



Future changes in the African monsoon through a pool of CMIP5 models

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Aims

- * To simulate the mean sahelian climate, are the CMIP5 models more relevant than the CMIP3 ?
- * In the future, what kind of changes can we expect ?

Expected future changes in the African monsoon between
2030 and 2070 using some CMIP3 and CMIP5 models
under a medium-low RCP scenario

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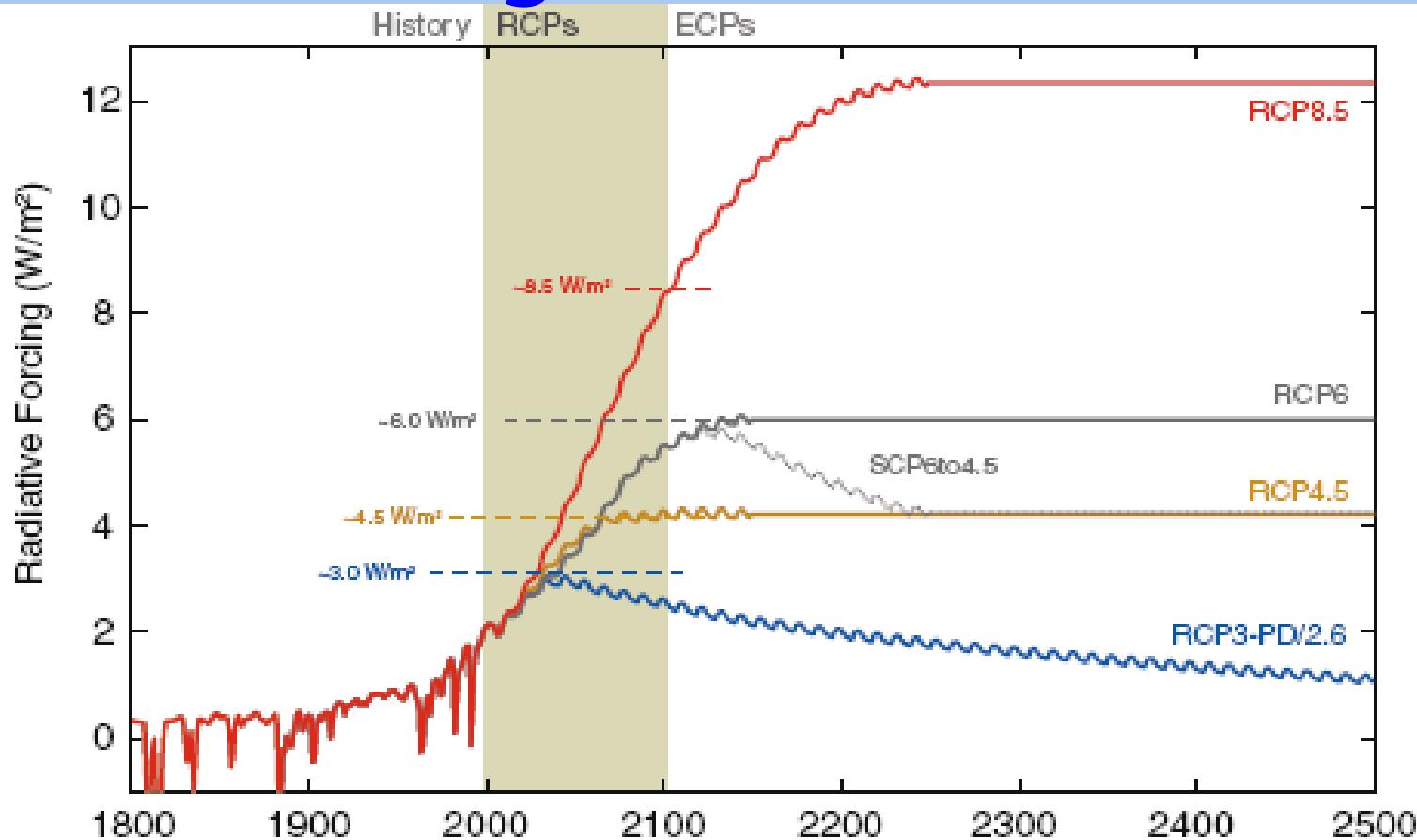
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- Reanalysis : NCEP R-2, GPCP and CRU data
- AOGCMs : 8 CMIP3 (CMIP5) models

Table : CMIP3 models and CMIP5 models used.

Organisms	Full name	Organisms	Full name
CCCMA : Canadian Centre for Climate Modeling and Analysis ; Canada.	CanESM2	INMCM : Institute for Numerical Mathematic ; Russia.	INMCM4
	CCCMA-CGCM3-1		INMCM3-0
CNRM : Centre National de Recherches Météorologiques ; France.	CNRM-CM5	IPSL : Institut Pierre Simon Laplace ; France.	IPSL-CM5A-LR
	CNRM-CM3		IPSL-CM4
CSIRO : CSIRO Atmospheric Research ; Australia.	CSIRO-MK3-6-0	MRI : Meteorological Research Institute ; Japan.	MRI-CGCM3
	CSIRO-MK3-0		MRI-CGCM2-3-2A
GISS : Goddard Institute for Space Studies ; USA.	GISS-E2-R	UKMO : Met office ; UK.	HadGEM2-ES
	GISS-MODEL-E-R		UKMO-HADCM3

Futur changes :



- CMIP5 :
Historical scenario
(1960-1999)
- CMIP5 :
RCP4.5 scenario
(2031-2070)

Fig. 4 Total radiative forcing (anthropogenic plus natural) for RCPs,—supporting the original names of the four pathways as there is a close match between peaking, stabilization and 2100 levels for RCP2.6 (called as well RCP3-PD), RCP4.5 & RCP6, as well as RCP8.5, respectively. Note that the stated radiative forcing levels refer to the illustrative default median estimates only. There is substantial uncertainty in current and future radiative forcing levels. Short-term variations in radiative forcing are due to both volcanic forcings in the past (1800–2000) and cyclical solar forcing—assuming a constant 11-year solar cycle (following the CMIP5 recommendation), except at times of stabilization

Multi-model approach (Randall et al. 2007)

- * Decreasing of the bias due to a small number of models
- * Removing of several biases

'One model one vote' (Santer et al. 2009).

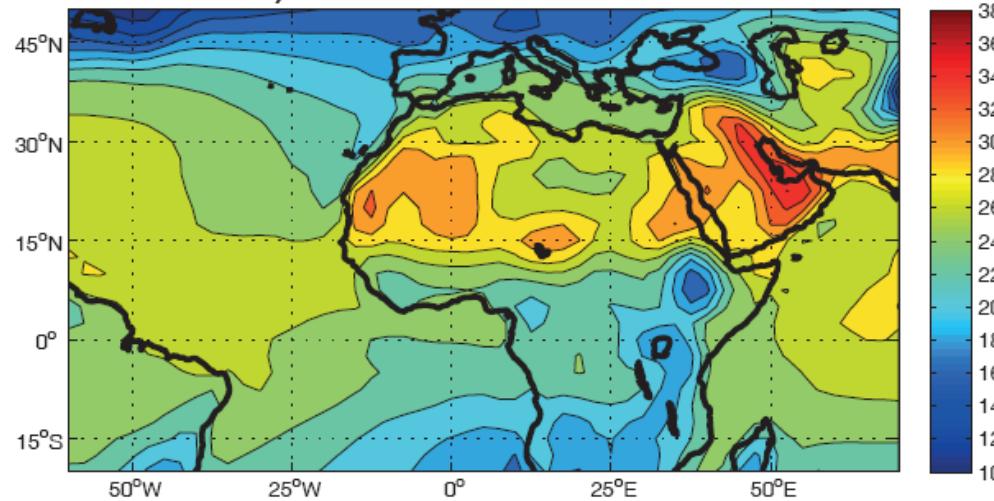
- * Calculus of the occurrences

Notation

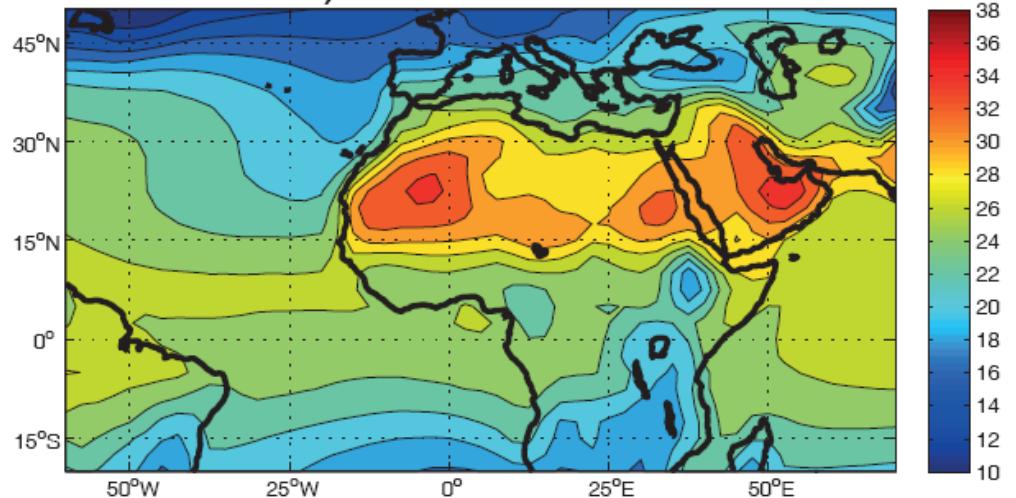
- * CMIP3 Multi-model : MM3
- * CMIP5 Multi-model : MM5

Surface temperature

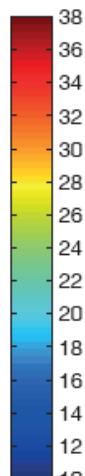
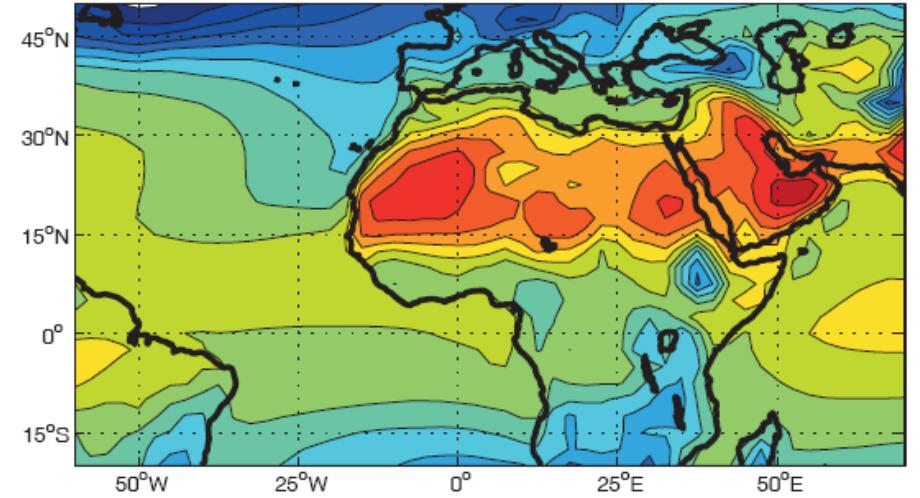
a) TS JAS NCEP R-2



b) TS JAS MM3

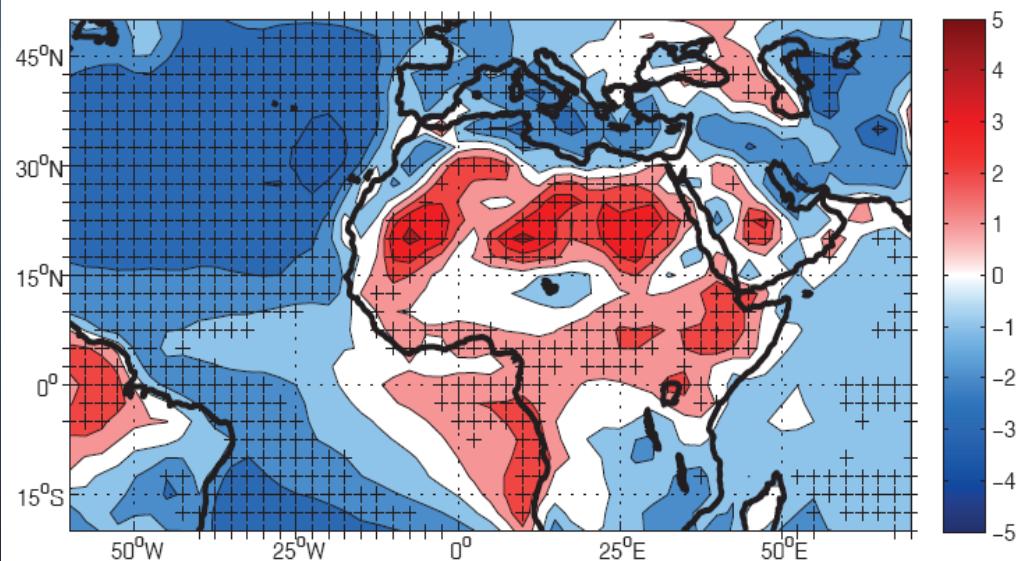


c) TS JAS MM5

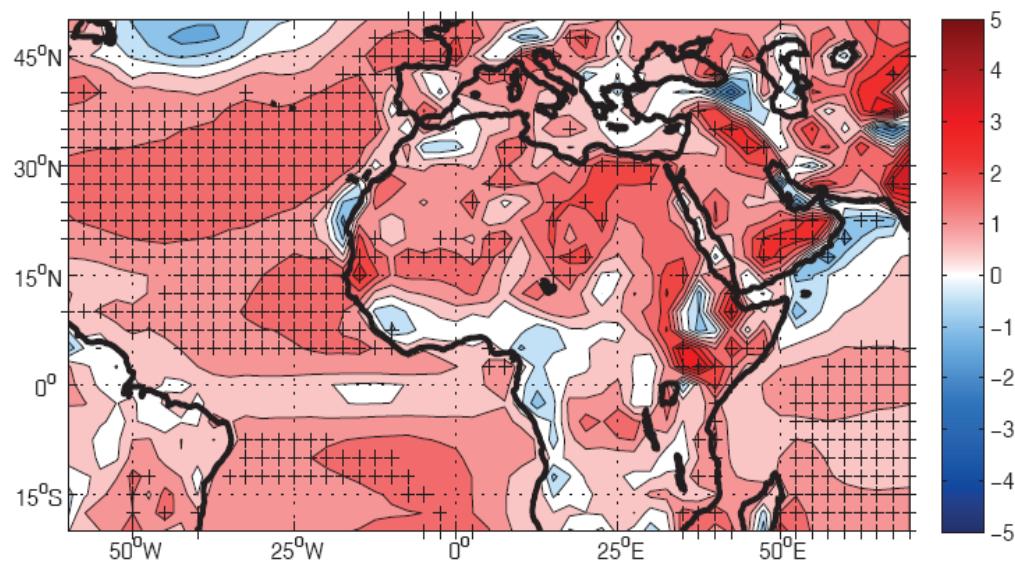


Surface temperature

d) TS JAS MM3 – NCEP R-2

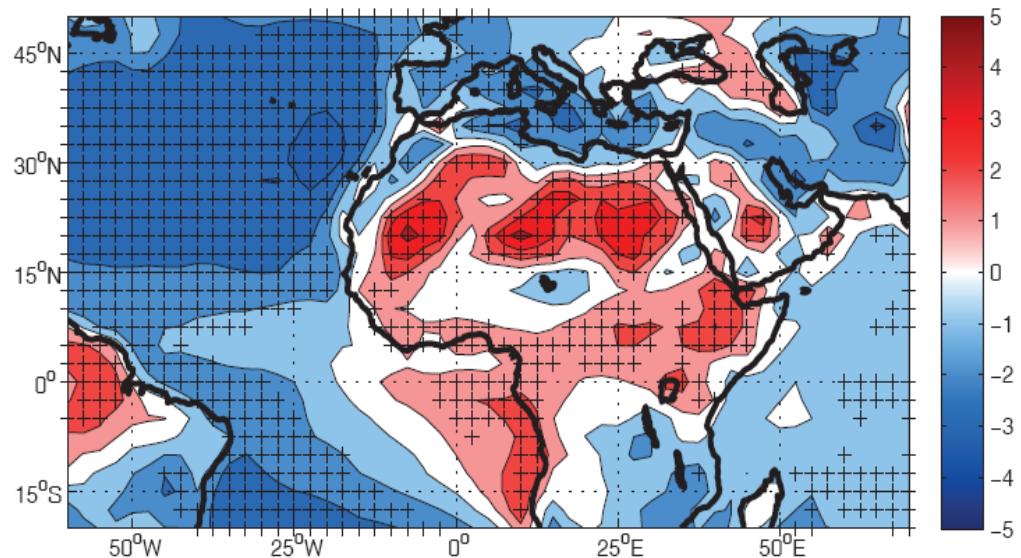


e) TS JAS MM5 – MM3

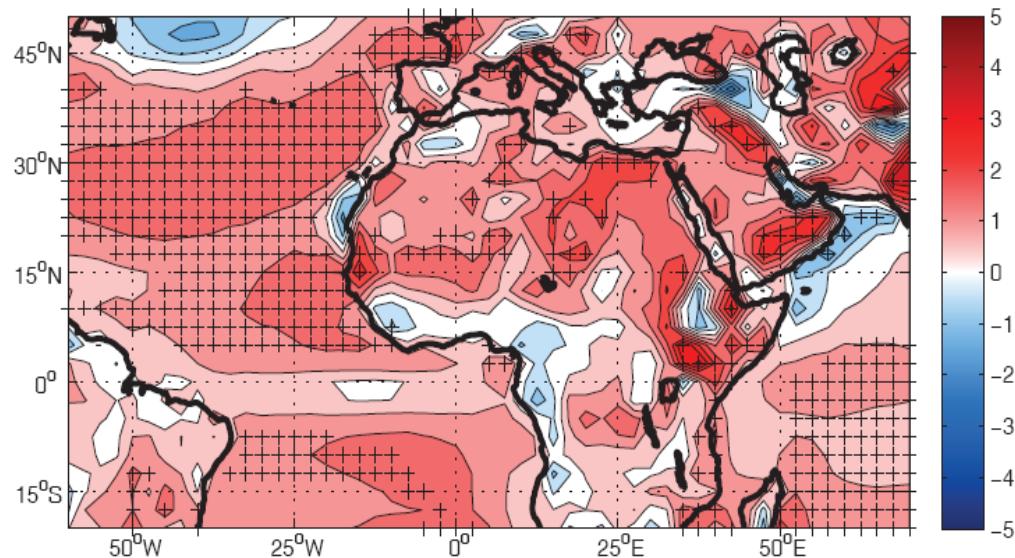


Surface temperature

d) TS JAS MM3 – NCEP R-2

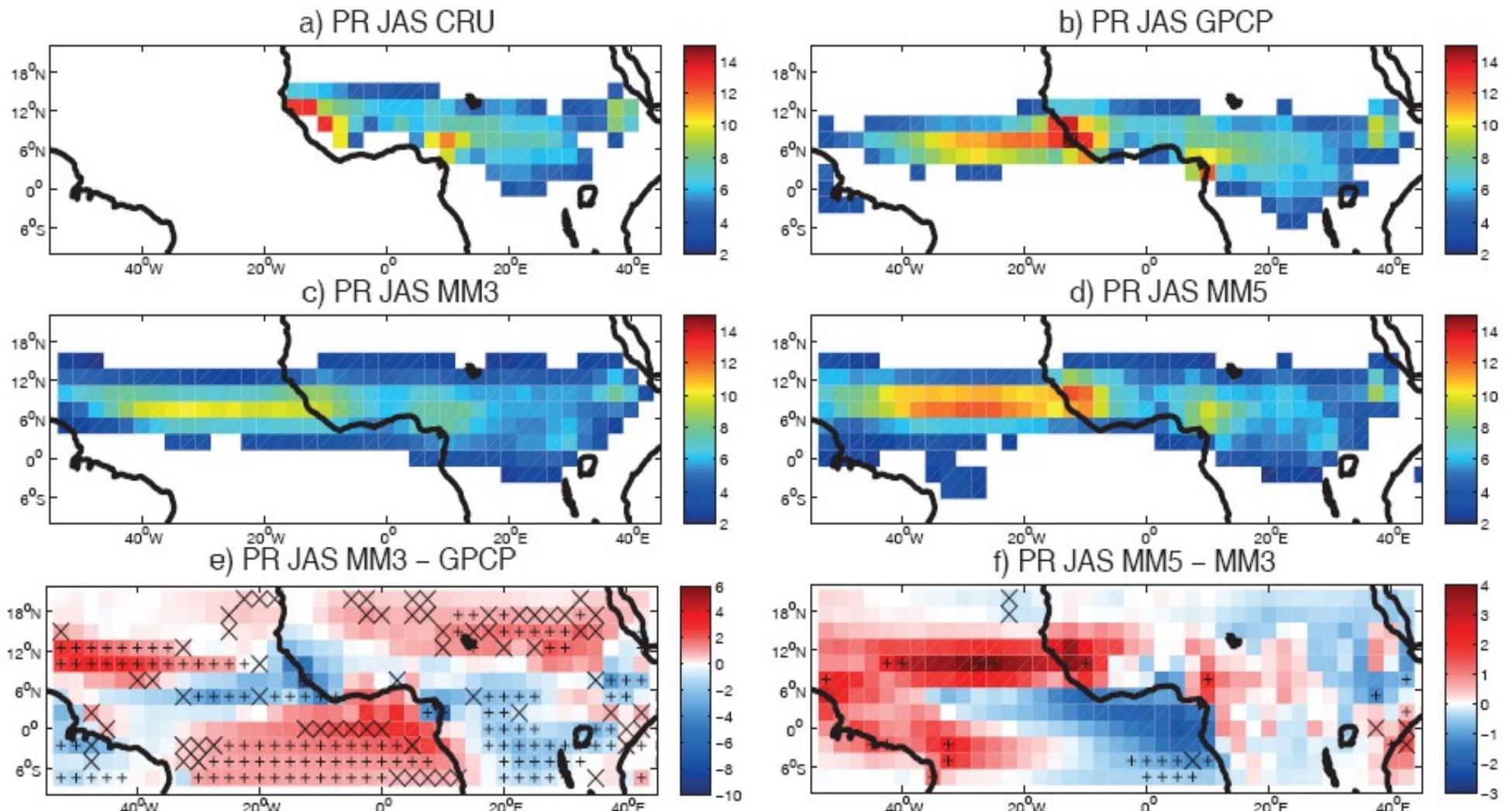


e) TS JAS MM5 – MM3



- SST seems more realistic in CMIP5 than in CMIP3

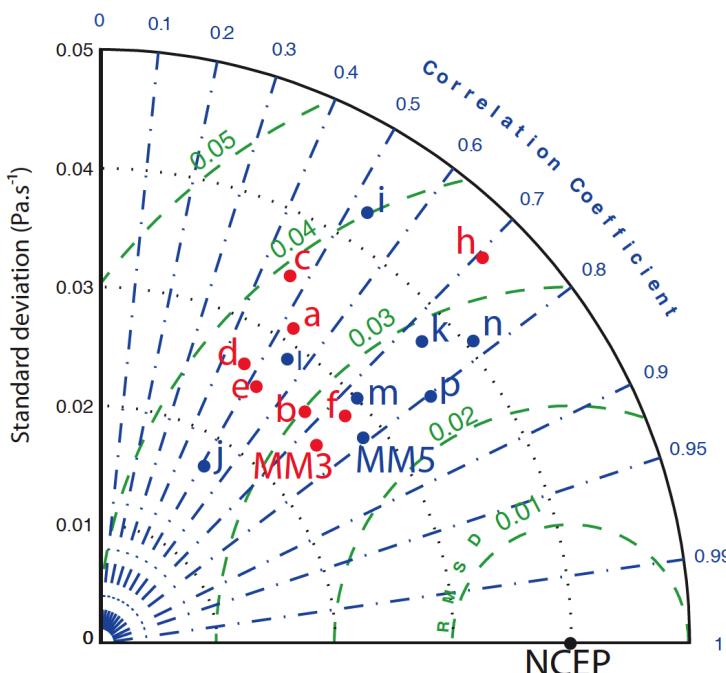
Rainfall amounts



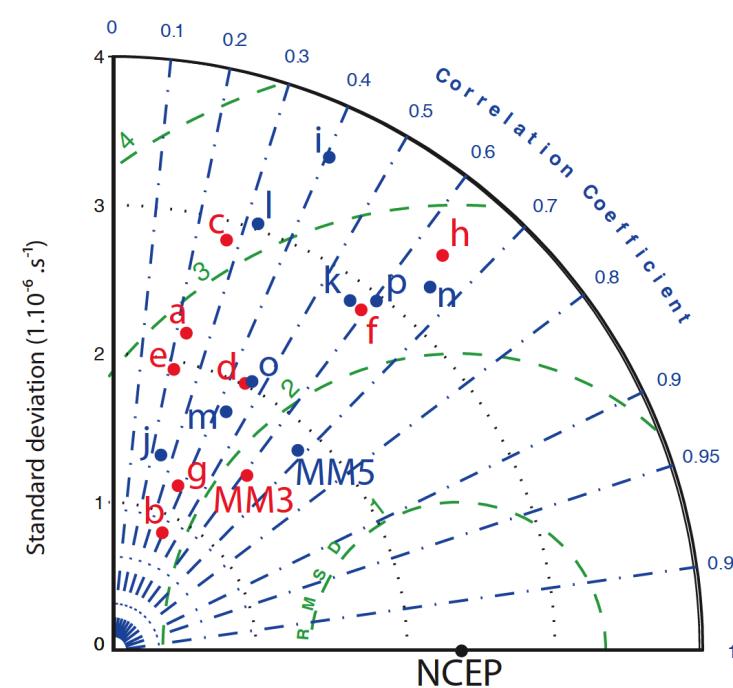
MM5 : Slightly better representation of the precipitation-field

Omega (400 hPa) and Wind divergence (250 hPa)

a) Omega Africa (NCEP R-2)



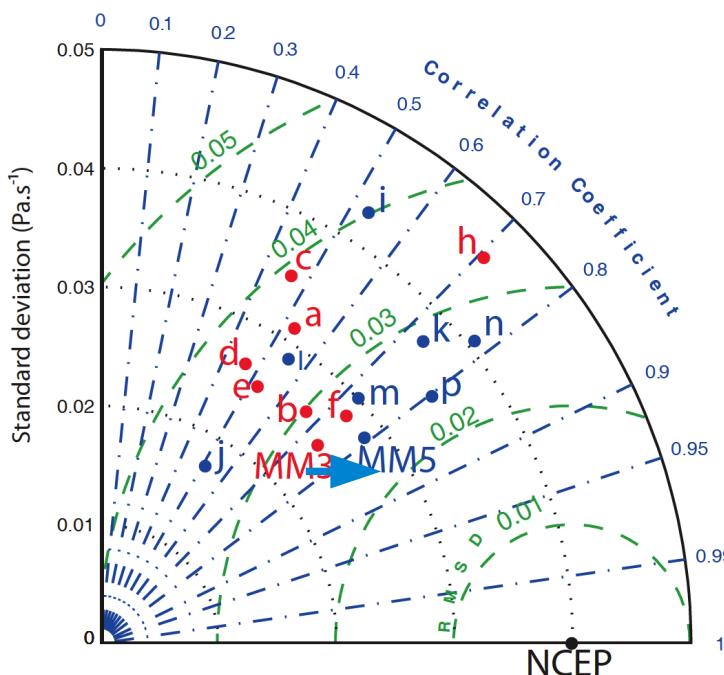
b) Divergence Africa (NCEP R-2)



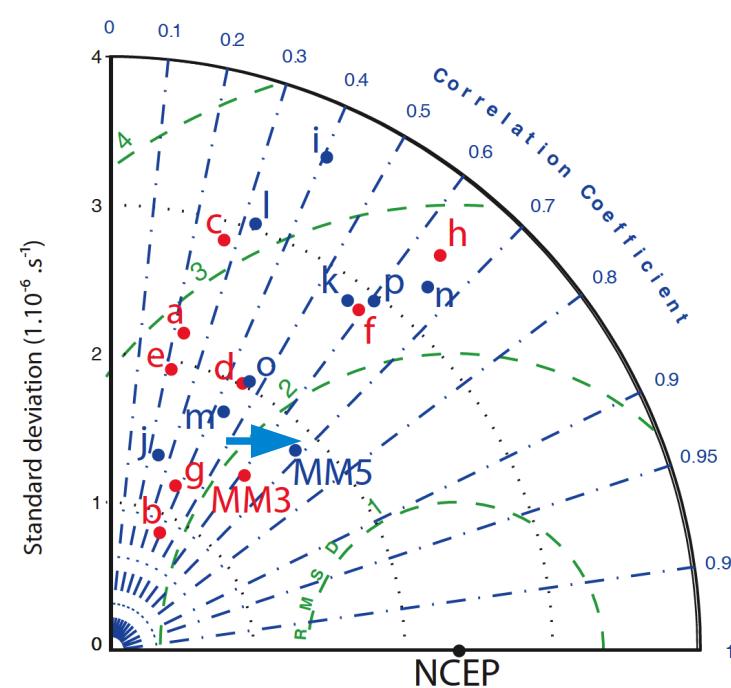
a : cnrm_cm3
 b : inmcm3_0
 c : ukmo_hadcm3
 d : giss_model_e_r
 e : cccma_cgcm3_1
 f : ipsl_cm4
 g : csiro_mk3_0
 h : mri_cgcm2_3_2a
 i : cnm_cm5
 j : inmcm4
 k : hadgem2-es
 l : giss_e2_r
 m : canesm2
 n : ipsl_cm5a_lr
 o : csiro_mk3_6_0
 p : mri_cgcm3
 MM3 : CMIP3 Multi-Model
 MM5 : CMIP5 Multi-Model
 OBS : Observation data

Omega (400 hPa) and Wind divergence (250 hPa)

a) Omega Africa (NCEP R-2)



b) Divergence Africa (NCEP R-2)

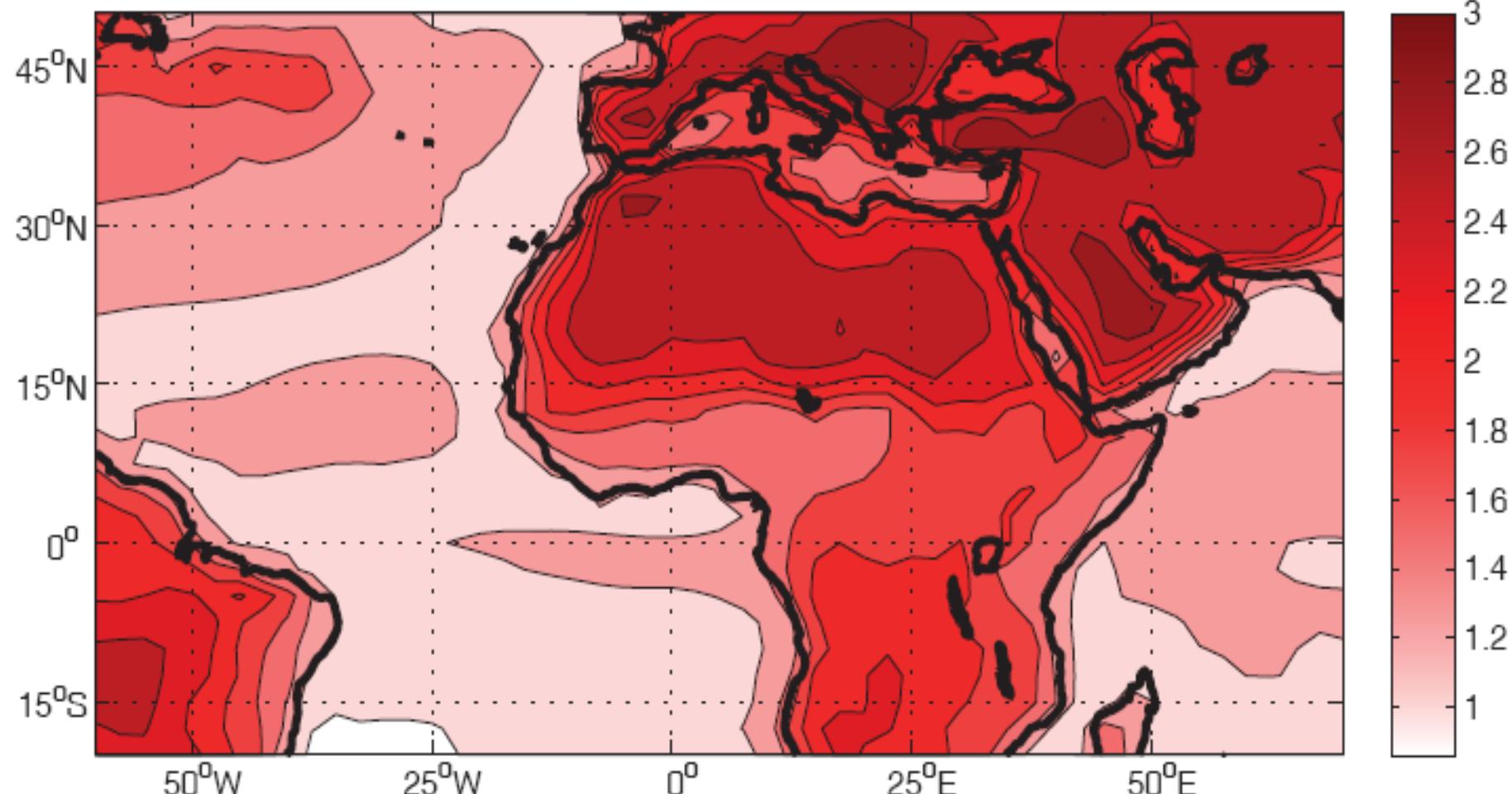


a : cnrm_cm3	b : inmcm3_0
c : ukmo_hadcm3	d : giss_model_e_r
e : cccma_cgcm3_1	f : ipsl_cm4
g : csiro_mk3_0	h : mri_cgcm2_3_2a
i : cnm_cm5	j : inmcm4
k : hadgem2-es	l : giss_e2_r
m : canesm2	n : ipsl_cm5a_lr
o : csiro_mk3_6_0	p : mri_cgcm3
MM3 : CMIP3 Multi-Model	
MM5 : CMIP5 Multi-Model	
OBS : Observation data	

- MM5 is better in terms of bias and spatial variability

Surface temperature

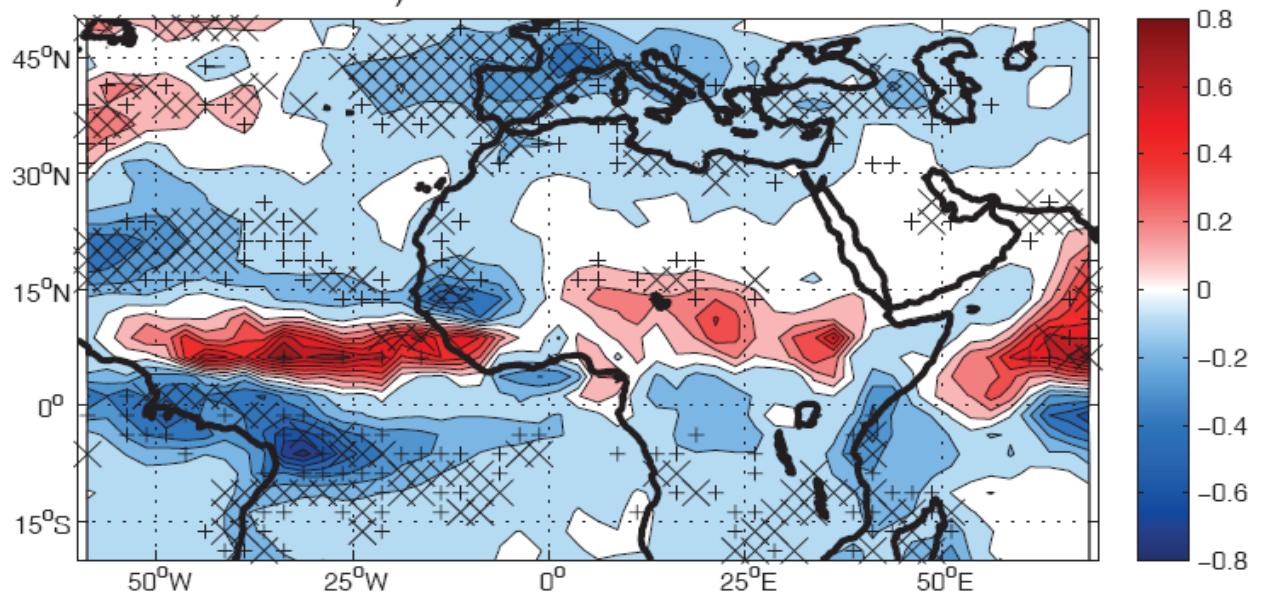
a) TS JAS RCP45-historical



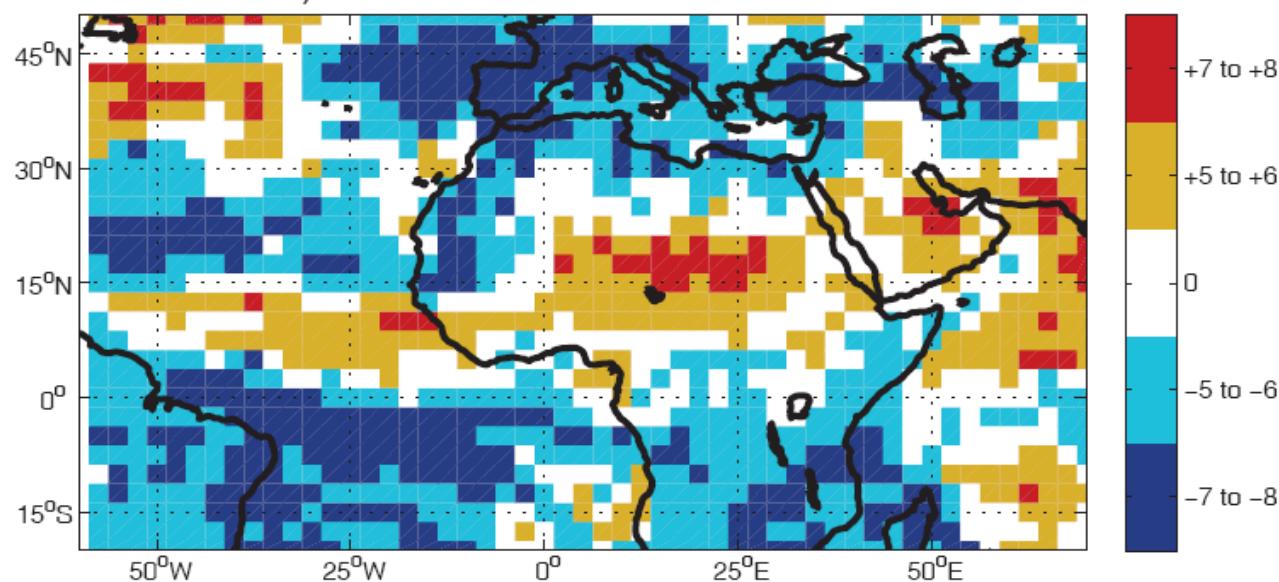
- Surface temperature gradients enhanced

Rainfall amounts

b) RAIN JAS RCP45-historical

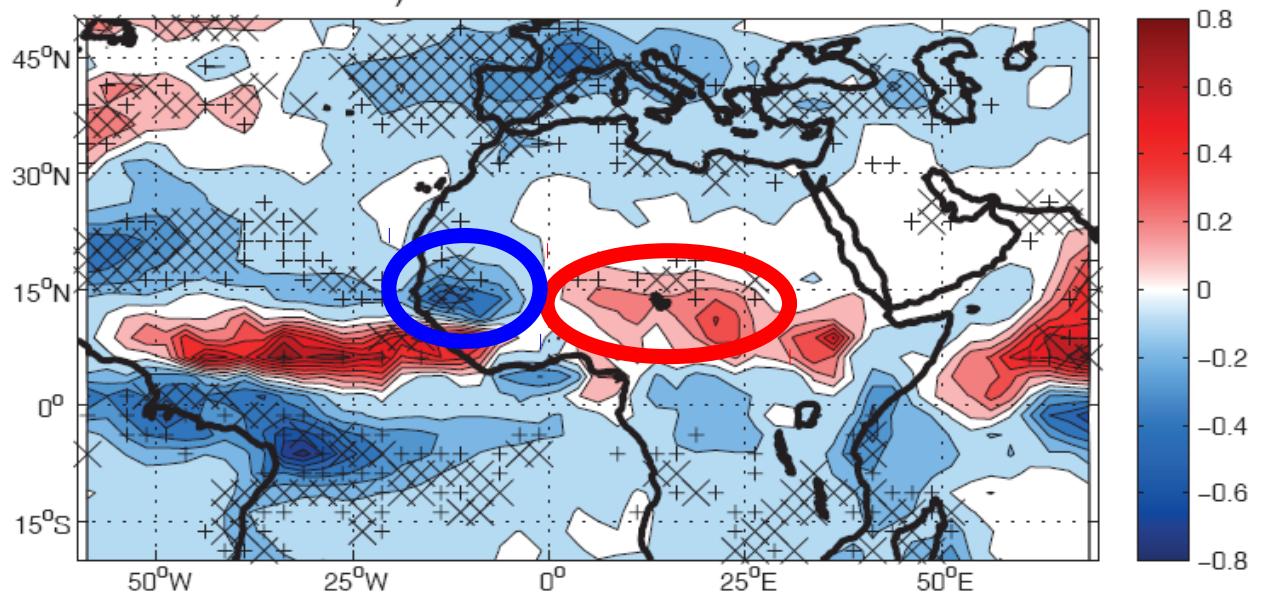


c) RAIN JAS RCP45-historical occurrences

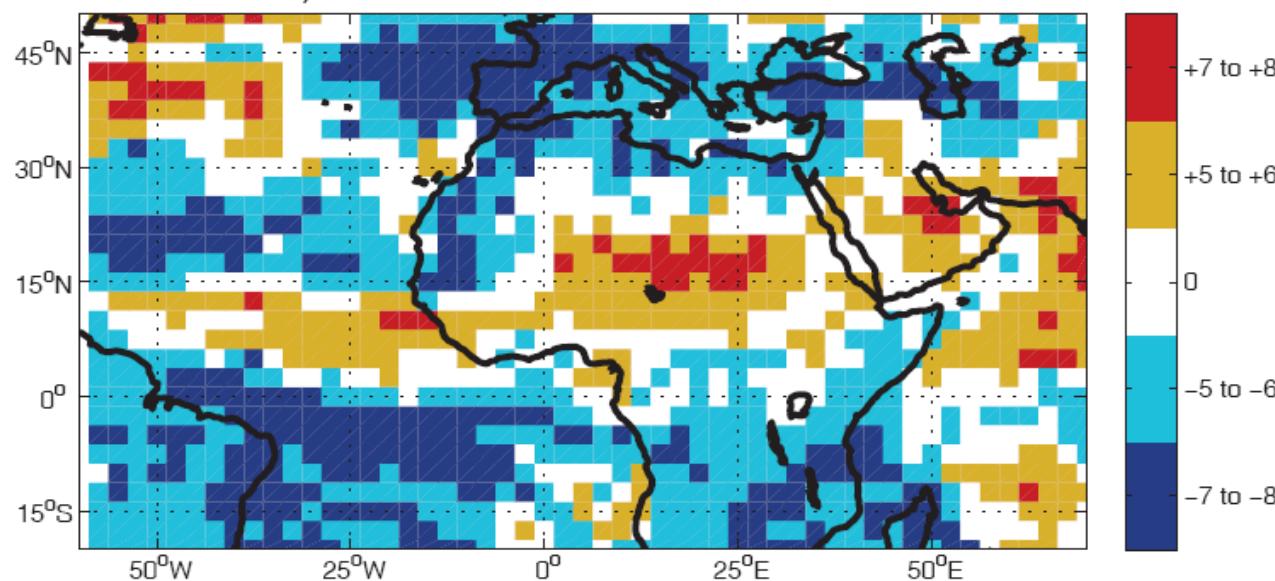


Rainfall amounts

b) RAIN JAS RCP45-historical



c) RAIN JAS RCP45-historical occurrences

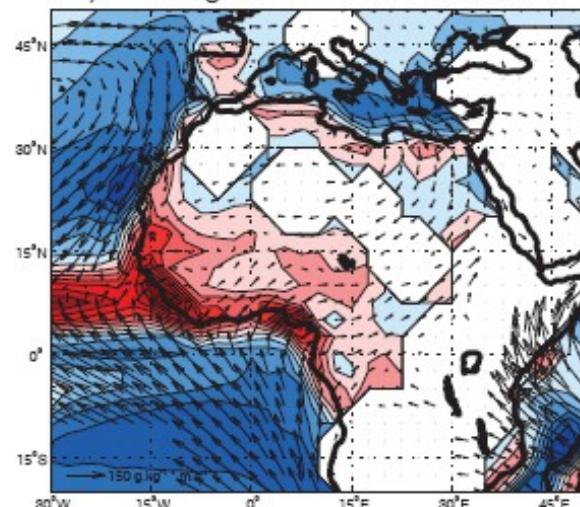


- More rainfall amounts above the central-east Sahel.

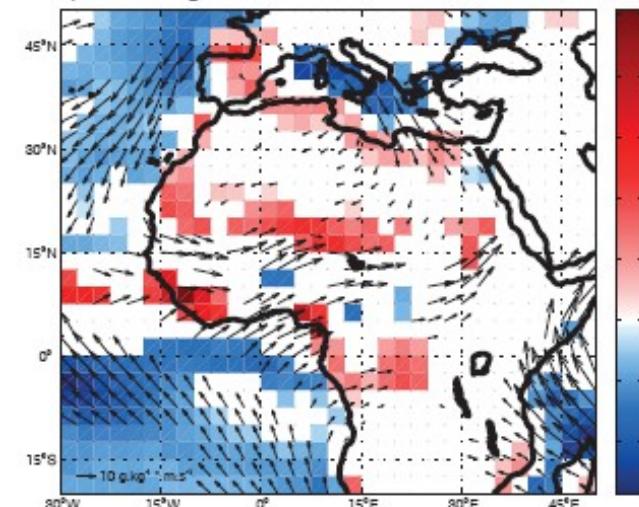
- Less rainfall amounts above the western part of the Sahel.

Vertical integrated moisture flux convergence

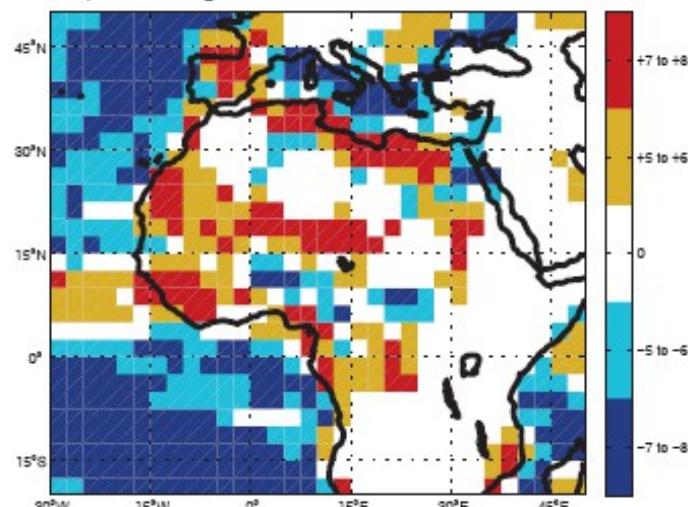
a) convergence 1000-850 historical



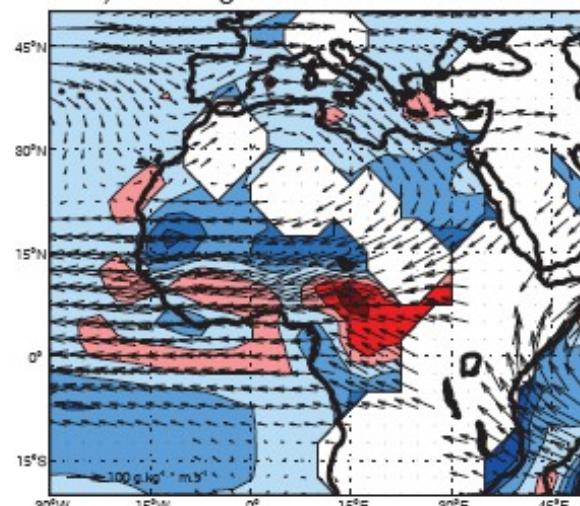
b) convergence 1000-850 RCP45-historical



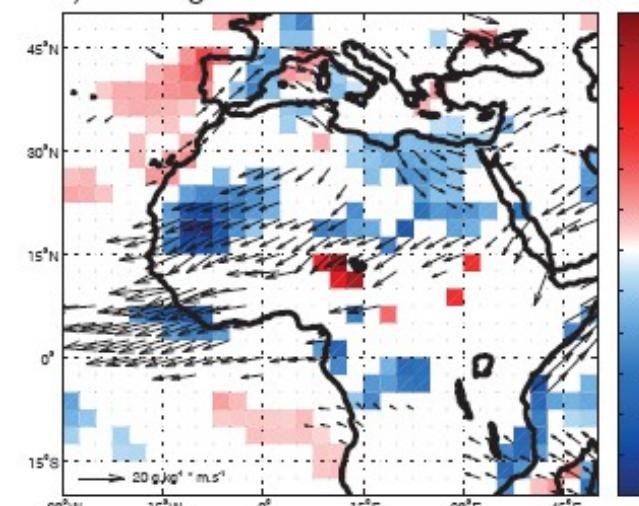
c) convergence 1000-850 occurrences



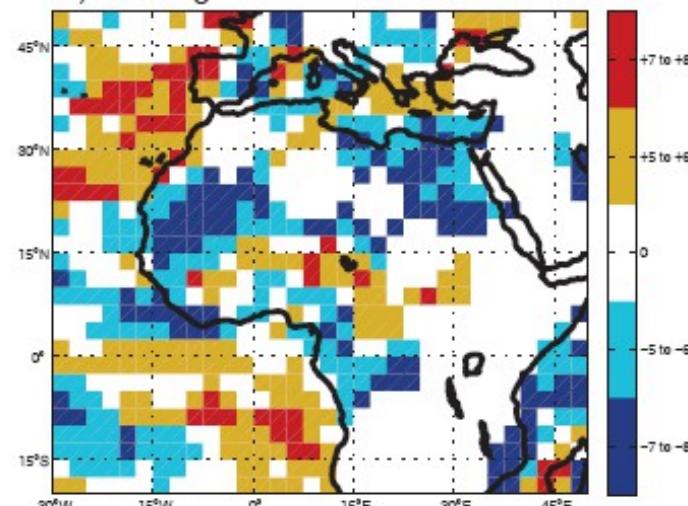
d) convergence 850-400 historical



e) convergence 850-400 RCP45-historical



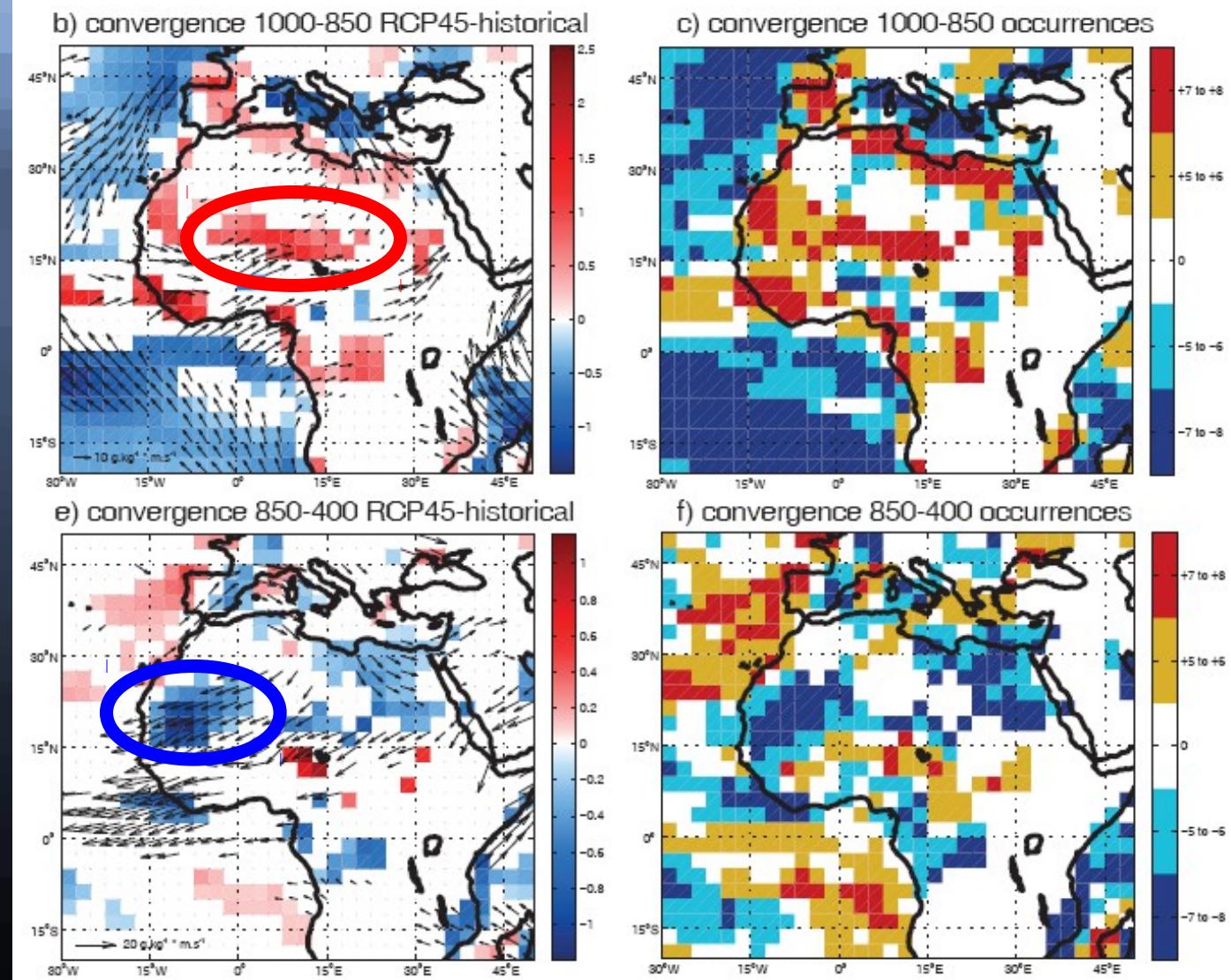
f) convergence 850-400 occurrences



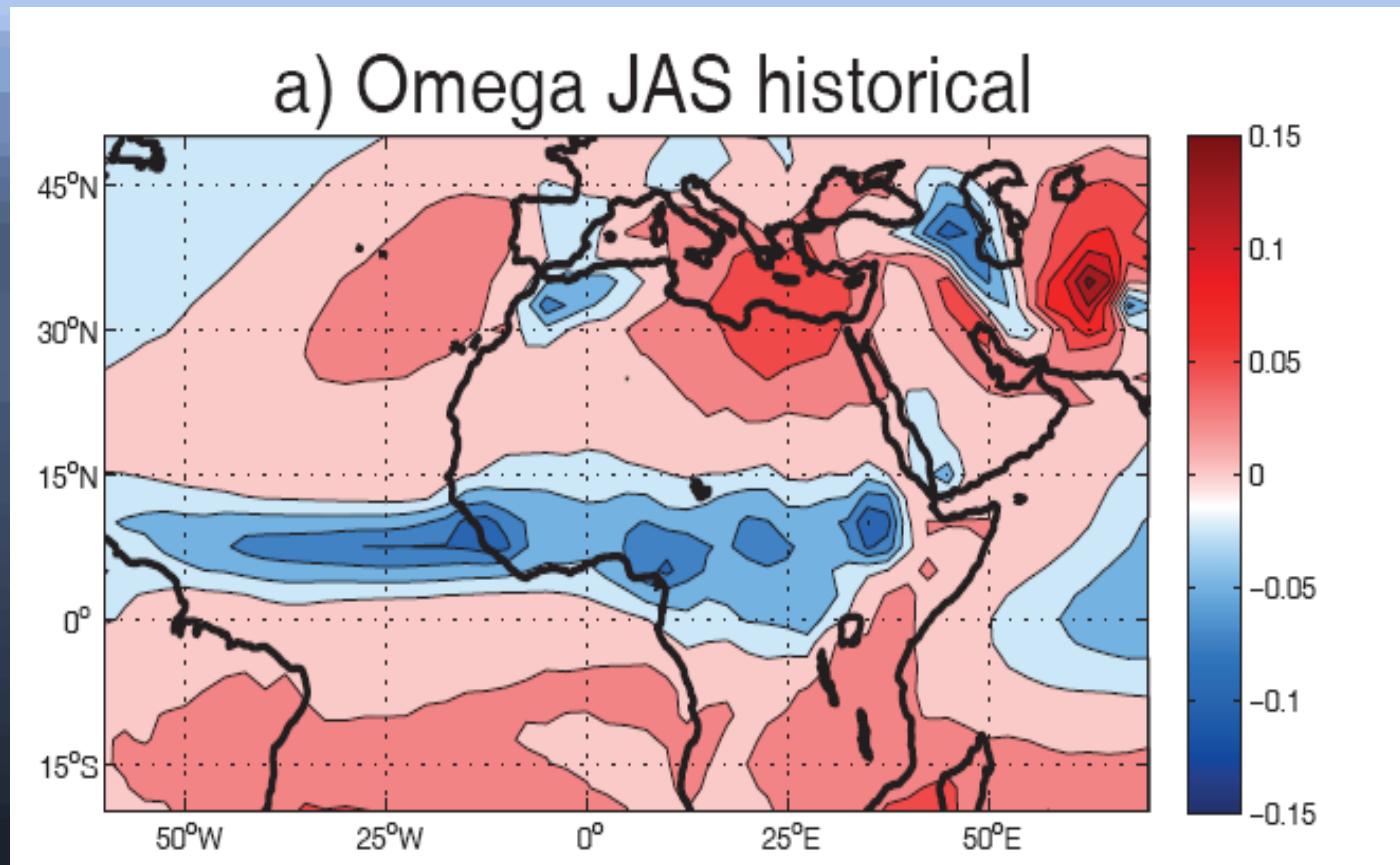
Vertical integrated moisture flux convergence

- Low levels :
convergence enhanced .

- Mid-levels :
stronger
divergence.



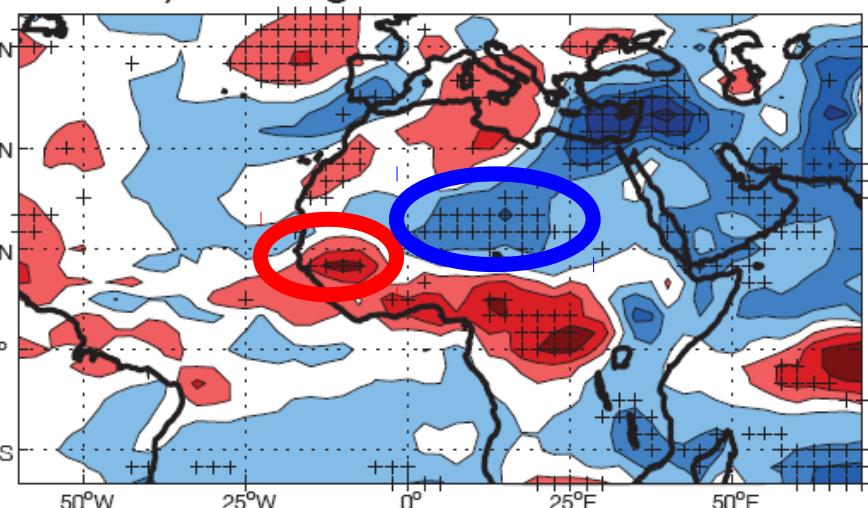
Omega (400 hPa)



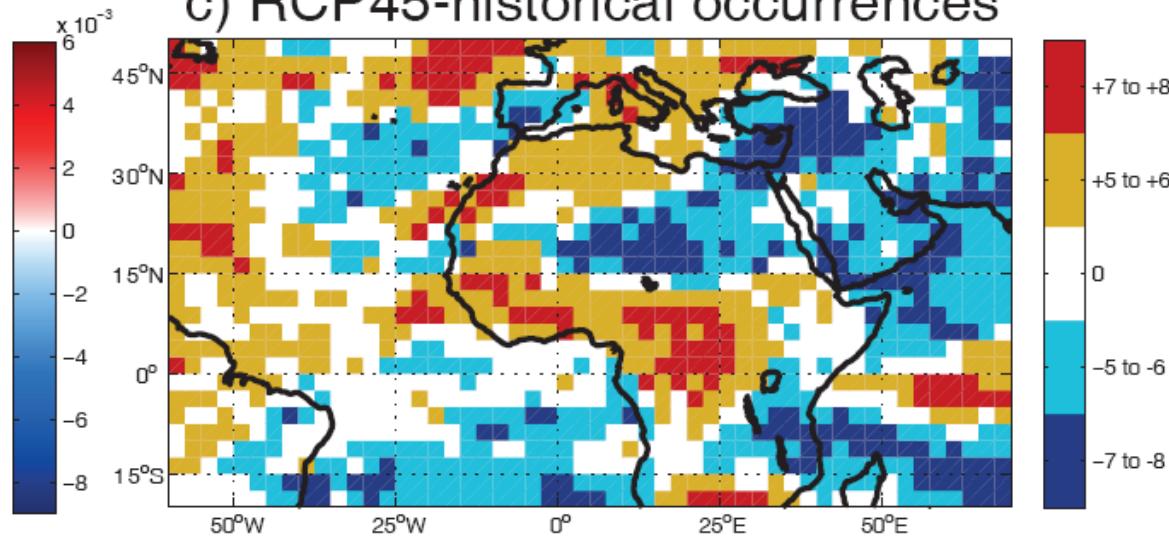
A process at a smaller scale, omega minima locates the regions of rainfall maxima

Omega (400 hPa)

b) Omega RCP45-historical

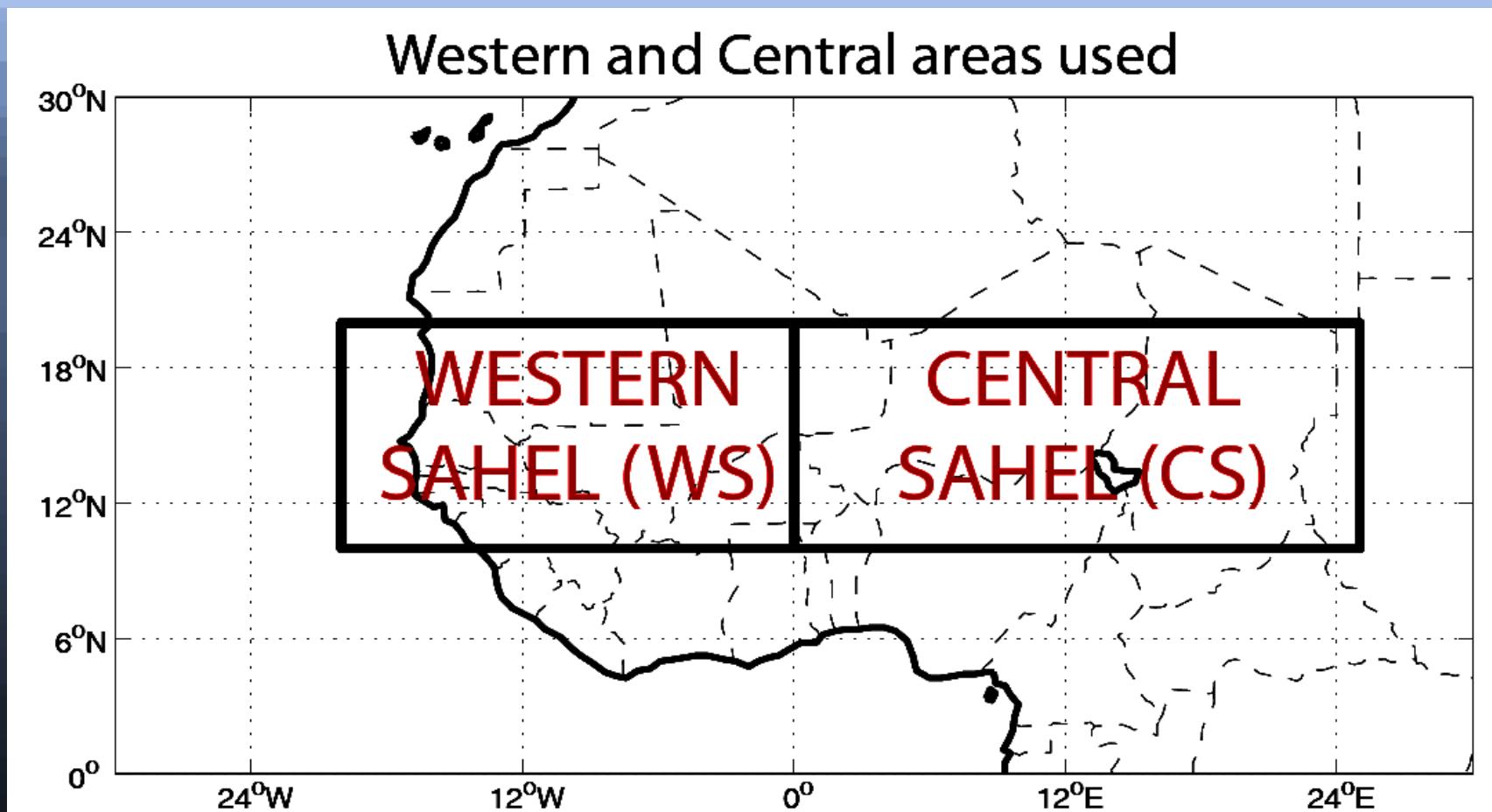


c) RCP45-historical occurrences



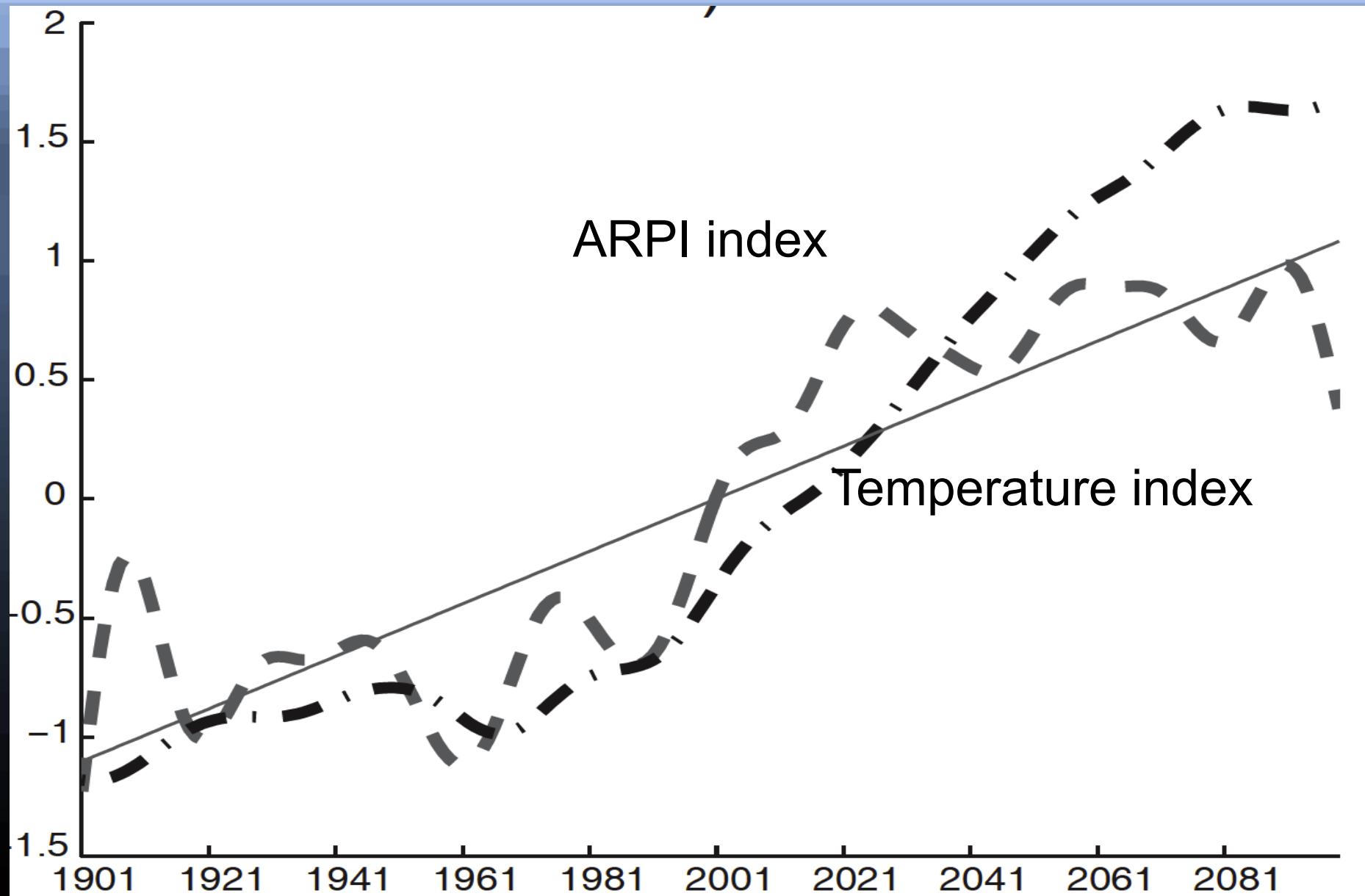
- Anomalies of subsidence westward to the Greenwich meridian
- More air ascents above central Sahel

The ARPI index



$$\text{ARPI} = \text{stan} (\text{stan} (\text{CS}) - \text{stan} (\text{WS}))$$

MM5 ARPI and temperature index



Conclusion

- The new CMIP5 simulations are slightly more realistic than previous ones
- An West /Central-East rainfall pattern change with
 - Rainfall amounts increase in the Central-East area :
 - more mean moisture flux convergence
 - Rainfall amounts decrease in the Western area :
 - subsidence anomalies
 - more atmospheric water export
- This contrasted rainfall pattern change is expected to occur more frequently in the future.



Thank you for your attention

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