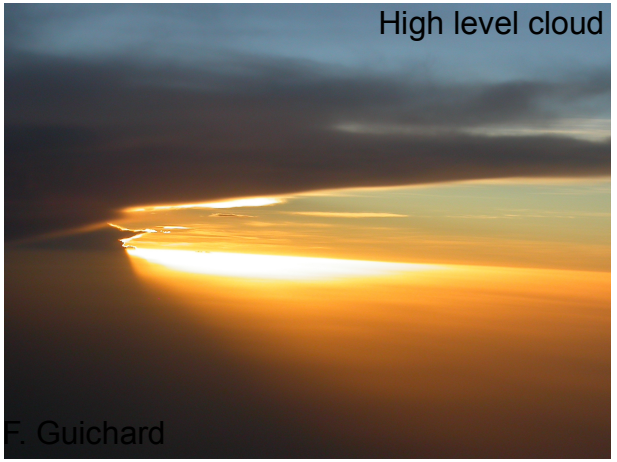
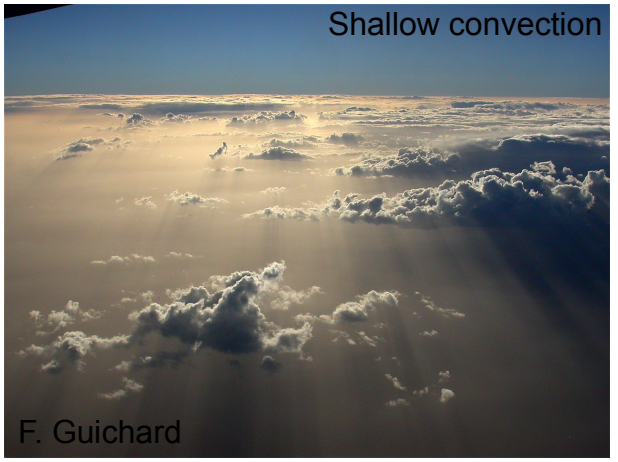
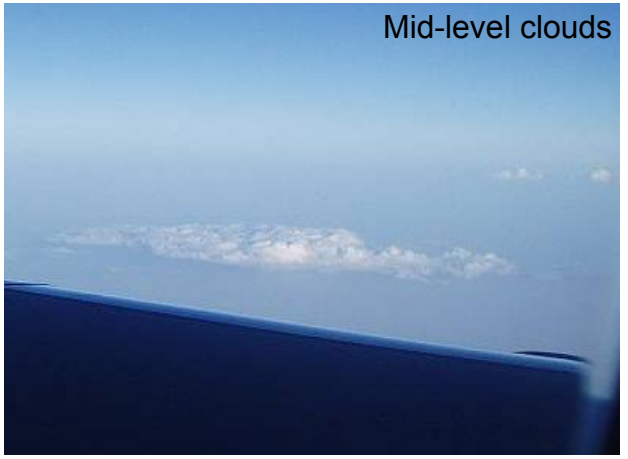






Analyses of CMIP5 simulations over the West African sites : cloudiness, radiation and rainfall relationships

D. Bouniol, F. Guichard, F. Couvreux, O. Geoffroy,
F. Favot, I. Beau, H. Douville, S. Tyteca

CNRM/GAME Météo-France/CNRS, Toulouse, France

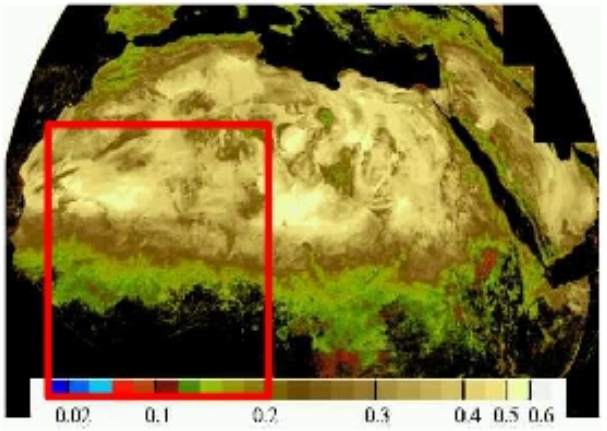
West African sites with AR5 model sub-hourly extractions

West Africa = one of largest land mass in the Tropics

1) Strong meridional structure in albedo and vegetation
2) Sharp transition for precipitation in the Sahel region – strongly correlated with the meridonal structure

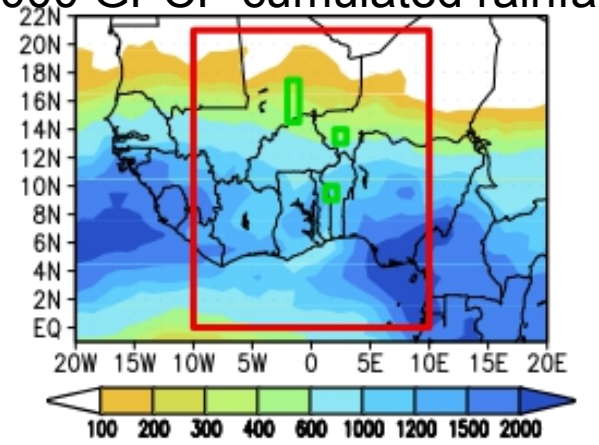
A

Surface albedo



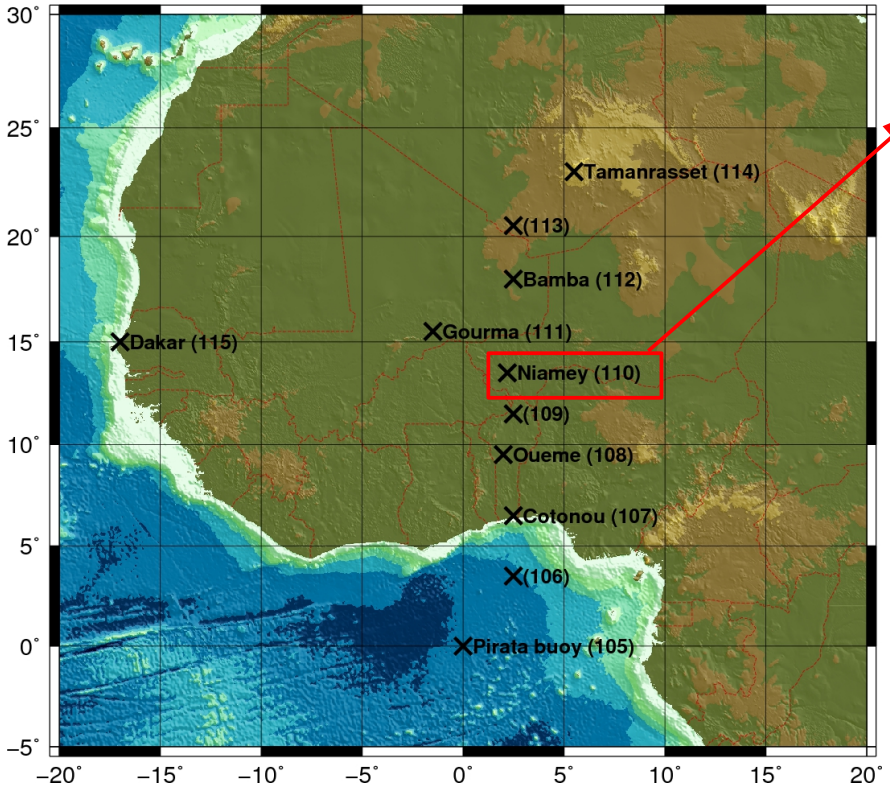
B

2000 GPCP cumulated rainfall



Analyse model simulations in a latitude-altitude cross-section by averaging outputs between 10W and 10E

Hourdin *et al.* (BAMS 2009)



2006 – ARM Mobile facility installed for one year

All the named sites include ground-based measurements
See AMMA data base :
http://database.amma-international.org/main.jsf

Sites are representative of their latitude band

African monsoon : seasonal scale

Rain – hovmuller diagram

Niamey

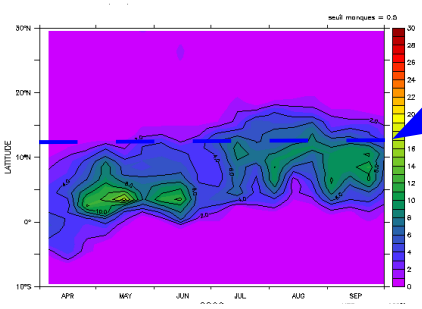
Vertical cross-section of cloud fraction

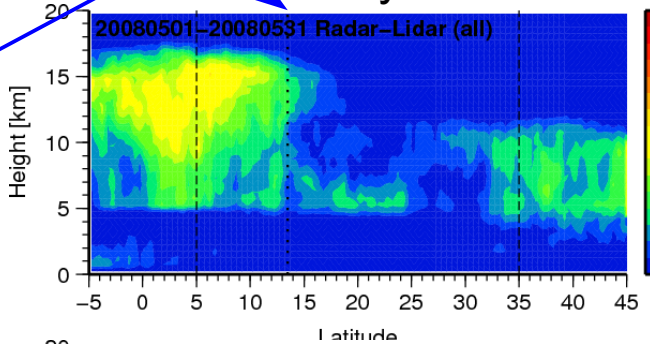
May

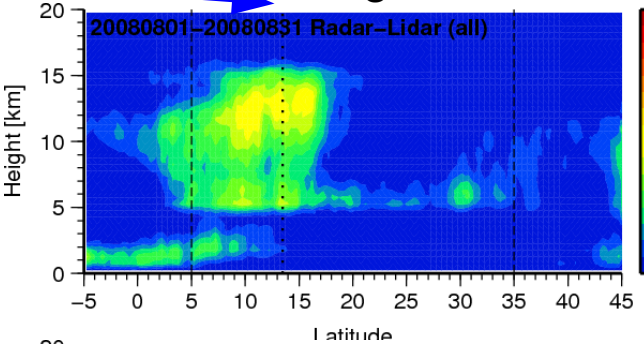
August

GPCP

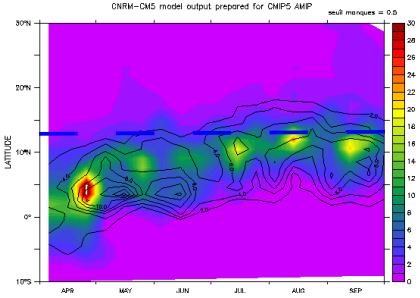
CloudSat/CALIPSO

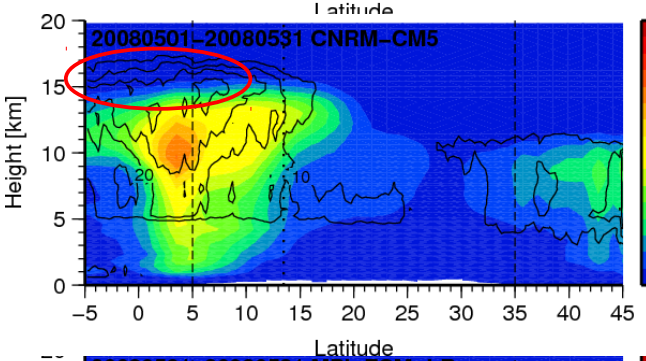


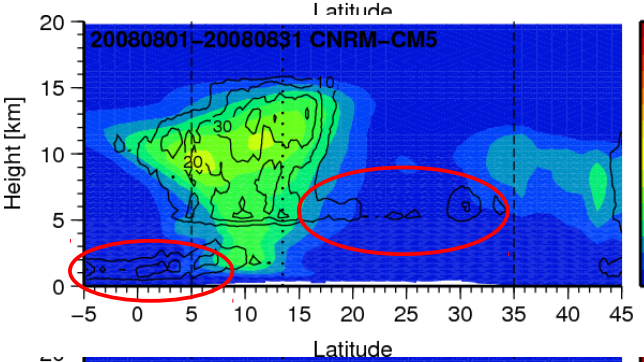




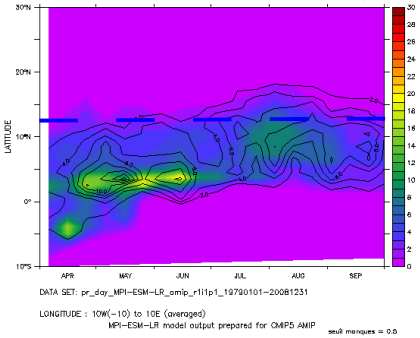
CNRM-CM5

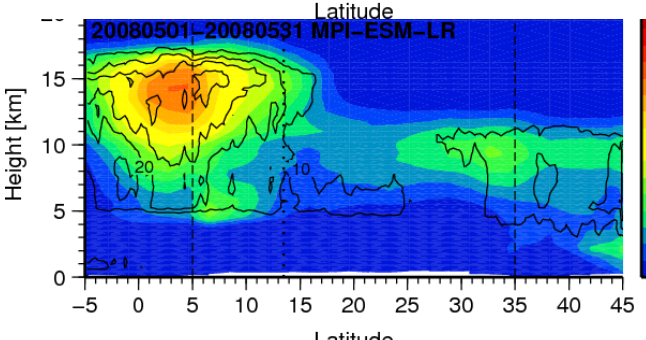


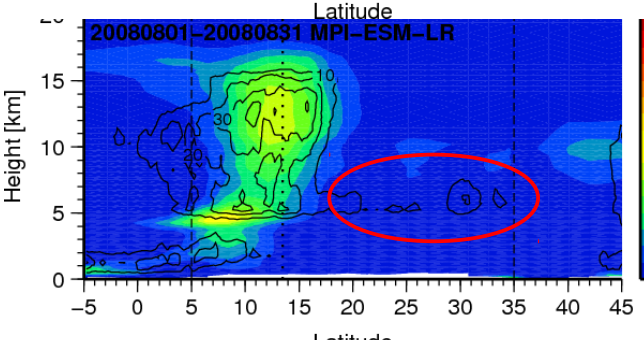




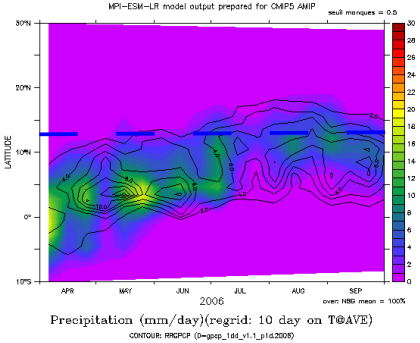
MPI-ESM-LR

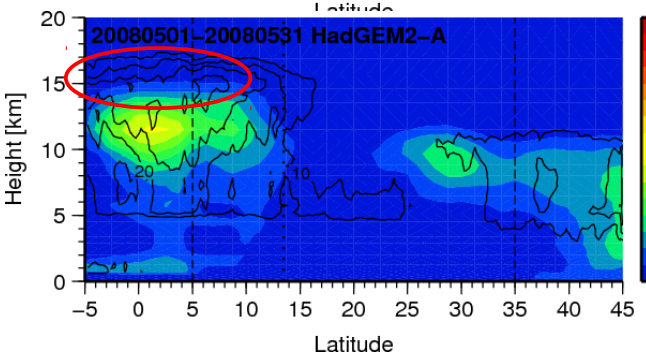


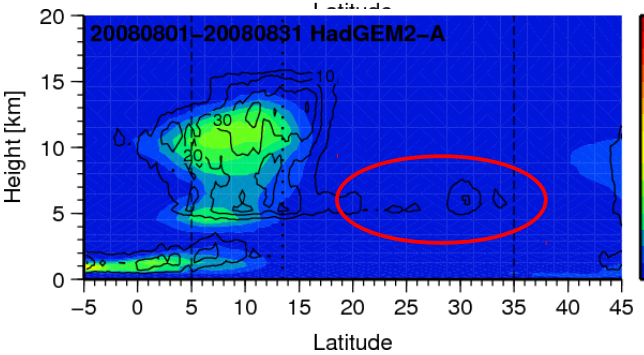




HadGEM2-A







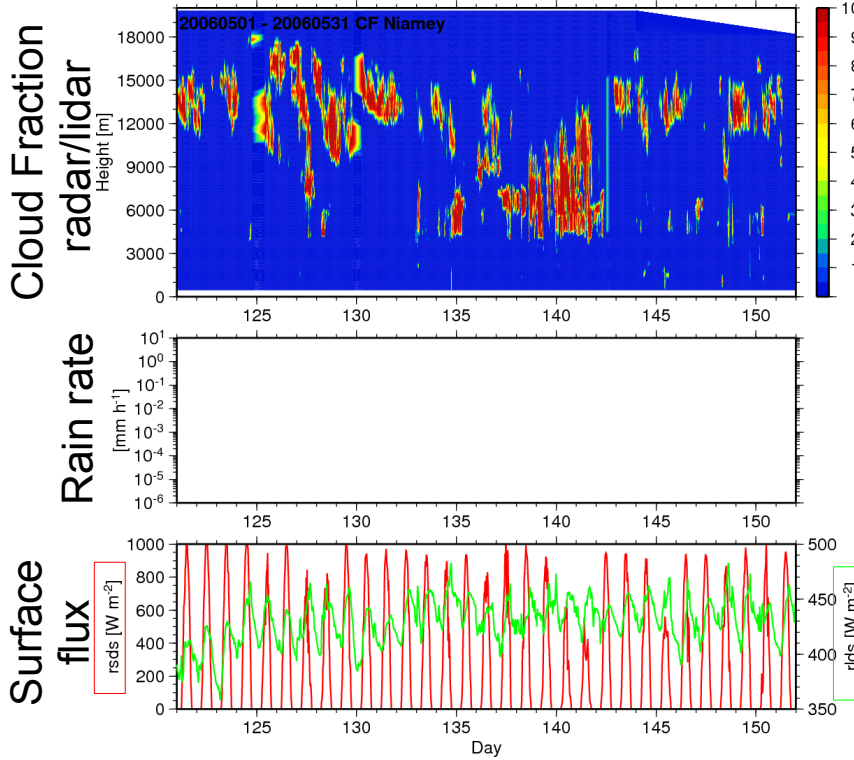
Reasonable dynamical and rain feature in the models, misses given cloud types

At smaller temporal scale : Niamey
May = pre-monsoon

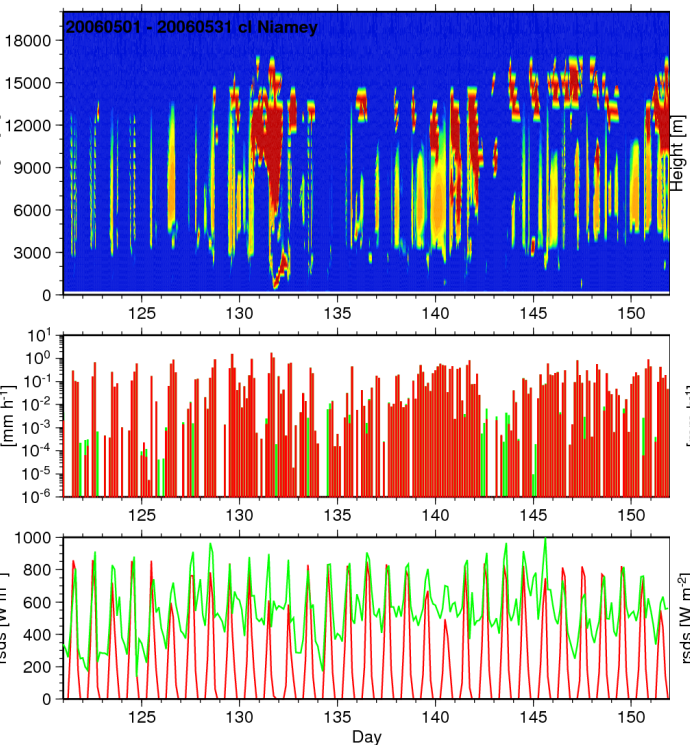
AMF measurements
30 mn averaged

Isolated cv system,
few rain event
Mid-level + Cirrus

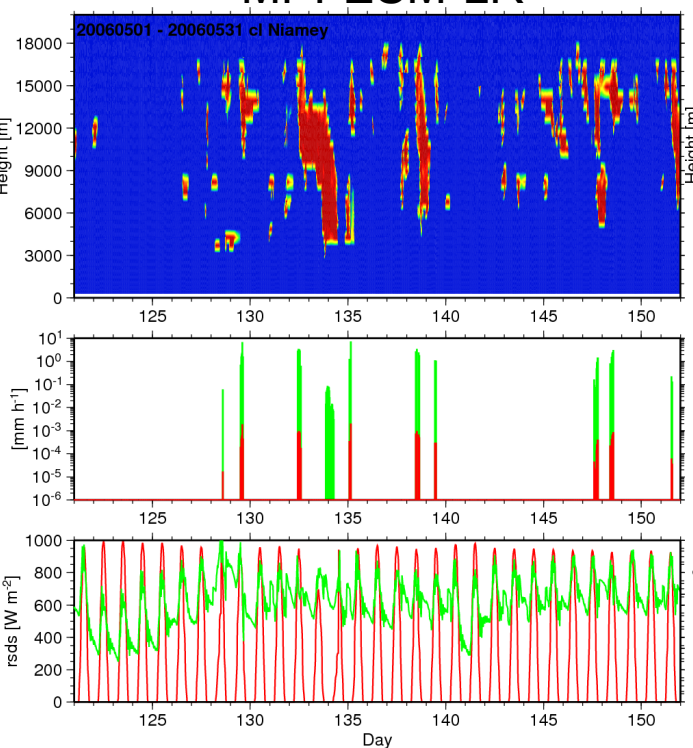
The relative good monthly agreement results from very different time series



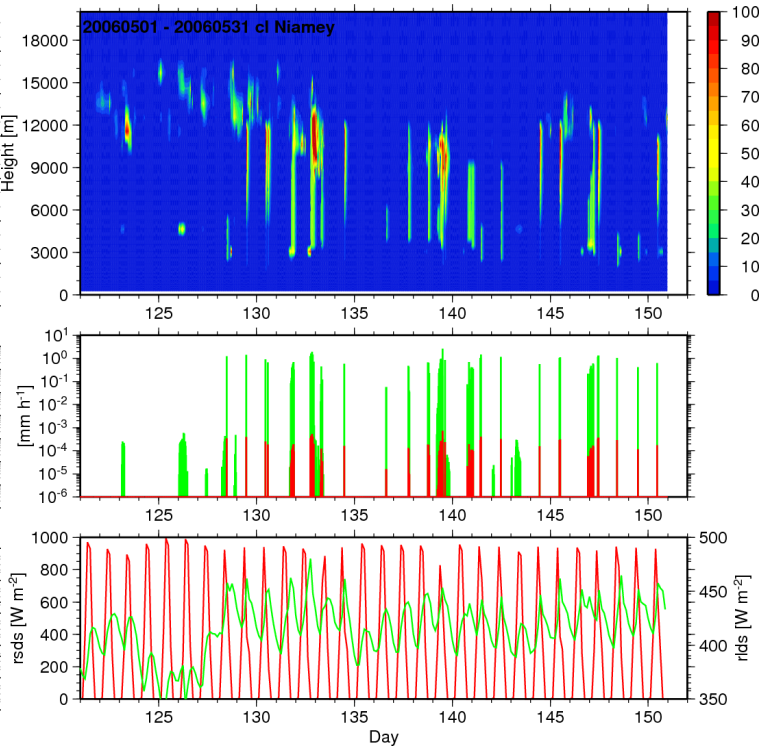
CNRM-CM5



MPI-ESM-LR



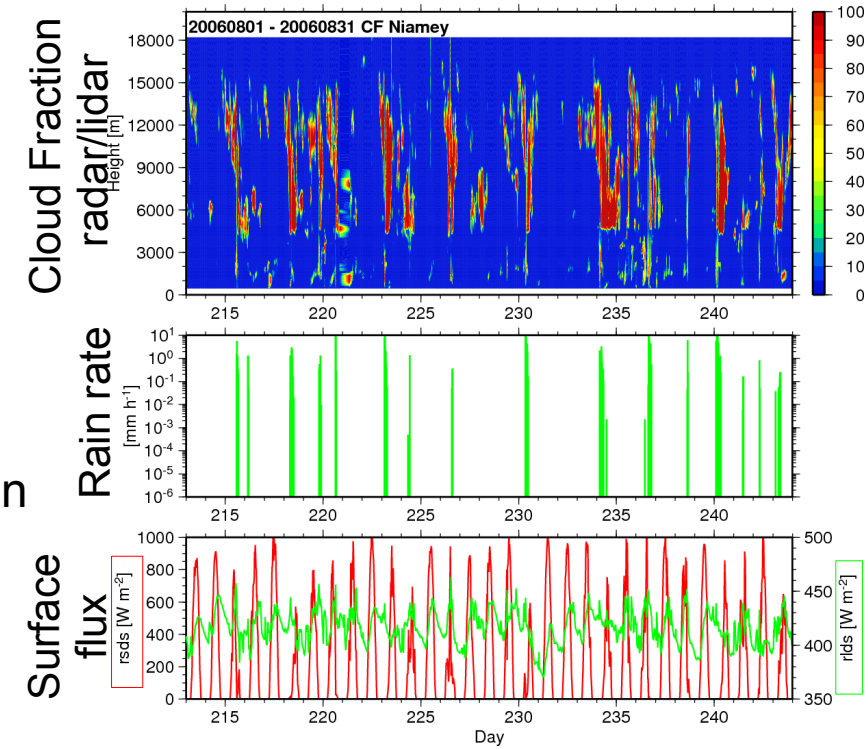
HadGEM2-A



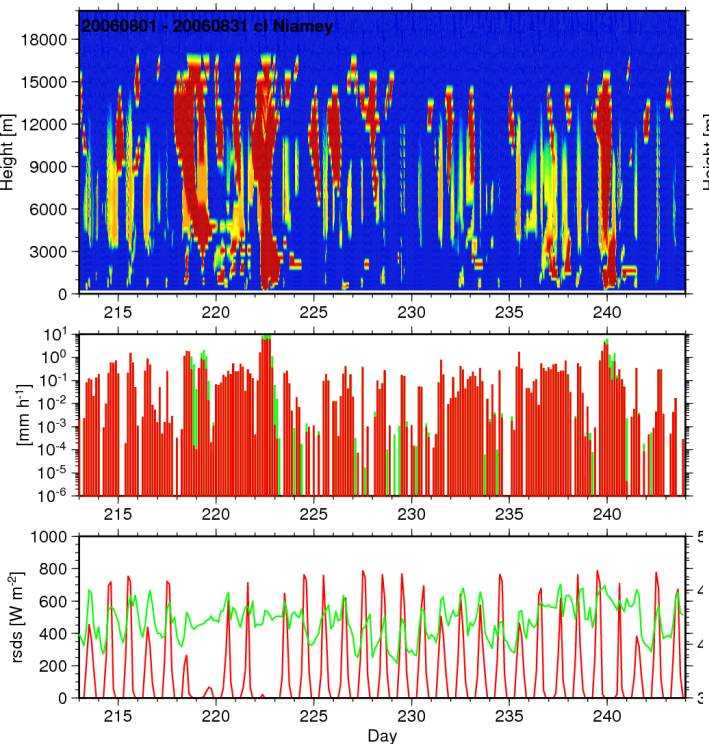
At smaller temporal scale : Niamey
August = monsoon

AMF measurements
30 mn averaged

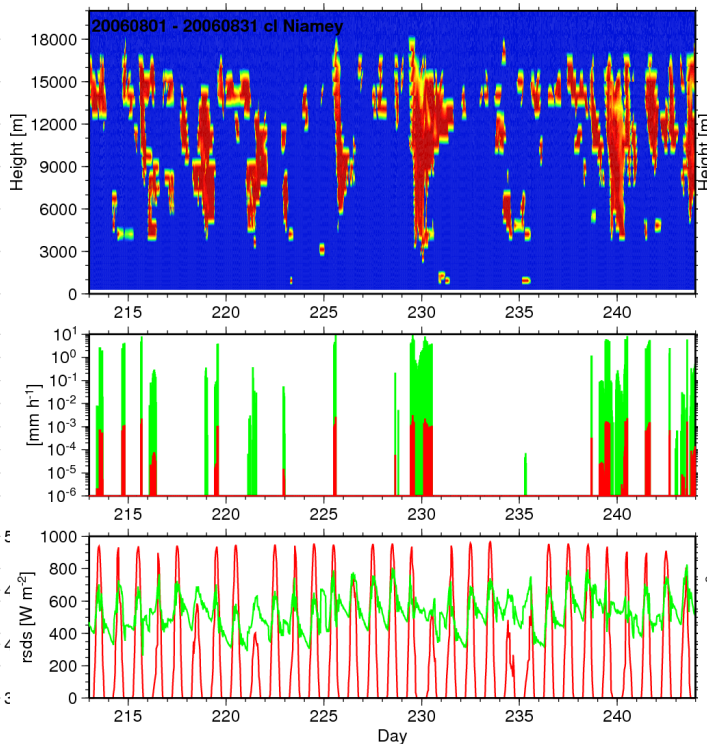
Rain associated with
cv system
~ 10 events
+ other cloud types (in particular low-level)



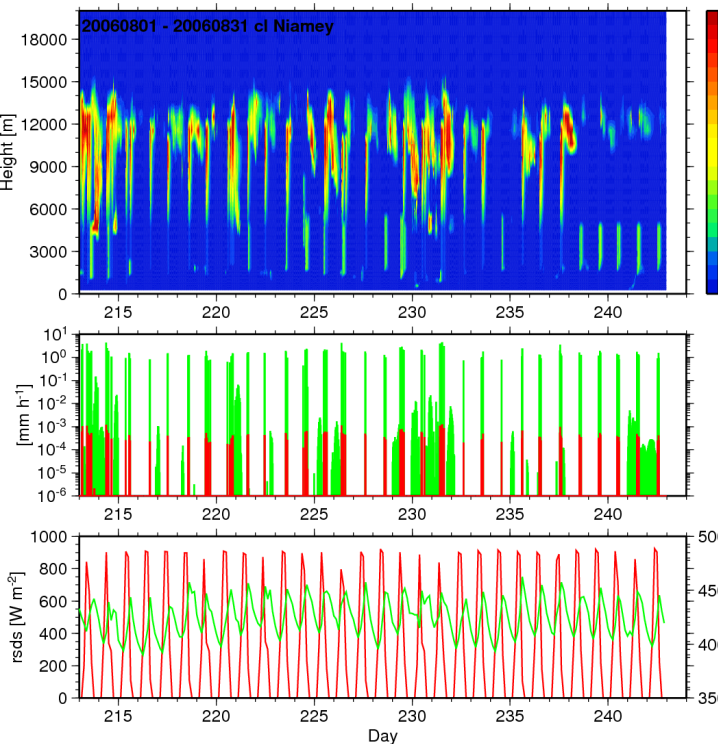
CNRM-CM5



MPI-ESM-LR



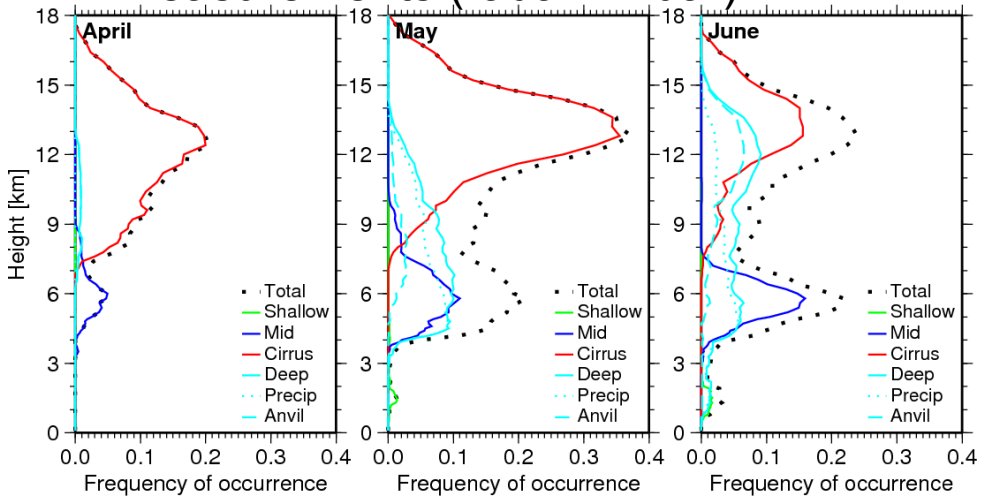
HadGEM2-A



Separation by cloud types : pre-monsoon

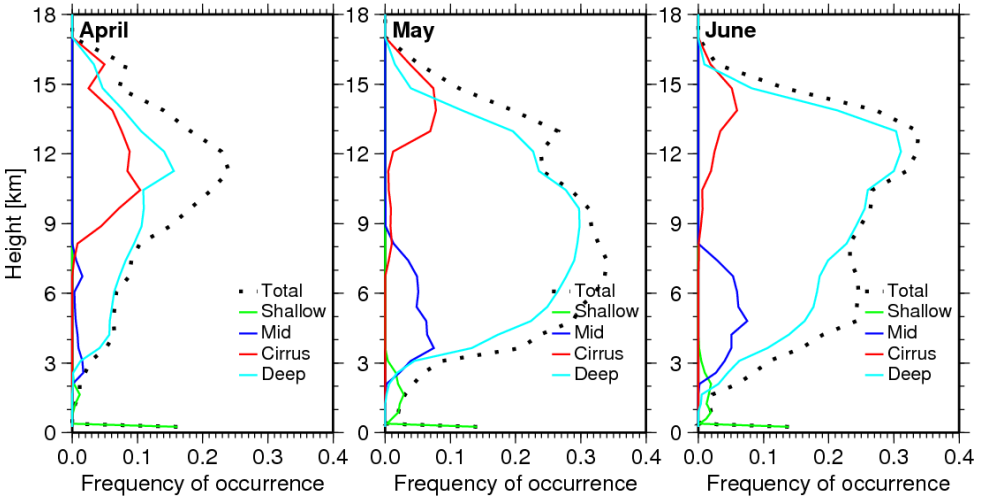
4 main categories (Bouniol *et al.*, JAMC 2012) :
Low-level : base < 2km + no deeper than 3.5 km
Mid-level : 2.5 < base < 7 km + top < 8km
Cirrus : base > 7 km
Cv : base < 8 km, top > 5 km, deeper than 5 km + continuity

AMF measurements (radar + lidar)

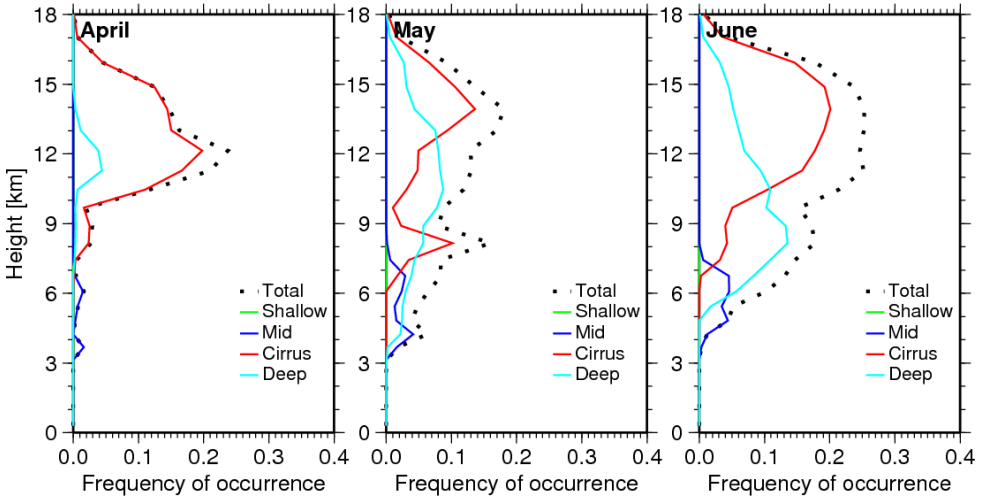


All models have mid-level clouds + cirrus (not numerous enough)
HadGEM2-A & CNRM-CM5 have deep cv clouds all the year long

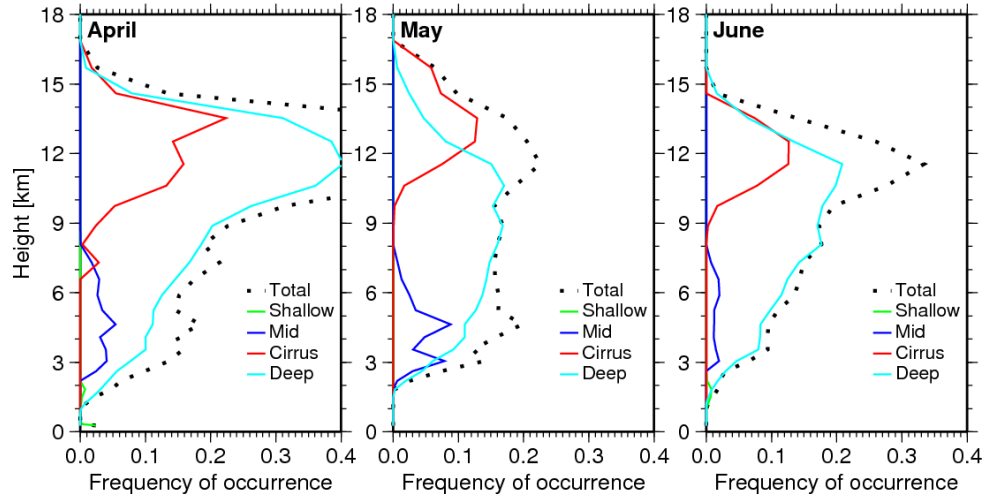
CNRM-CM5



MPI-ESM-LR

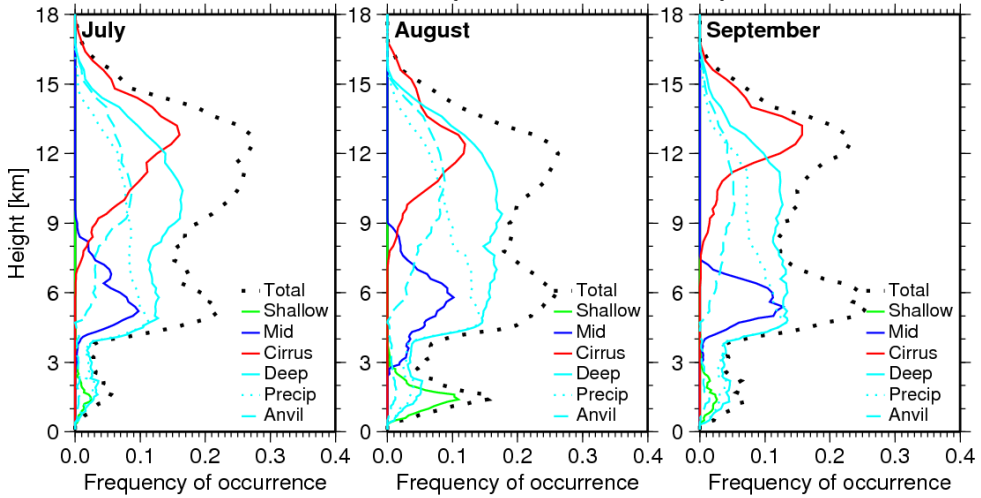


HadGEM2-A

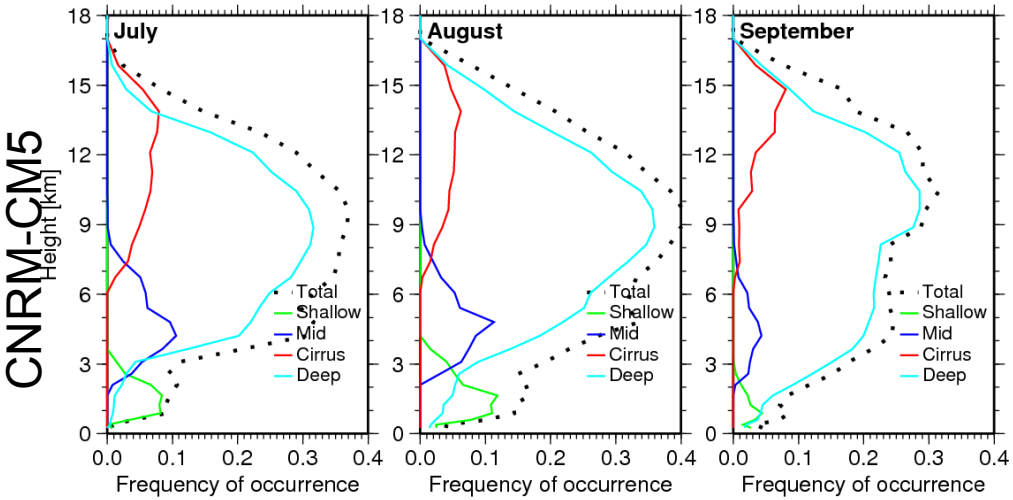


Separation by cloud types : monsoon

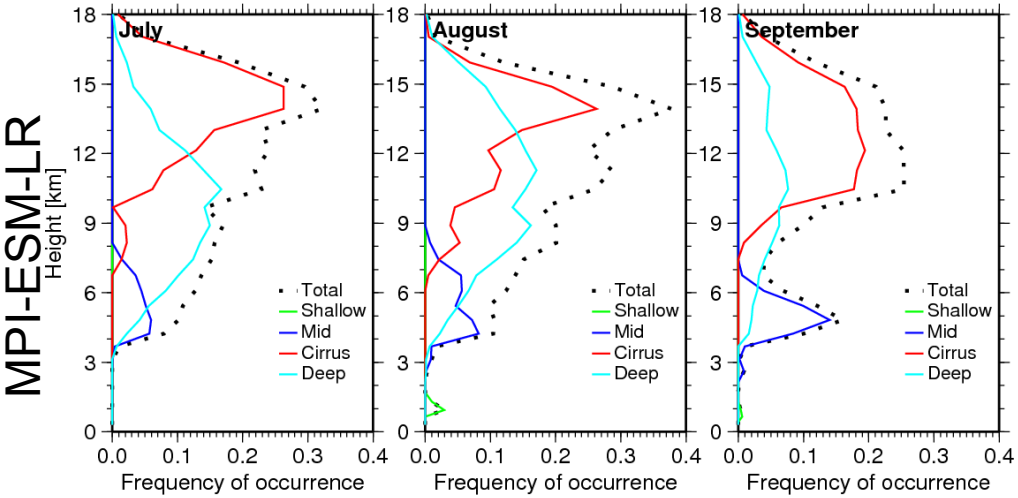
AMF measurements (radar + lidar)



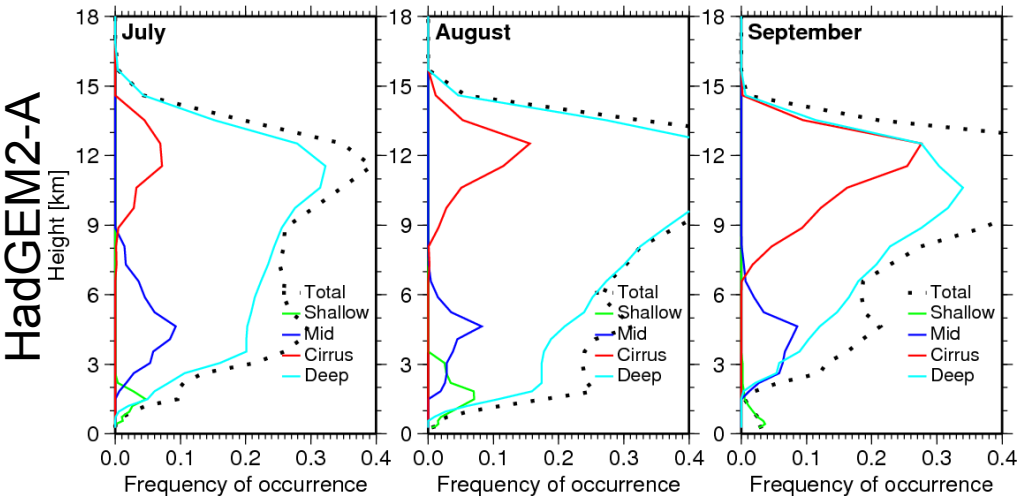
CNRM-CM5



MPI-ESM-LR



HadGEM2-A



Relatively good occurrence of cirrus & mid-level clouds for all models

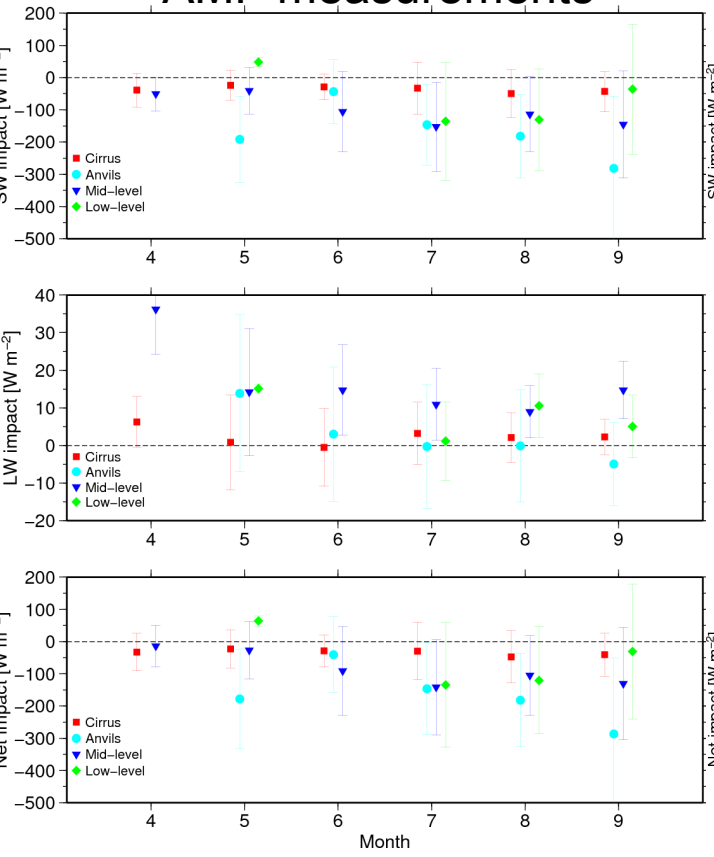
HadGEM2-A & CNRM-CM5 :

- too strong cv occurrence (too low CF)
- relatively good occurrence for low-level clouds

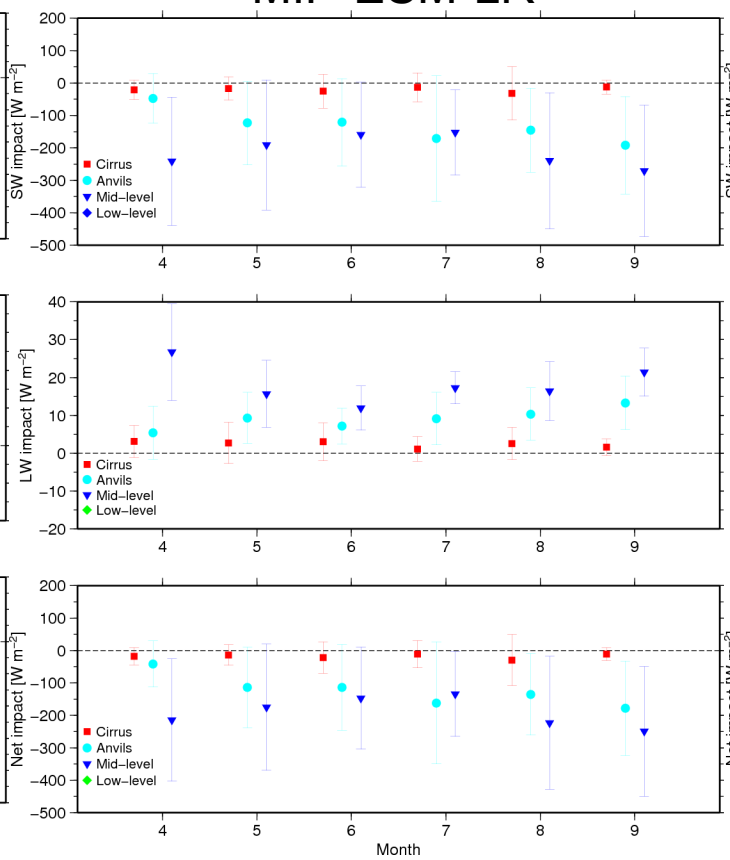
MPI-ESM-LR misses a lot of low-level clouds

Cloud radiative effect by cloud types at the surface

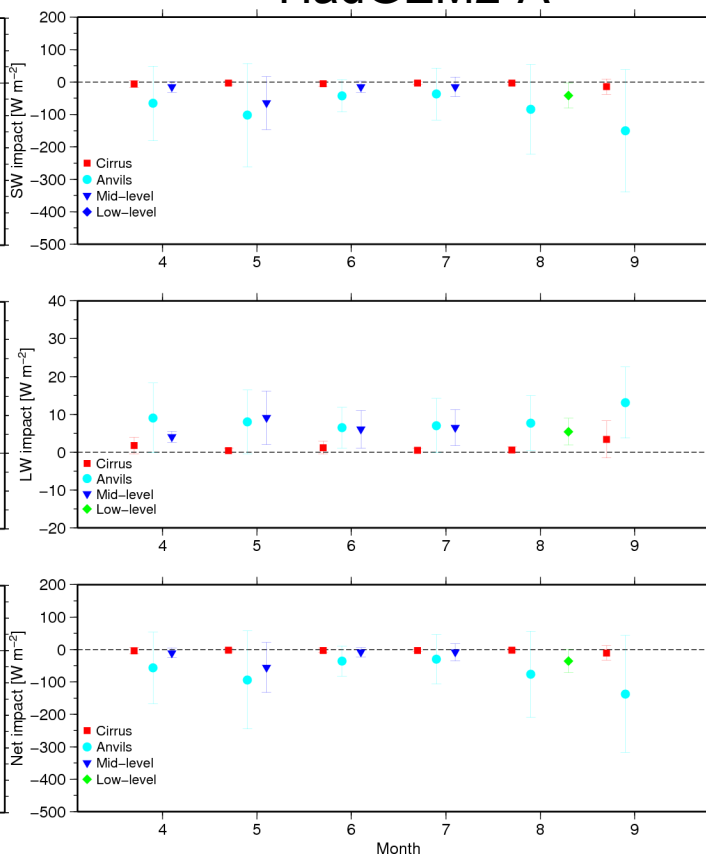
AMF measurements



MIP-ESM-LR



HadGEM2-A



Emperical estimations (Bouniol et al., JAMC 2012) that will be refined in a near future see O. Geoffroy poster

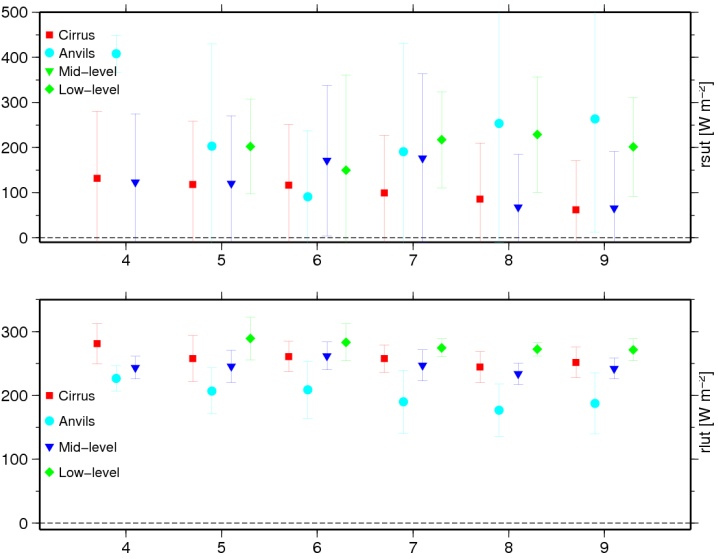
Larger impact of anvils and mid-level clouds

Good order of magnitude for CRE , but too large for mid-level (too low in the model => water/ice partition ?)

Net CRE not large enough because of too large SW↓ : too low CF ?

Fluxes by cloud types at the TOA

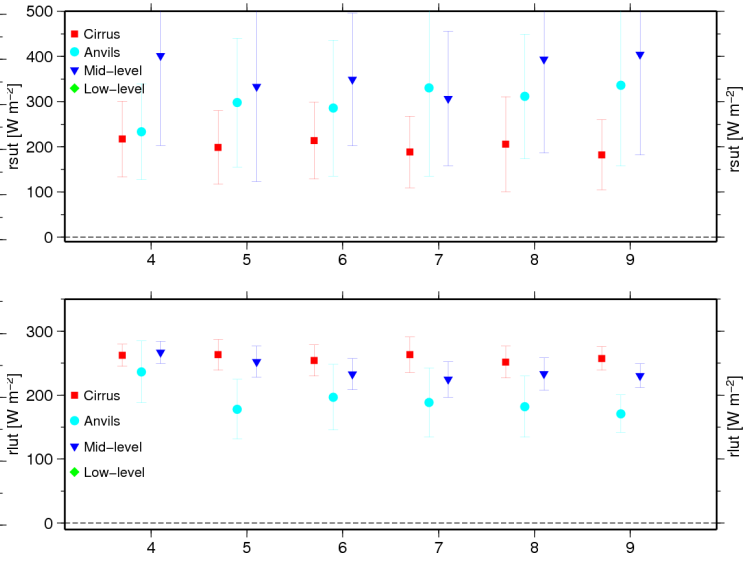
GERB + AMF measurements



Smallest OLR for anvils and large SW↑ as well as for low-level

OLR of the same order of magnitude for mid-level and cirrus

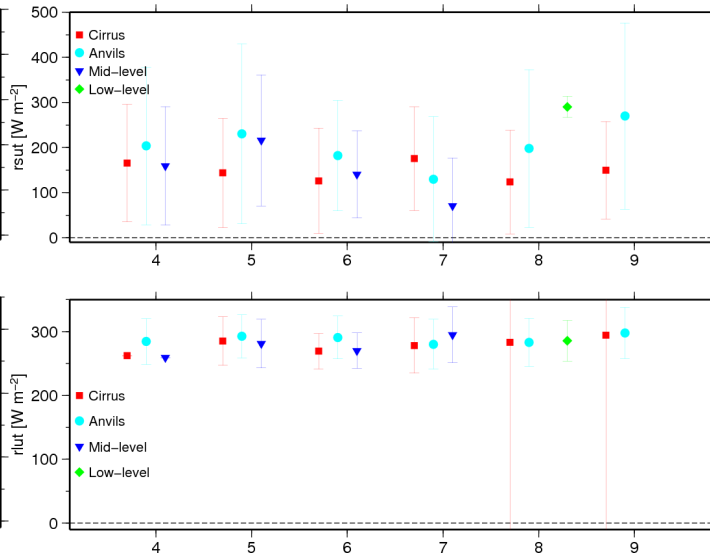
MPI-ESM-LR



Too large SW↑, in particular for mid-level

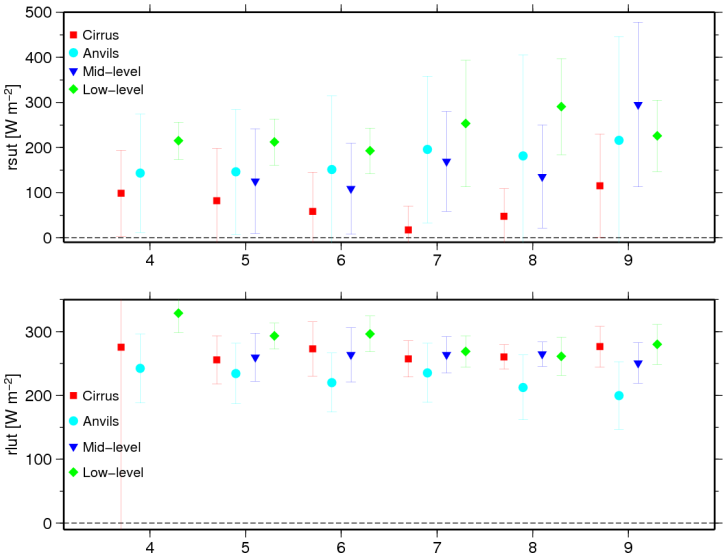
OLR in good agreement with obs.

HadGEM2-A



OLR too strong for anvils

CNRM-CM5



Good agreement with observations for all cloud types

Summary

- All the models display the broad African Monsoon general features (dynamics, Monsoon jump, precipitations)
-Differences exist in term of cloud cover, even if the main cloud area moves well northward

When zooming to the sites:
- Very different answers of the cloud parameterizations (CF distributions, nb of events)
  Some models (CNRM, Had) with clouds near all the time but with low CF
  Difficulty in generating low levels clouds (in particular MPI over land, CNRM over the ocean)

- Very different CRE in SW and LW incoming at the surface by cloud type and by model (altitude/CF/microphysics)

- At TOA : very different answers depending of the cloud type that model are not all able to reproduce => on average compensating effect (SW-MPI) / cumulative effect (LW - HadGEM)

Future work

- Systematically extend the documentation to all the EUCLIPSE models and all the African points (changes along the transect = different forcing conditions (thermo, surface...))

- Improve the quantification of the CRE in the observations at BOA and TOA (for all the African points) by using radiative transfer calculations (see Olivier Geoffroy poster)