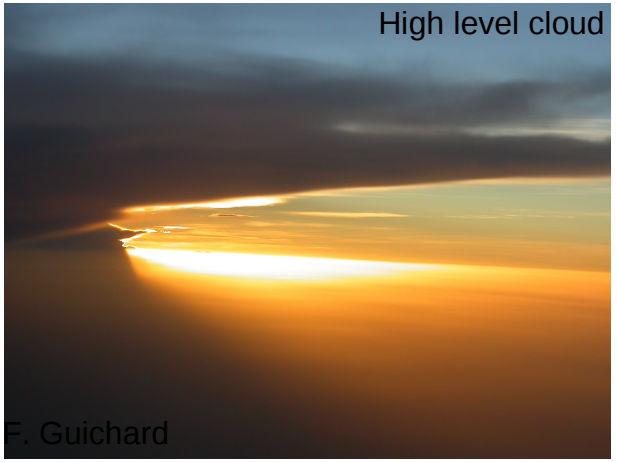
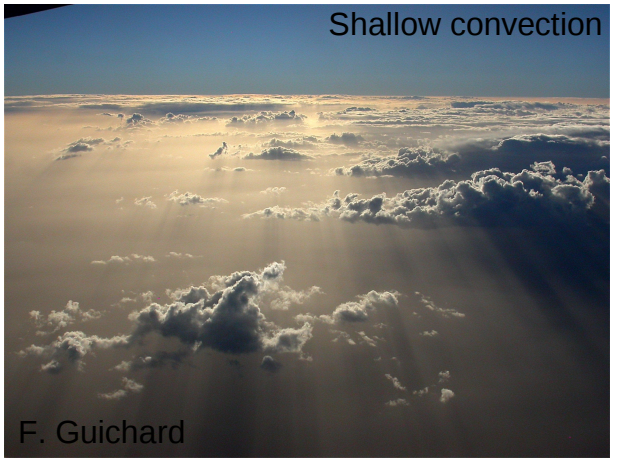
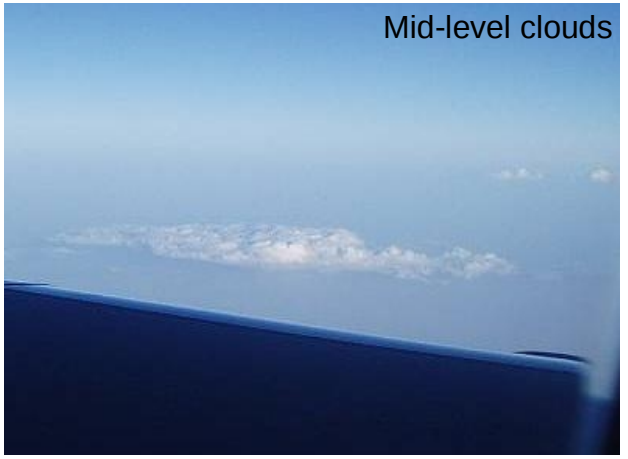






Model evaluation using AMMA data

Dominique Bouniol, Françoise Guichard, Fleur Couvreux

Thanks for their contributions to:

P.-H. Kamsu-Tamo, M. Leplay, E. O'Connor, I. Beau, F. Bouyssel, H. Douville, F. Favot, F. Hourdin, J-M Piriou, B. Pohl, S. Tyteca

Why West Africa ?

Continental/tropical region:

- Not only MCS !
- Highly coupled system: Cloud/Radiations/Surface processes
- Importance of clouds in the water cycle
- Clouds feedbacks are expected on large scale dynamics, atmospheric chemistry, surface processes...
- Very few constraints exists in models for this region

Unprecedent data base (ground-based and spaceborne measurements)

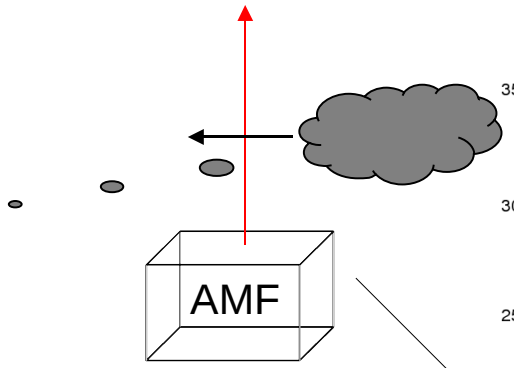
- Documentation up to the continental scale
- Several time scales

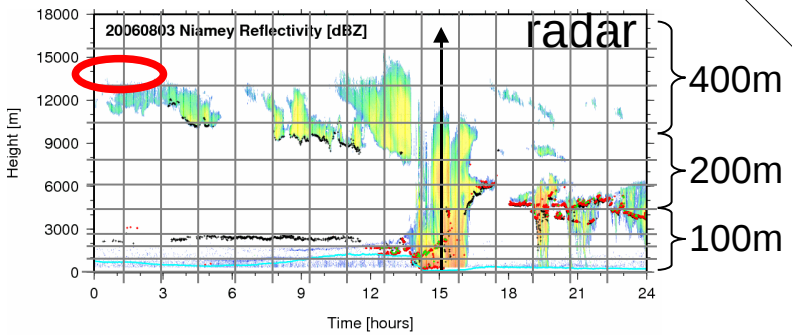
- Cloud cover documentation within West-Africa and its temporal evolution
- Evaluation of cloud representation within models
- Evaluation of cloud radiative impact

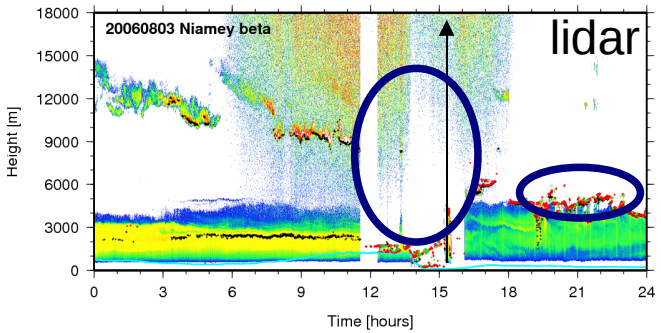
Data sets

ARM Mobile Facility

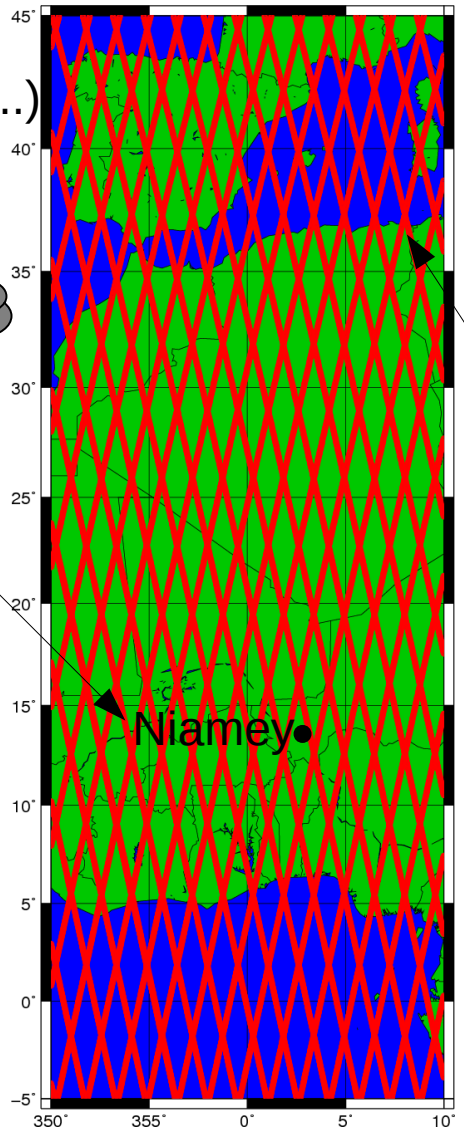
Continuous ground-based measurements of cloud properties (radar+lidar verticaly sampling)
+ additional measurements (RS, flux...)
April-september 2006





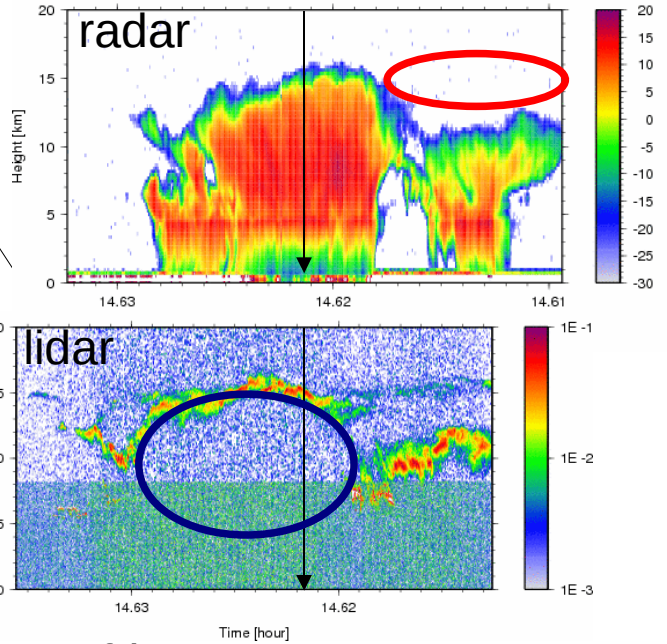


Résolution:30 mn x (100/200/400 m)



A-Train (CloudSat/CALIPSO)

Spaceborne measurements lof cloud properties
(radar+lidar verticaly sampling)
Sampling twice a day ~ 1h30, 13h30 LT
Since April 2006



West Africa transect:
10W/10E -5N/45N
Resolution: 0.5° x 500 m

2 strategies:
Documentation/Evaluation
- time series at Niamey and ground fluxes stations
- in transect (no zonal variability)

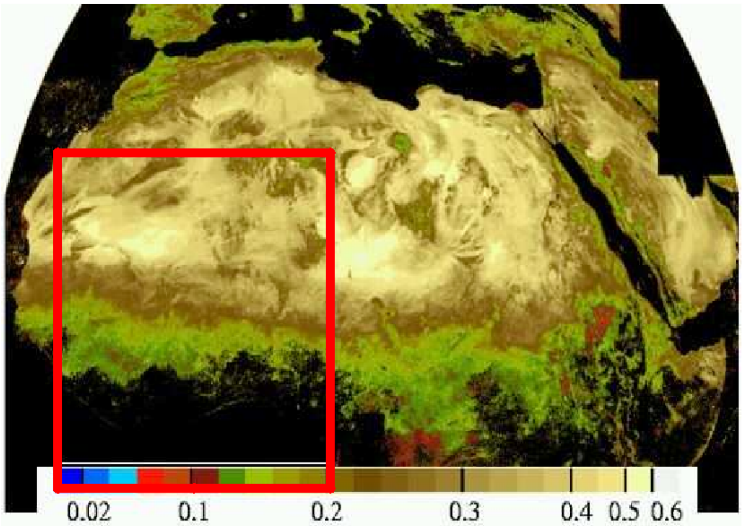
AMMA MIP Transect

(model intercomparison project)

Hourdin et al. (BAMS 2010)

"A meridional cross-section analysis provides the framework to assess regional and global model skill at simulating seasonal and intraseasonal variations of the West African monsoon, and thus mechanisms for the region's rainfall."

albedo , source EUMETSAT/GEM

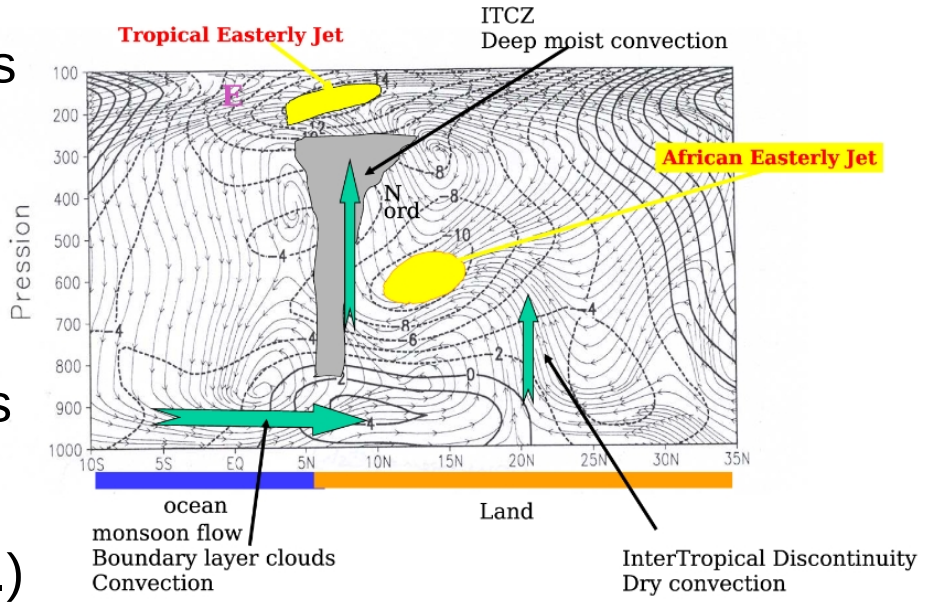


- Motivated by well defined meridional structures over West Africa (surface & atmosphere)

- In the spirit of EUROCS Pacific cross section (Siebesma et al 2004)

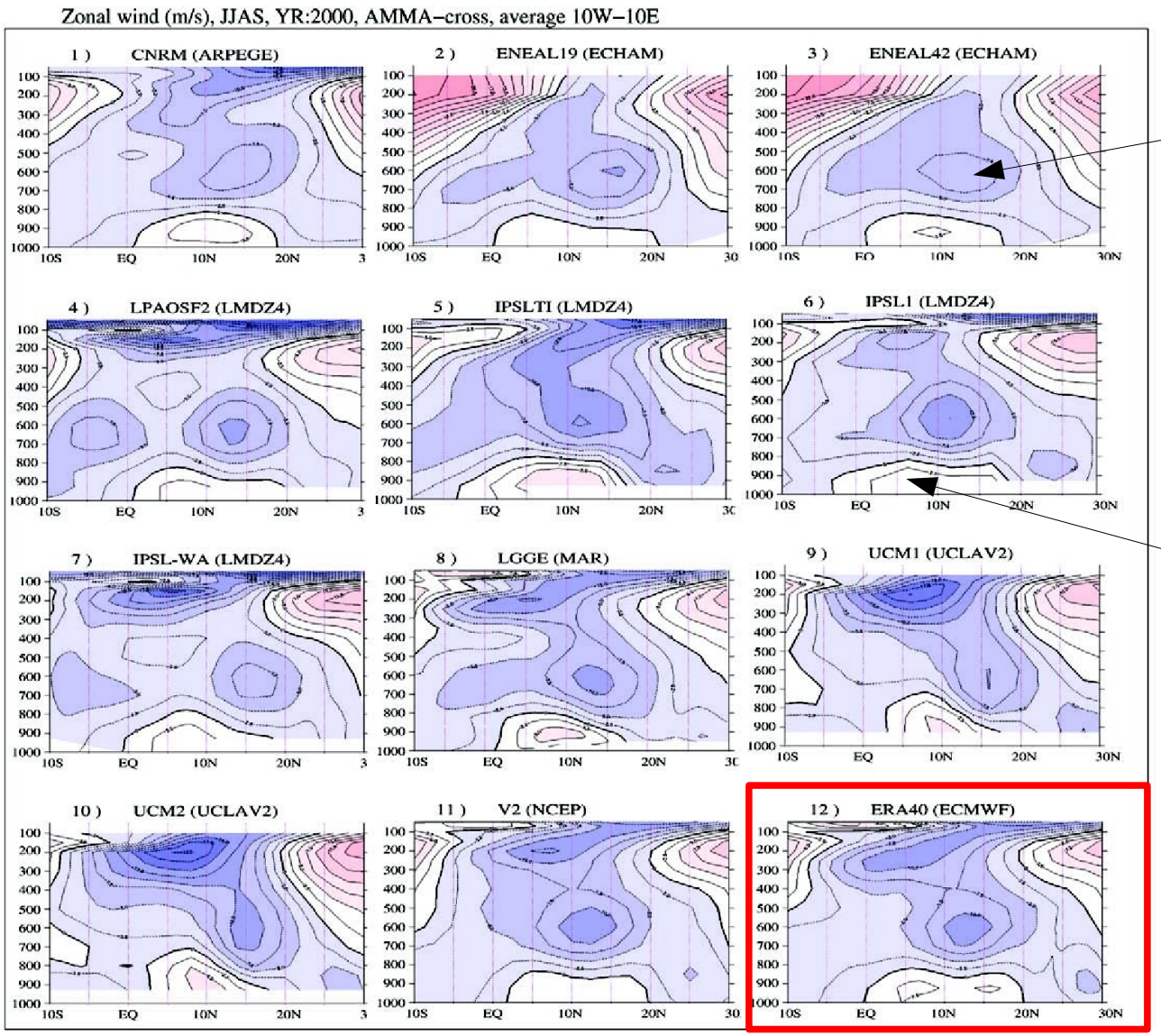
- A light framework for evaluating GCMs, RCMs
  SST prescribed, a few years only

- Ongoing work (phase 2: AMMA data, param...)



Institute	CNRM	ENEA	UCM	IPSL	IPSLTI	IPSLWA	LPAOSF	LGGE
Model	ARPEGE	ECHAM4	UCLA7.3	LMDZ4	LMDZ4	LMDZ4	LMDZ4	MAR
Specificity	Climate version	2 vertical resolutions	Ensemble (10)	Ensemble (5)	convection Tiedtke Emanuel	Zoom West Africa	Zoom West Africa	LAM

ZONAL WIND (latitude, height) in GCMs and reanalyses [JJAS mean]



All GCMs simulate an African easterly jet in Summer

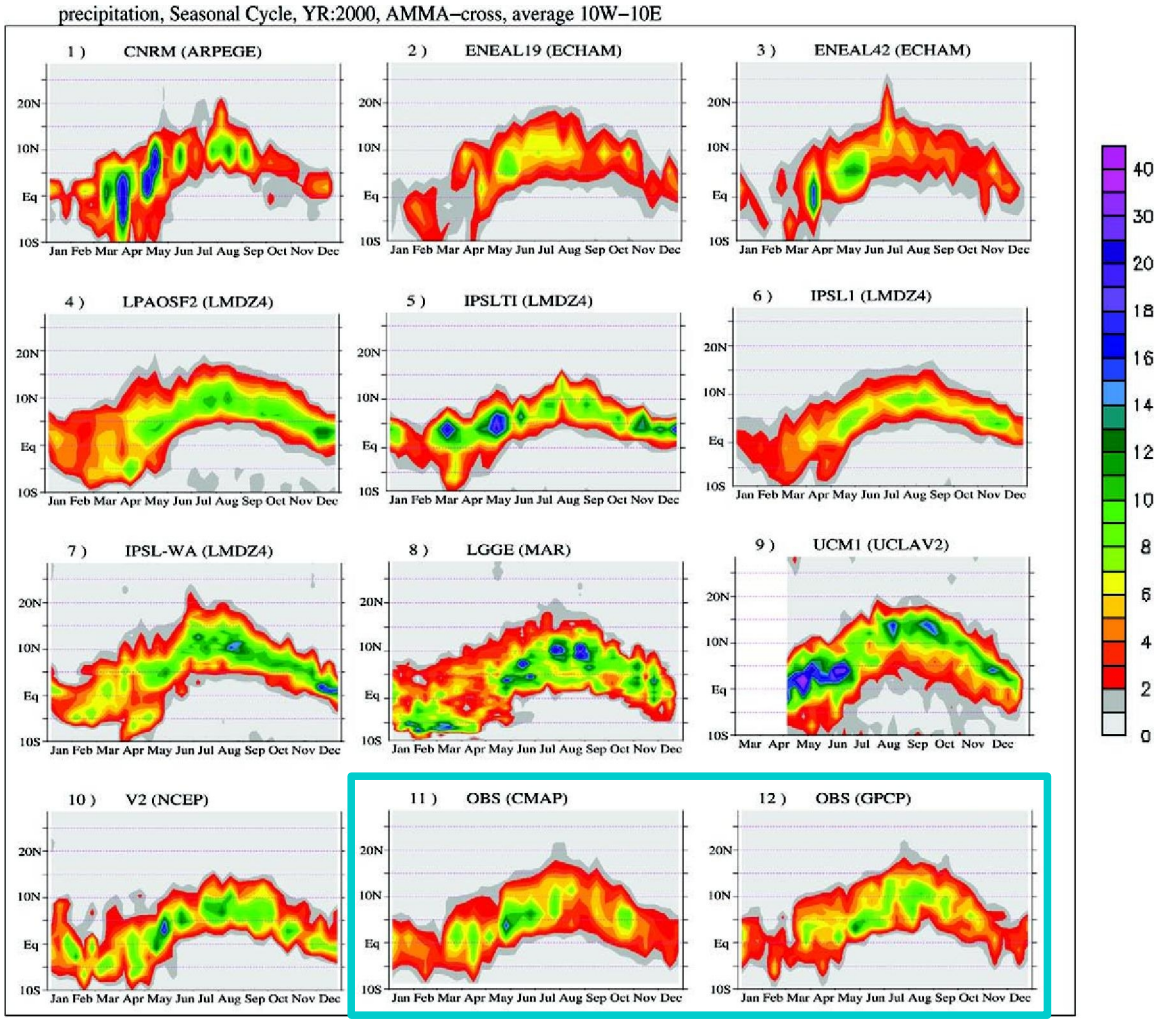
however...

- varied strength & location (lat, z)

- monsoon flow : low-level flow; issue in NWPs as well

ERA40

PRECIPITATION (time,latitude) in GCMs, reanalyses & satellite products



CMAP GPCP

All GCMs simulate a summer northward migration of rainfall

however...

- *rainfall amount quite varied*
- *intraseasonal variations more or less pronounced*
- *ITCZ location & width differ*
- *NWP not really better*

most existing studies focused on large-scale dynamics and rainfall only
not much studies / considerations of physical processes & feedbacks

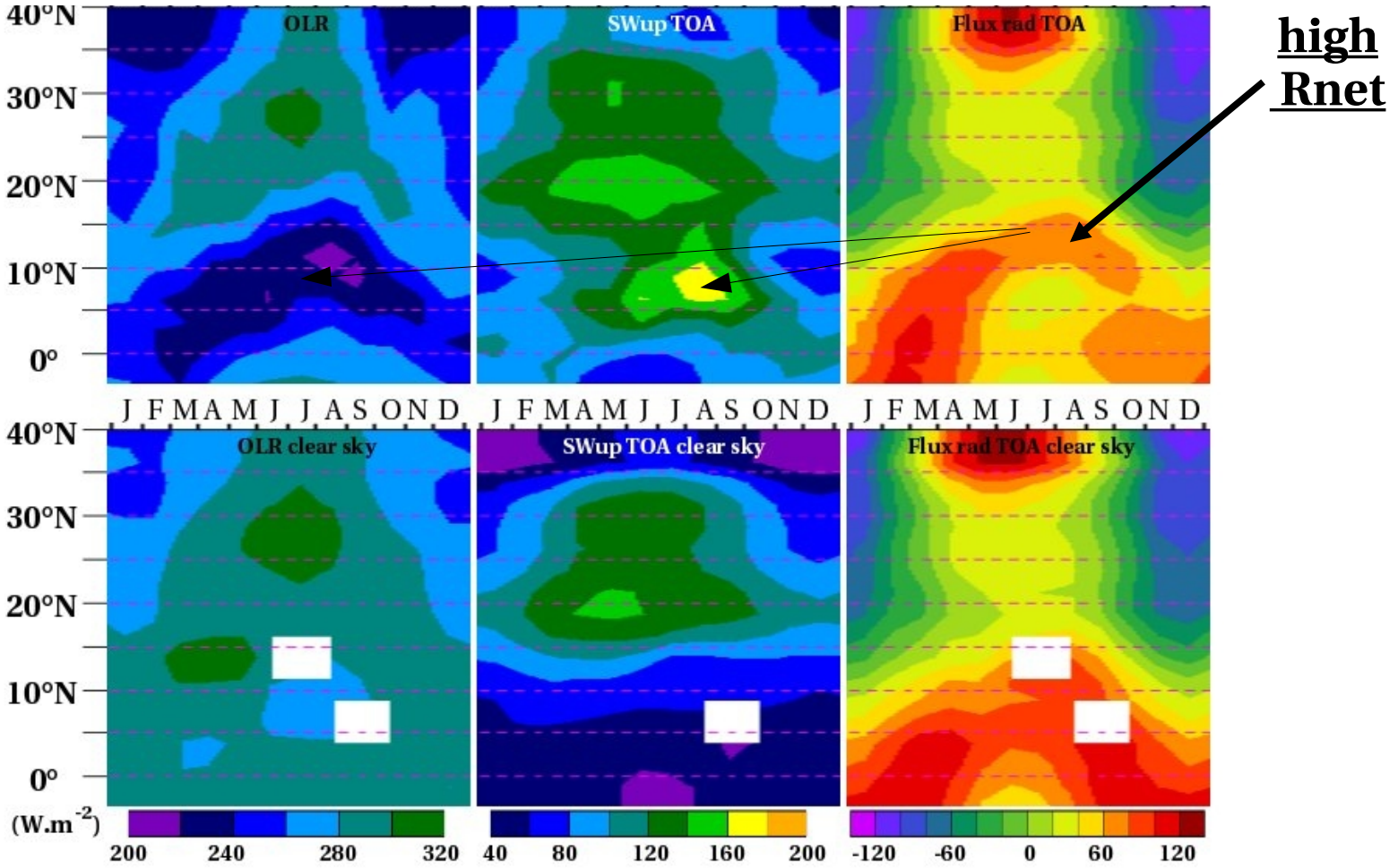
TOA RADIATIVE FLUX : Rnet = SW↓ – SW↑ – OLR

(CERES TERRA monthly mean, 2003)

OLR **SWup** **Rnet (net radiation)**

ESTIMATES

CLEAR SKY ESTIMATES



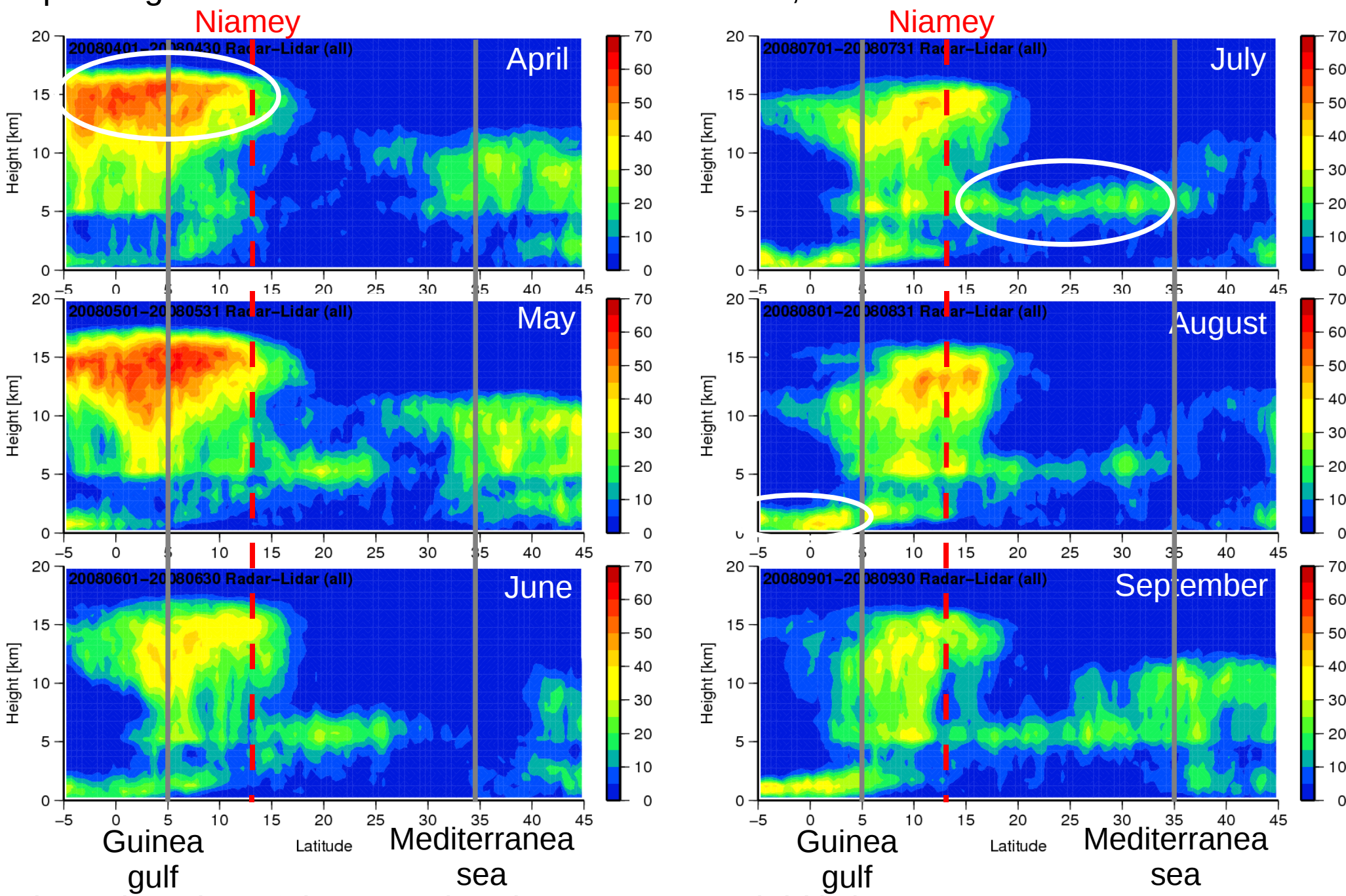
well defined structure of TOA net radiative flux: seasonal cycle, surface (desert) but not only...

a tongue of **high Rnet** *emerges, migrates northward in the Sahel (10-15°N) during the monsoon* ***shaped by the structure of cloud radiative impact*** *(Rnet TOA ~ energy input atmos. column)*

..... is this feature reproduced by models ? (preliminary answer: not so well)

Seasonal evolution at the West-Africa scale (2008)

Compositing the CloudSat and CALIPSO data => CF, cloud occurrence



Northward motion of the ITCZ (low inter-annual variability)

Not only deep convection, mid-level clouds are extending over the Sahara

Within models...

NWP => day to day comparison

ECMWF : 91 vertical levels Agusti-Panareda et al. (2009)
analyses (25 km), reanalyses (40 km), forecast (12h->36h)

ARPEGE : Arpege_2006 forecast (6h->30h) T538 60 vertical levels
stretched grid
Arpege_2008 forecast (0h->24h) T127 31 vertical levels

Climate => statistical comparison

AMMA-MIP for 2000 and 2003 (average 10W-10E) Hourdin et al. (2009)
Arpege_climat : 31 levels, 300 km
LMDZ : 19 levels, 2.5°
LPOASF: IPSL zoomed on West Africa, 150 km
ECHAM4 : 19/42 levels 370 km
LGGE : 40 levels, 40 km

Arpege_climat_2006 : control and nudged runs Polh et al. 2009
31 levels, 300 km
31 levels, 300 km

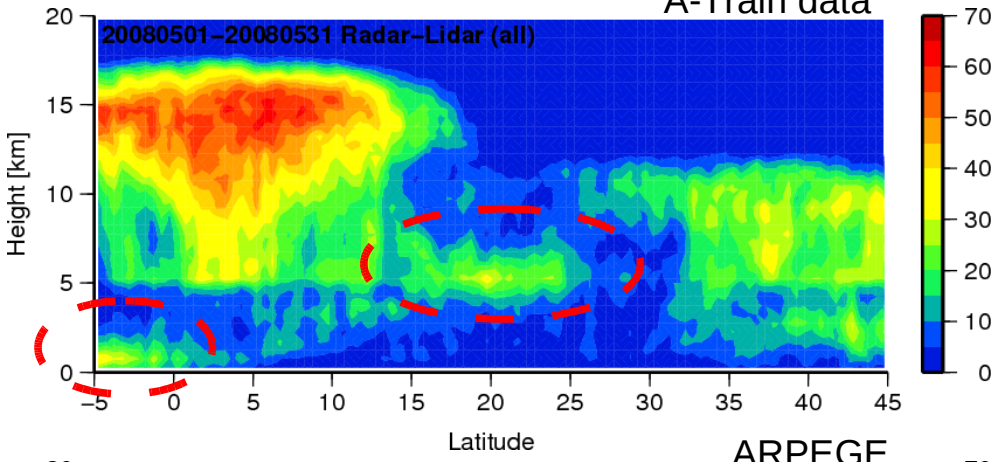
Arpege_climat : pre-run AR5/CMIP5 (AMIP, Transpose_AMIP-Surfex, ...)

Evaluation of the cloud cover at the West Africa scale

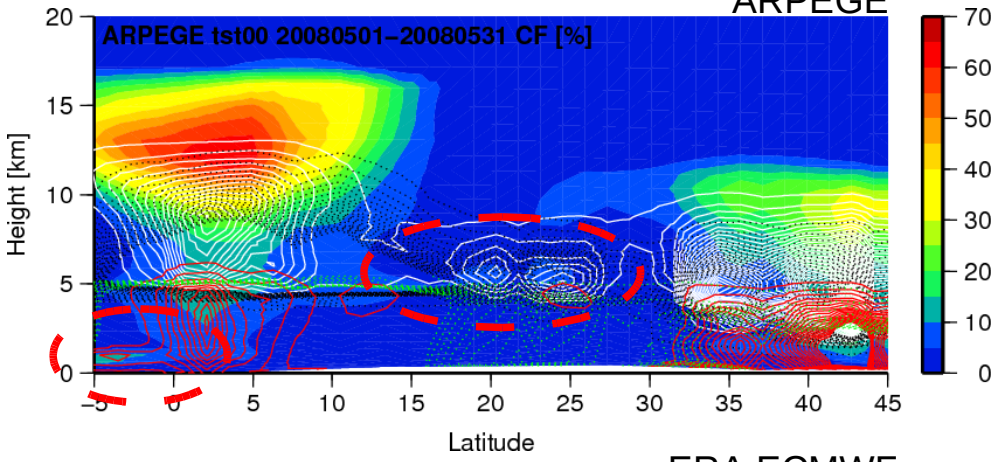
Pre-monsoon

NWP

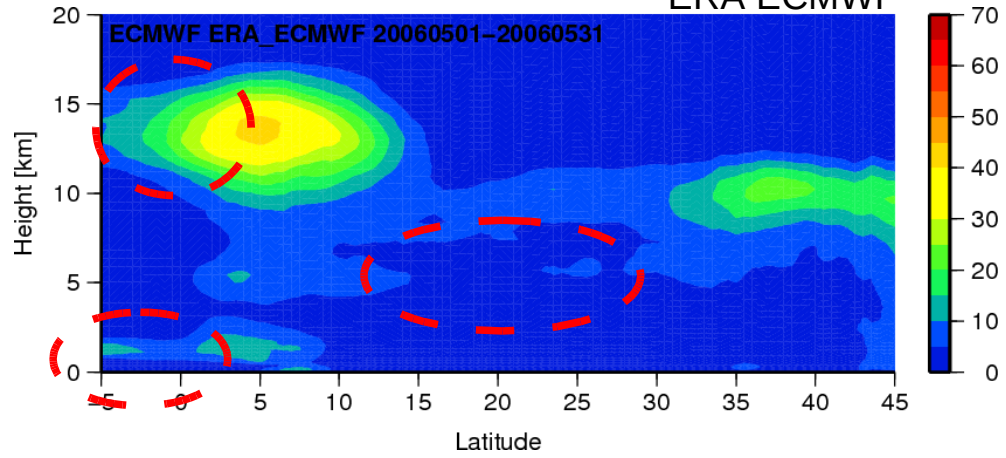
A-Train data



ARPEGE

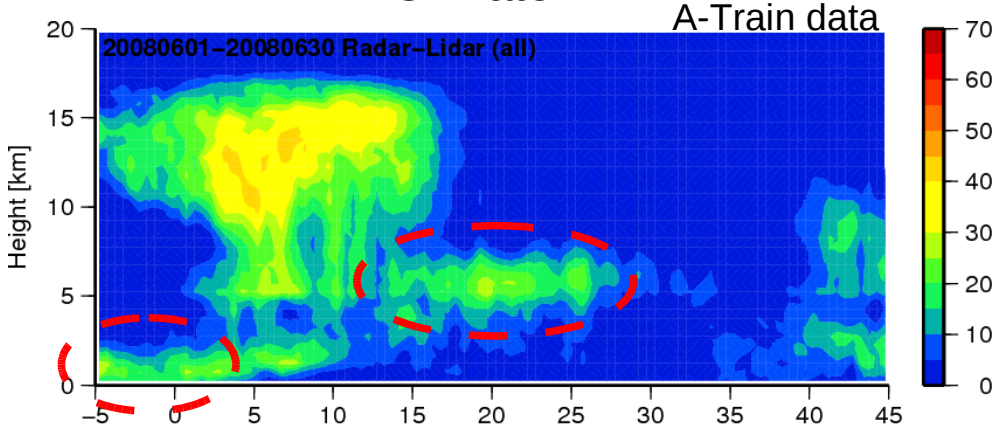


ERA ECMWF

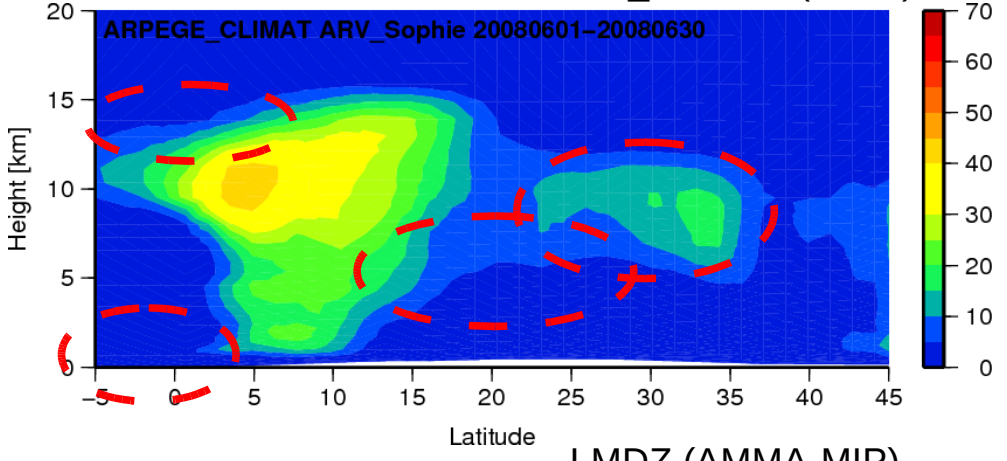


Climate

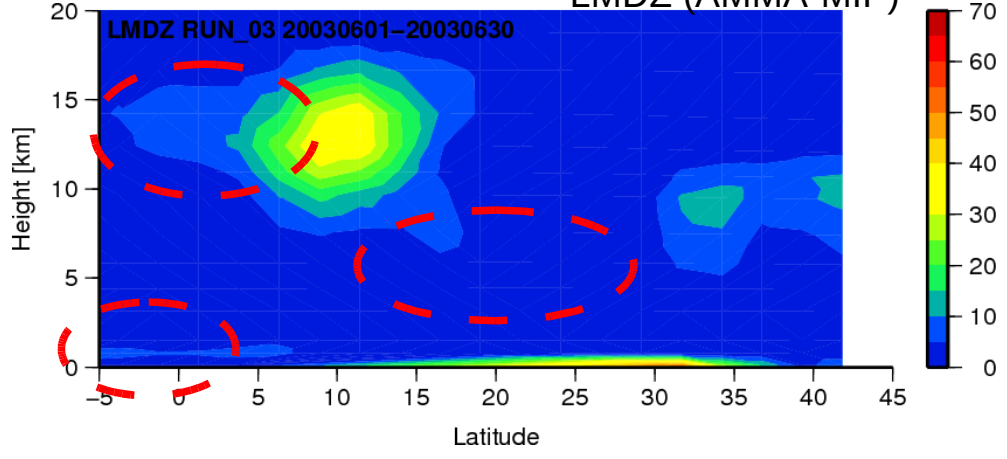
A-Train data



ARPEGE_CLIMAT (AMIP)



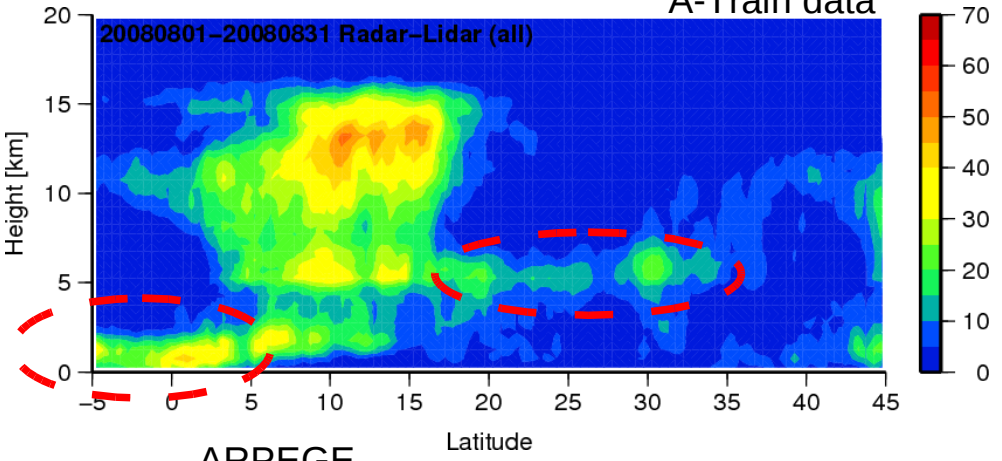
LMDZ (AMMA-MIP)



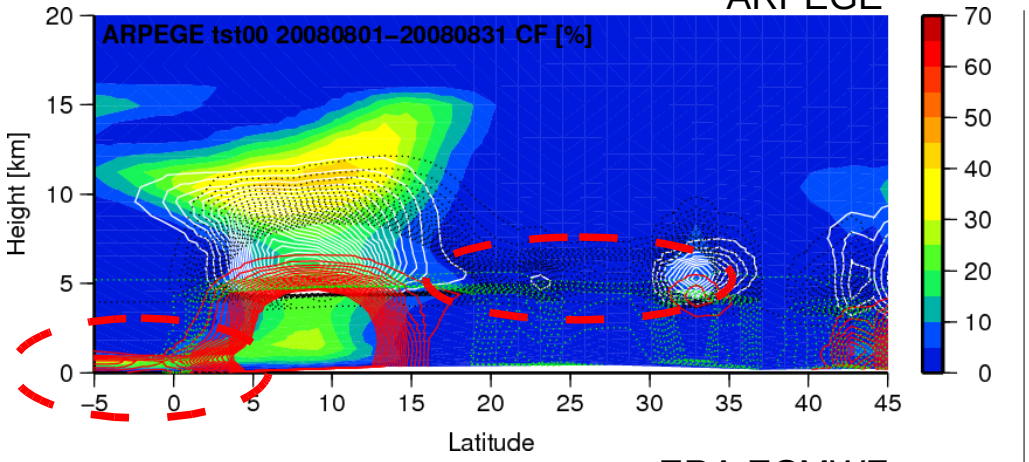
Evaluation of the cloud cover at the West Africa scale

Monsoon

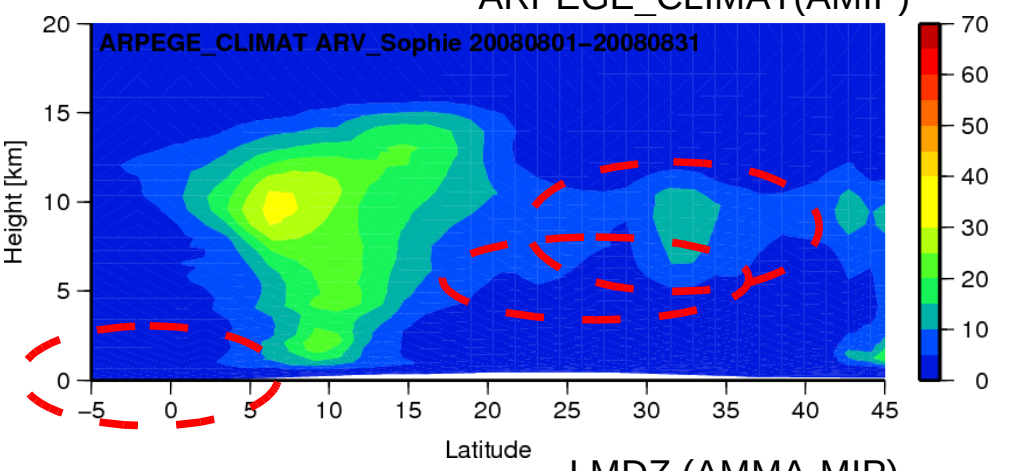
A-Train data



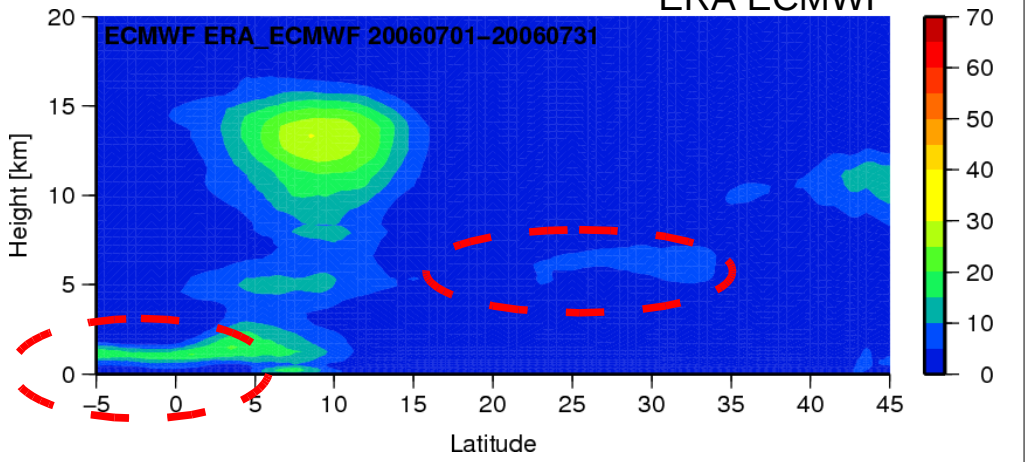
ARPEGE



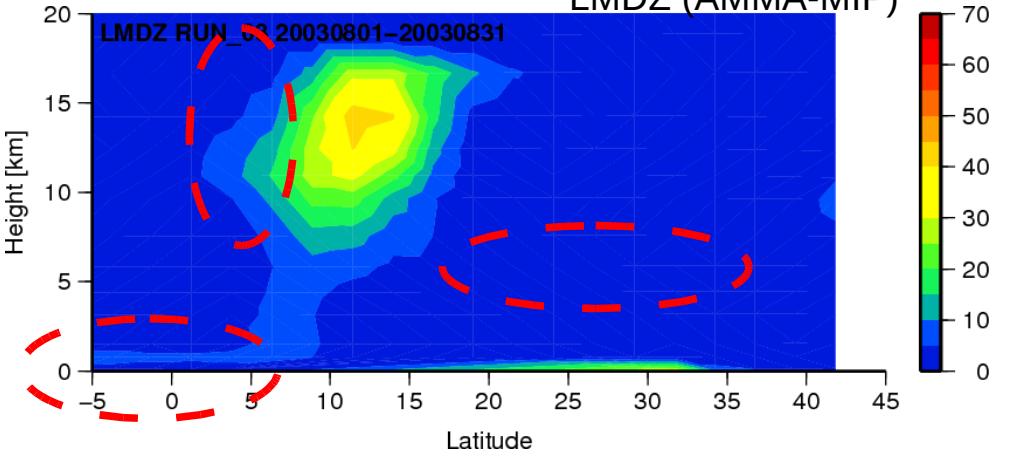
ARPEGE_CLIMAT(AMIP)



ERA ECMWF

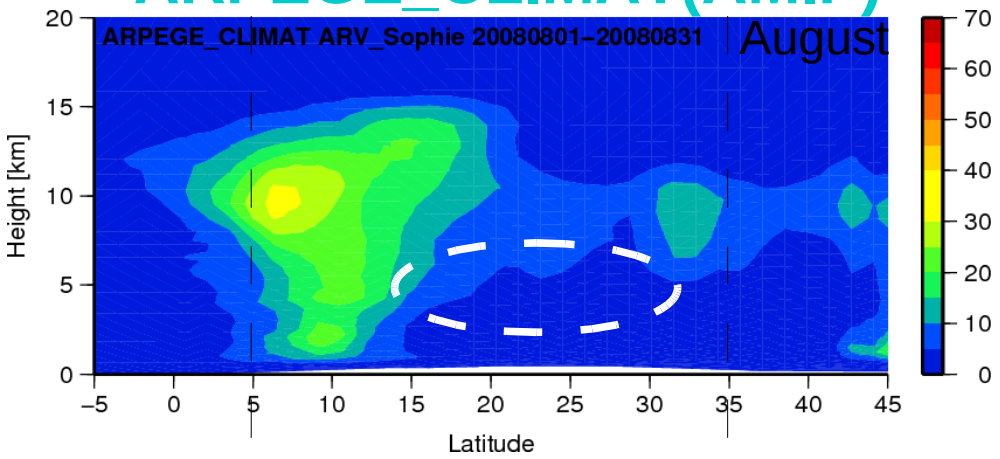


LMDZ (AMMA-MIP)

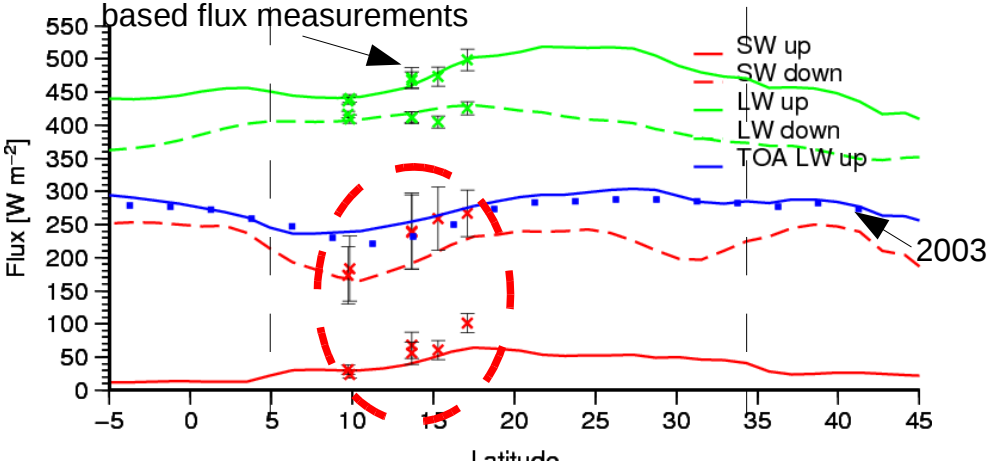


Relationships between cloud cover and radiative fluxes in Climat models

ARPEGE_CLIMAT(AMIP)

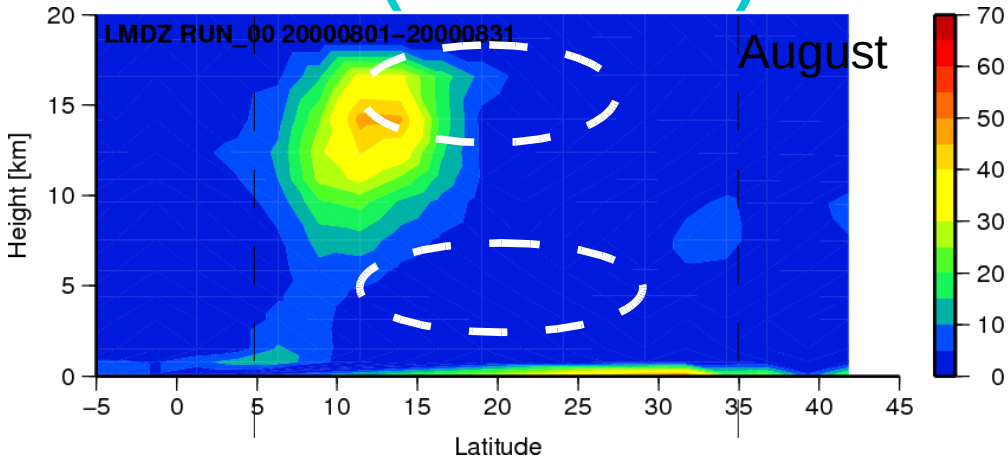


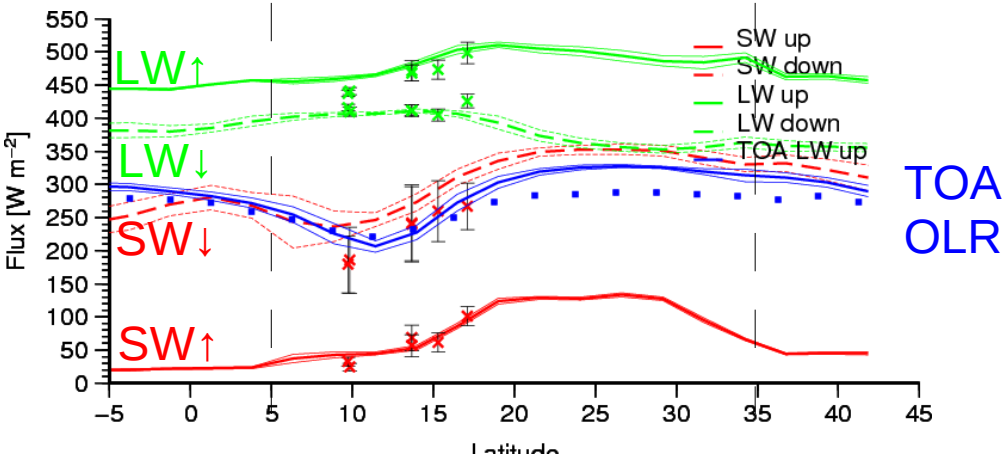
Monthly mean over several years of ground based flux measurements



At the surface good agreement for LW
Strong underestimation of SW (↓ and ↑):
optical properties of mid and low level clouds ?

LMDZ (AMMA-MIP)

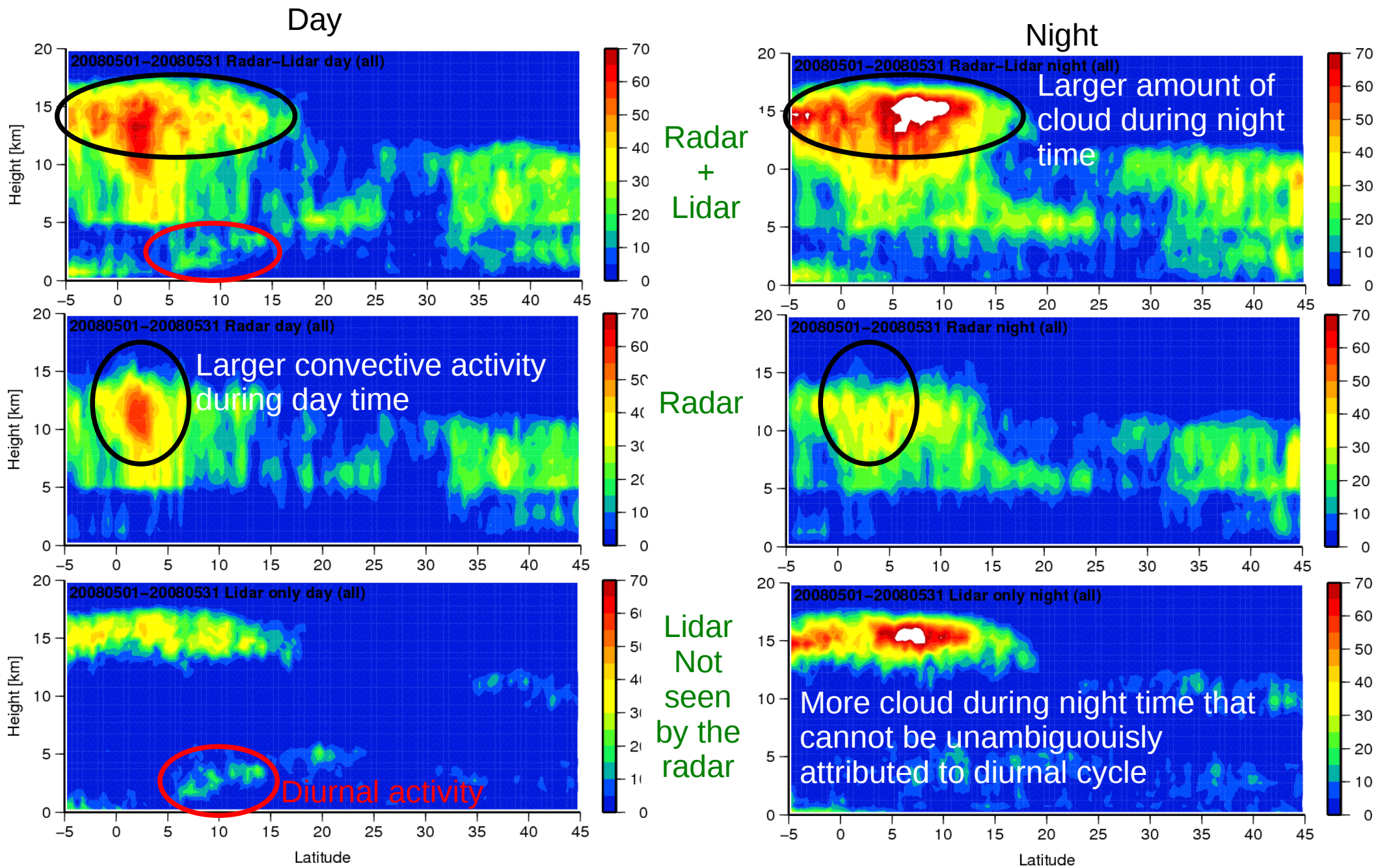




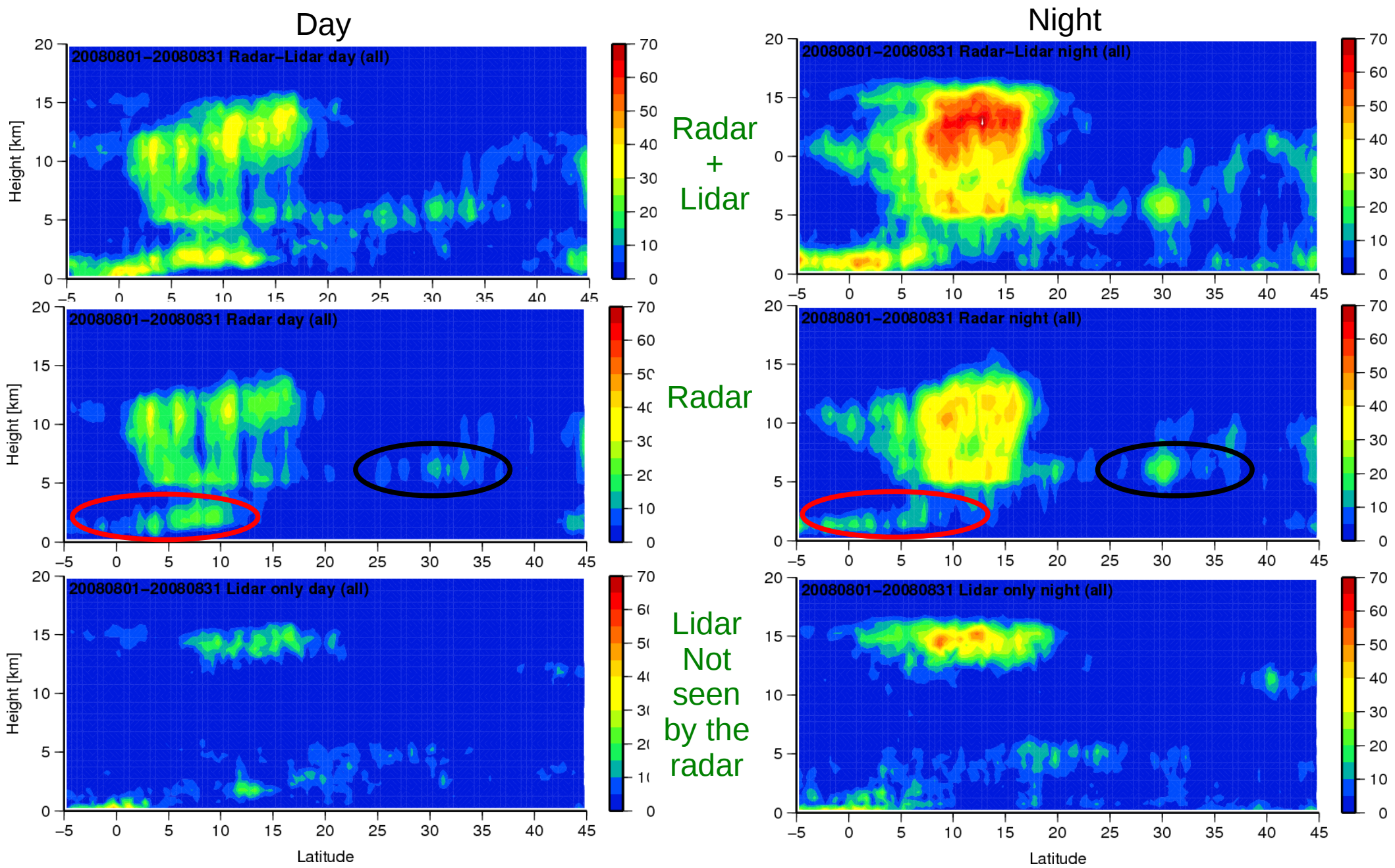
Underestimation of cloud cover =>
overestimation of SW↓
overestimation of TOA OLR
small impact on LW↓

Diurnal cycle from CloudSat/CALIPSO data : May

Radar: same sensitivity day or night time
Lidar: more sensitivity during night time => may bias the observation of the diurnal cycle

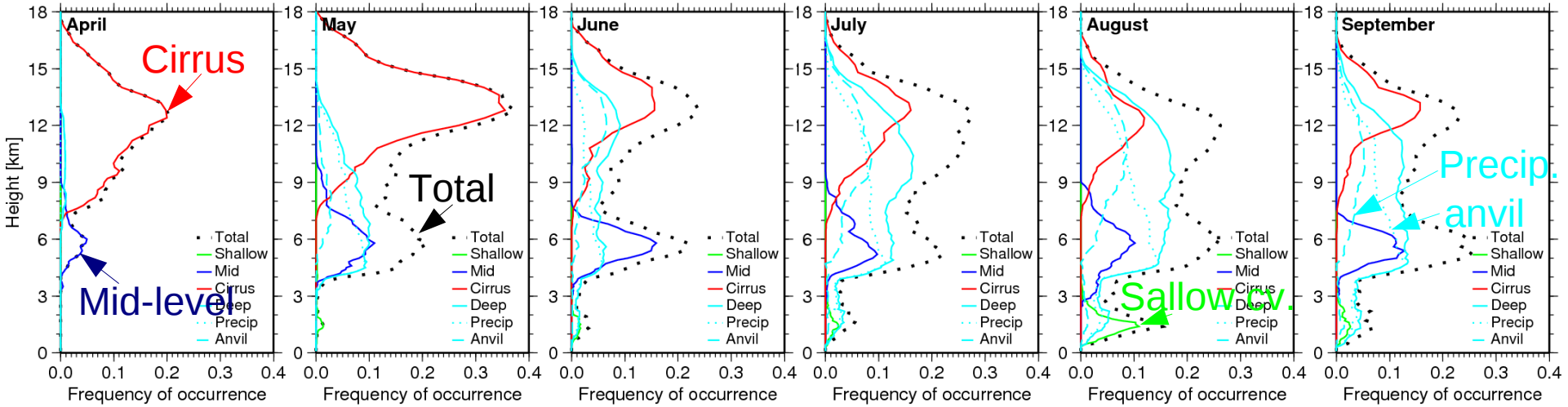


Diurnal cycle from CloudSat/CALIPSO data : August



Seasonnal cycle of cloud cover at Niamey

Cloud frequency of occurrence

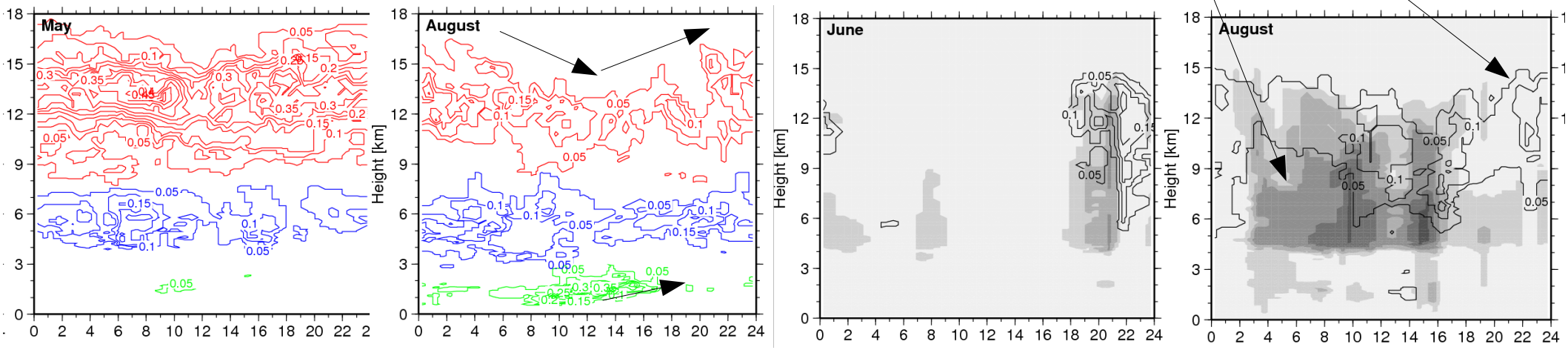


4 « categories » of clouds with cirrus and mid-level clouds occurring all along the season

Diurnal cycle

Cirrus, Mid-level, Shallow cv.

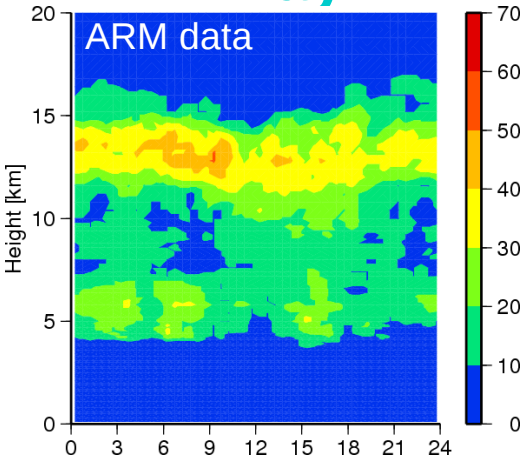
Deep cv.: precipitating or anvil



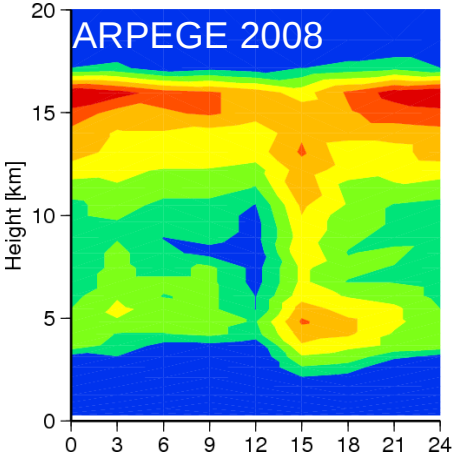
Each « category » presents a diurnal cycle that evolves during the Monsoon season

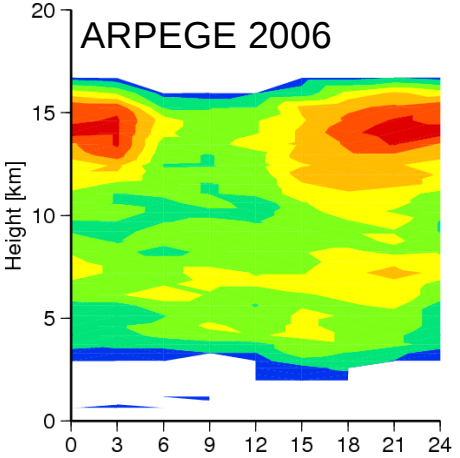
Diurnal composite of cloud occurrence at Niamey

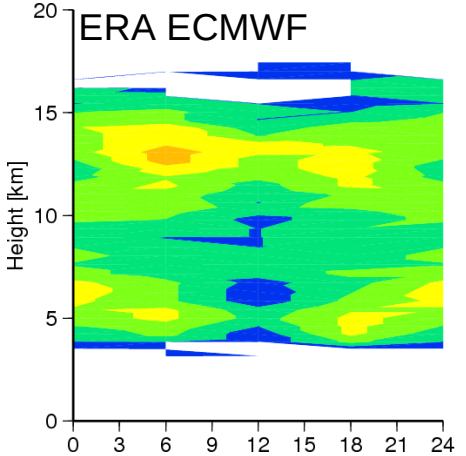
May

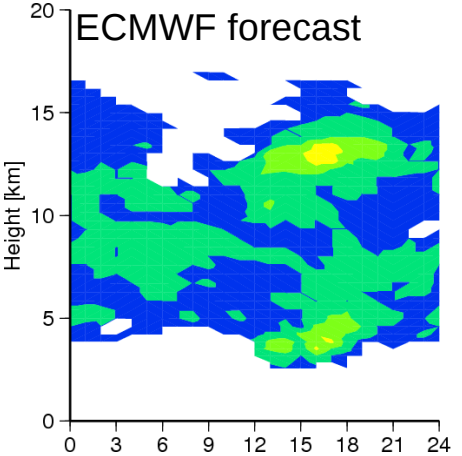


All models tends to reproduce a diurnal cycle but +/- accurately

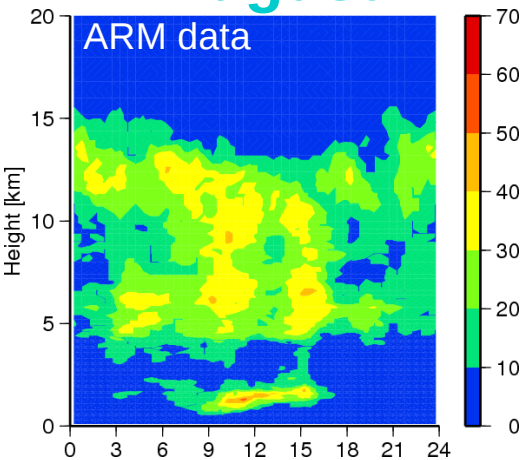


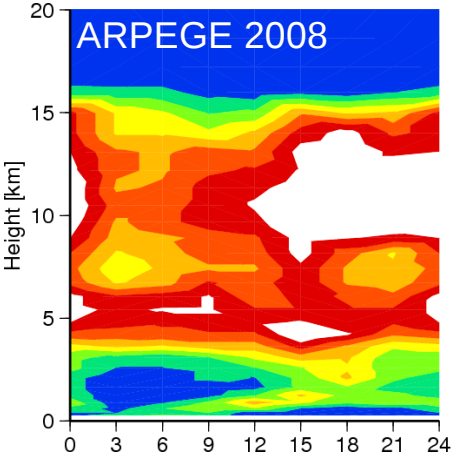


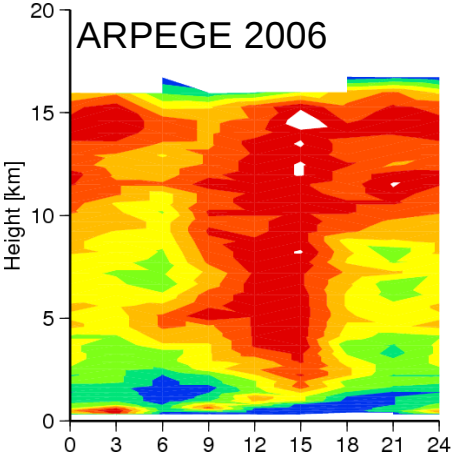


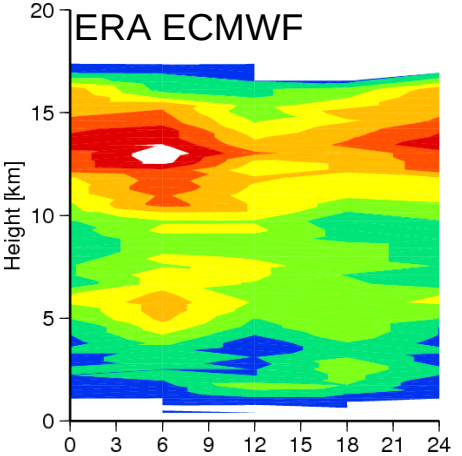


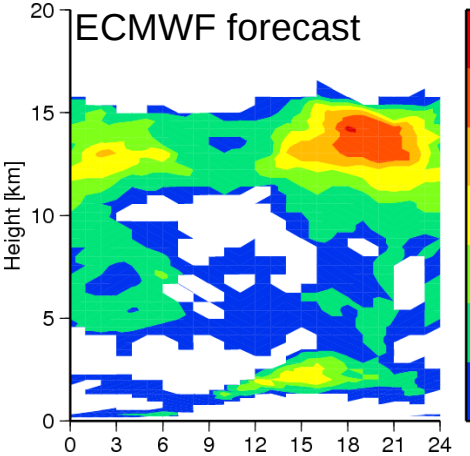
August



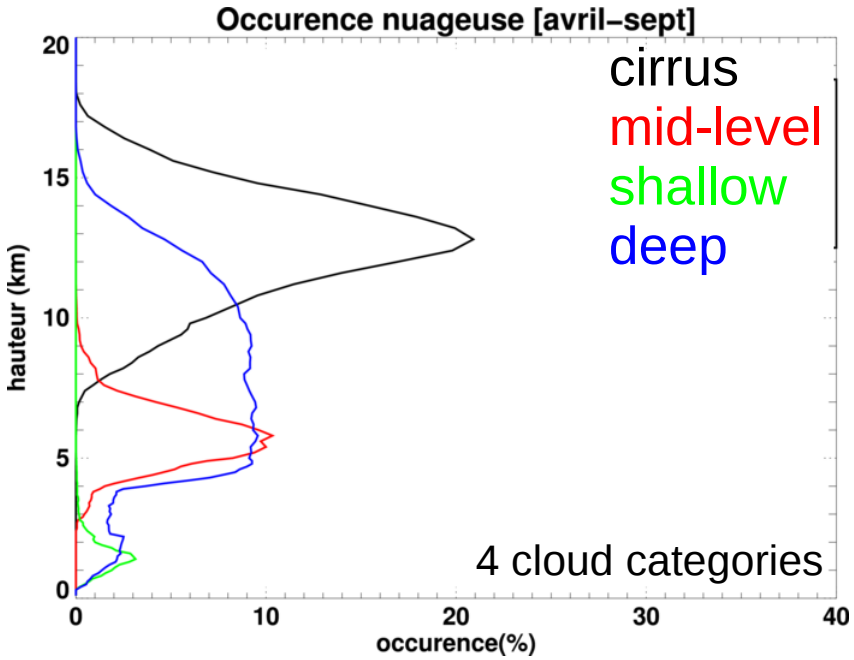




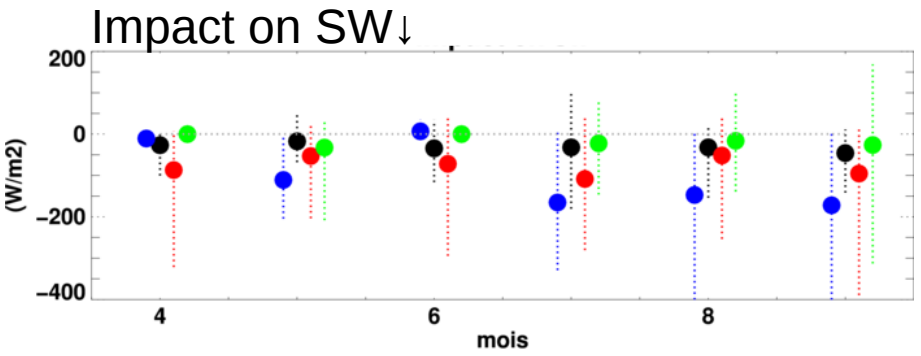


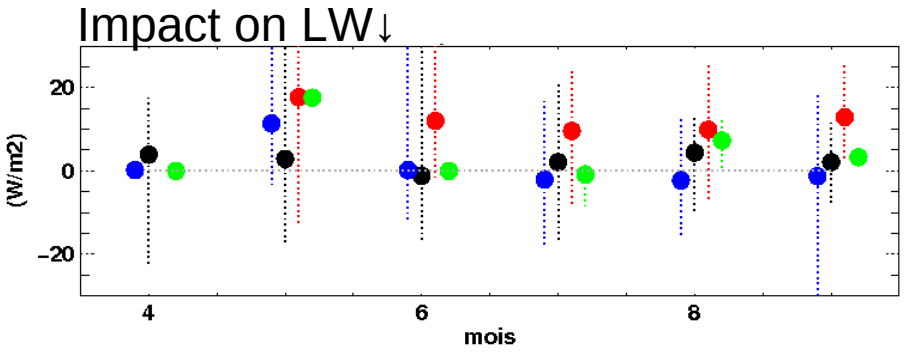


Evaluation of cloud radiative impact at Niamey



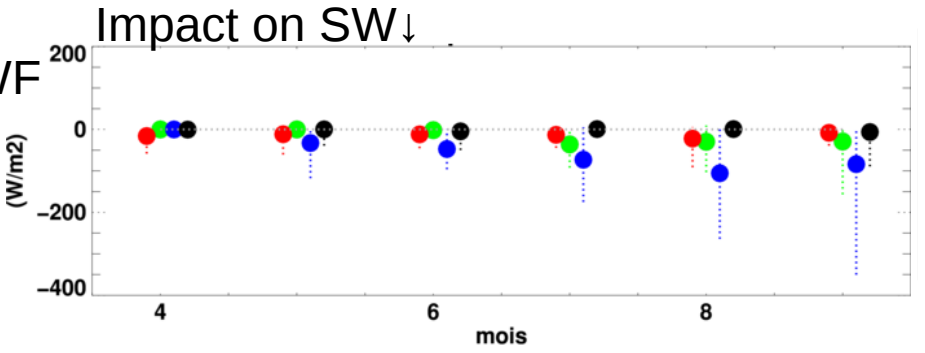
ARM data

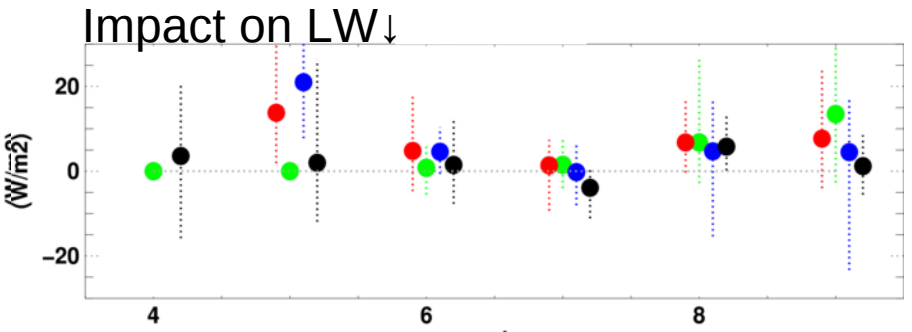




flux (every 30 min): sorted clear sky/occurrence of a given cloud category diurnal composite of F_{cloud}-$F_{clear\ sky}$: impact min/moy/max by month

ERA ECMWF





ARM data

- Radiative impact of mid-level in SW↓ and LW↓
- Strong radiative impact of deep cv (SW↓)
- Small impact of cirrus even in LW↓

ERA ECMWF

- Strong underestimation of mid-level radiative impact
- Agreement on deep cv radiative impact

Conclusions/Perspectives

Unprecedent data base is now available for studying the cloud processes and evaluate the representation of clouds in models in a region where very low constraints exists

• Temporal variability at ground-based sites (ARM data) or spatial variability (A-Train)

Four cloud categories are identified + Sc over the Guinea gulf

• High-level and mid-level clouds are ubiquous before and during Monsoon
• All present a diurnal cycle that evolves during the Monsoon season
• Strong impact of mid-level clouds in SW and LW, small impact of high-level clouds

Comparison with Climate models

• Underestimation of mid-level and low-level clouds + high-level (in LMDZ)/ overestimation (in ARPEGE_Climat)
• Small impact on surface radiative fluxes for ARPEGE_Climat / overestimation of SW at the surface and an overestimation of OLR at TOA for LMDZ

Future work

• Generalise the « category » sorting in the satellite data and in the model outputs
• Quantification at the scale of WA of each cloud category impact / comparison with models
• At ground based sites, study of the relationships between cloud cover and surface/TOA fluxes