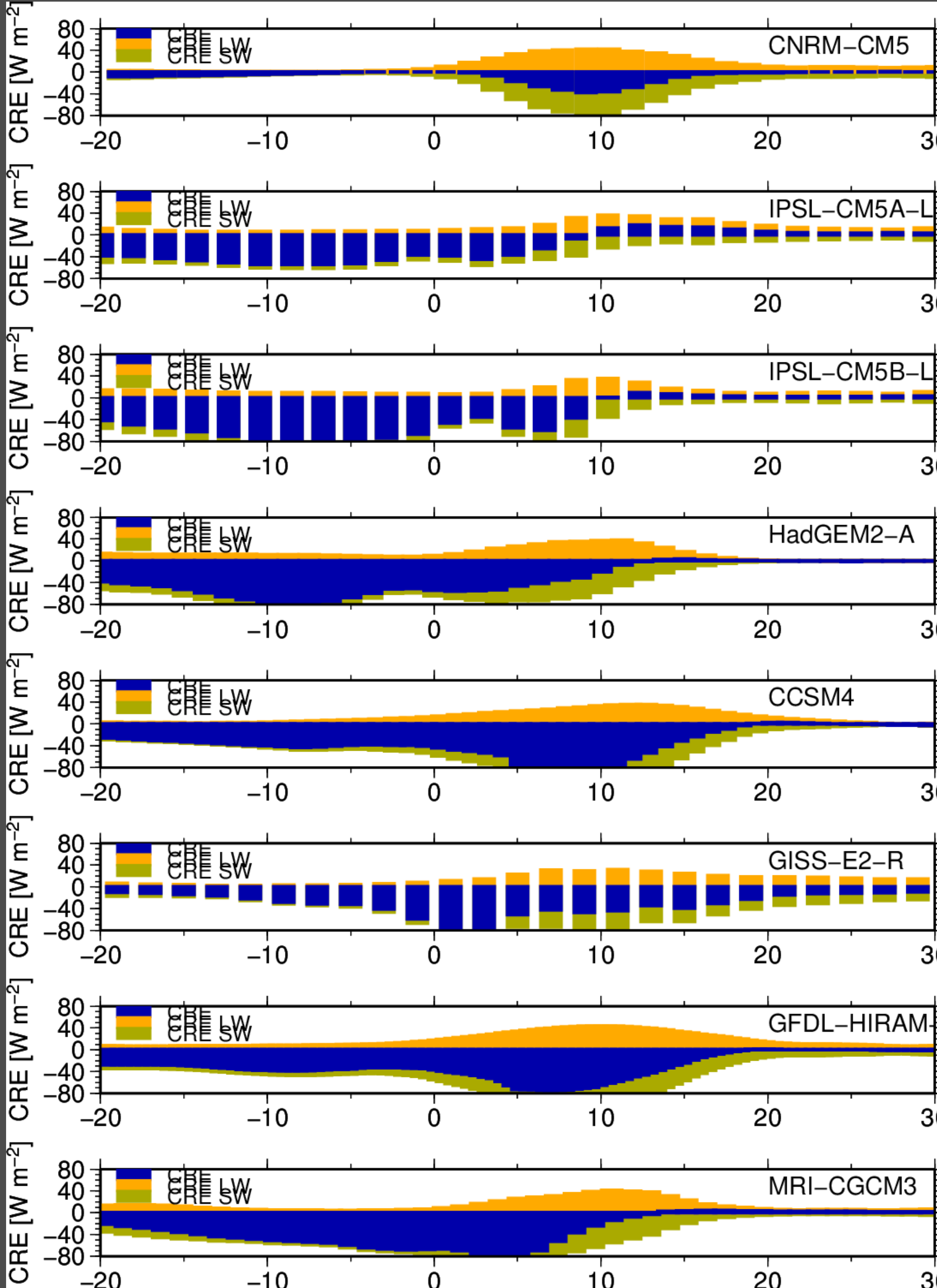

Overestimation
of Swup
=> too small
Rnet TOA
=> too south
precipitation ?

# Summary

In AMIP mode : almost all models capture the broad features of a monsoon, but
- large spread of average Sahel rainfall (+/- 50%)
- meridional structure of cloud cover and its radiative impact are tough challenges for CMIP5 models
- wrong phasing of precipitations in the diurnal cycle

More results in particular for coupled models ability in Roehrig et al. (2013)

Idealized 2D simulations + COOKIE experiments
- rain in the Sahel strongly responds to radiative forcing at the TOA through surface processes
- CMIP5 model seems to react in the same direction (CNRM-CM5)
- large effects are expected because of the strong overestimation of SWup at TOA


CNRM−CM5
IPSL−CM5A−LR
IPSL−CM5B−LR
HadGEM2−A
CCSM4
GISS−E2−R
GFDL−HIRAM
MRI−CGCM3
CRE
CRE LW
CRE SW
CRE [W m−2]
80
40
0
−40
−80
−20
−10
0
10
20
30