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Cultiver le Savoir pour Accéder au Développement

INTERCONTINENTAL TRANSPORT AND CLIMATIC IMPACT OF SAHARAN AND SAHELIAN DUST

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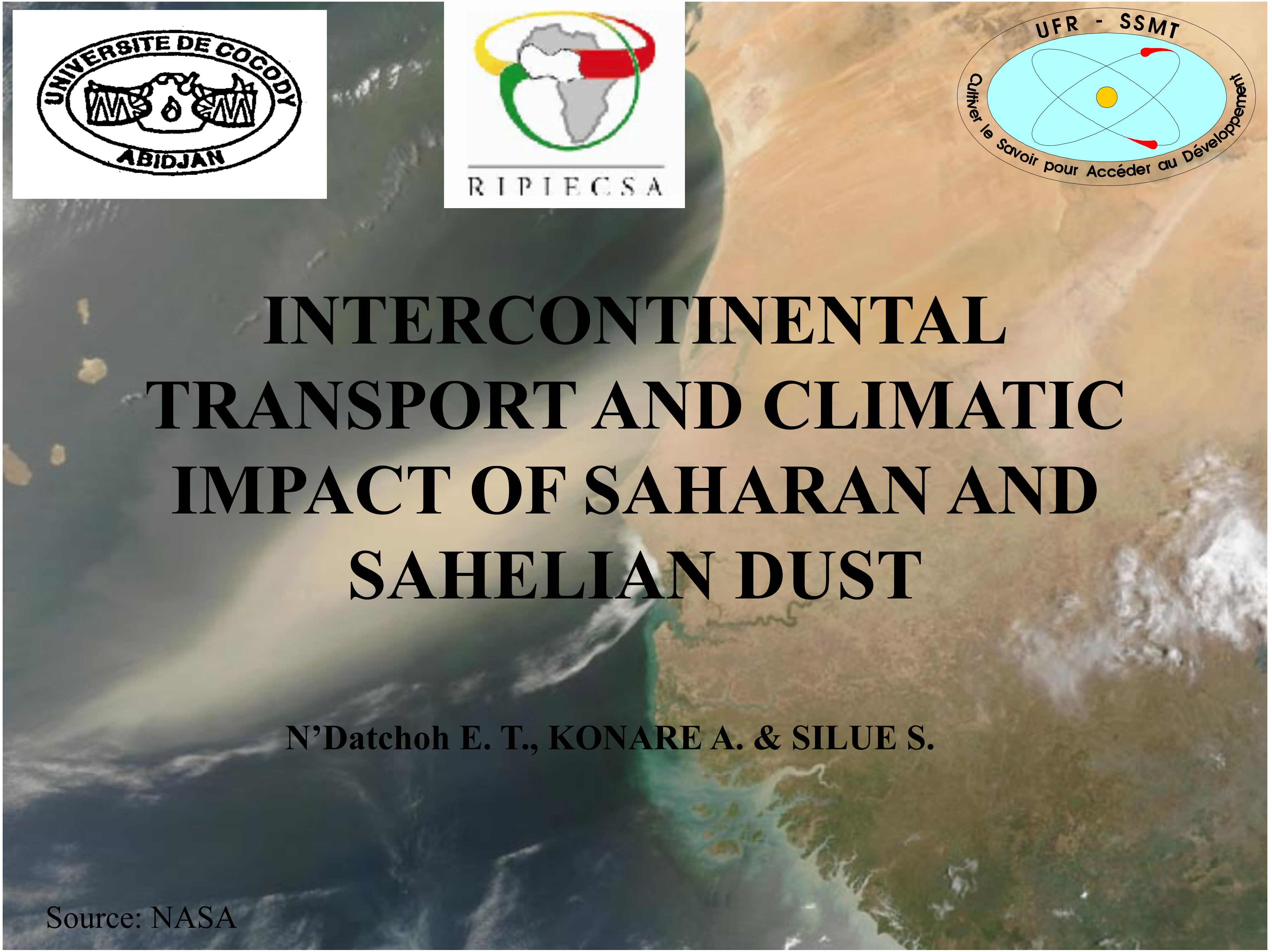


Source: NASA

Introduction

Sahara and Sahel: important sources of dust particles into the atmosphere.

Dust transportation characteristics (direction, speed, altitudes, trajectories, distance travel and duration of transport) depend on meteorological conditions in the sources zones.

Dust influence atmosphere and induce modification in Earth radiation budget (Tanre et al., 2003).

Purposes:

(i) Inter-seasonal analysis of dust transport using regional climatic modelling.

(ii) Assess impact of dust radiation and associated effects (Focus on spring 2010).

Methodology

RegCM 4.0 was used for the simulations (developed by ICTP).

Spatial resolution: 60 km x 60 km; 18 pressure levels

Two sets of simulations have been done (Nov 2004 to Dec 2010):

- First with Dust
- Second without dust

The aerosol and dust in RegCM (Regional Climate Model)

➢RegCM 4: - (ICTP/UNESCO, Trieste, Italie) *Giorgi and Mearns (1999),* - RegCNET

➢Aerosol and dust module developments *(Solmon et al., 2006; Zakey et al., 2006)* :¶

$$\frac{\partial \chi}{\partial t} = \underbrace{-\overline{V} \cdot \nabla \chi + F_H + F_V + T_{CUM}}_{\text{Transport}} + \underbrace{S_\chi}_{\text{Primary Emissions}} \underbrace{- R_{w,ls} - R_{w,cum} - D_{dep}}_{\text{Removal terms}} + \underbrace{\sum Q_p - Q_l}_{\text{Physico – chemical transformations}}$$

➢Aerosol particles in RegCM4

SO_2	SO_4^{-}	BC (soot)		OC (total organic carbon)		DUST (4 bins)			
Aqueous and gazeous conversion (Qian et al., 2001)		*Hydrophilic (20% at emission)*	Hydrophobic (80%at emission)	*Hydrophilic (50%at emission)*	*Hydrophobic(50%at emission)*	0.01-1 µm	1-2.5 µm	2.5-5 µm	5-20 µm

Presribed emission inventories

On line emissions

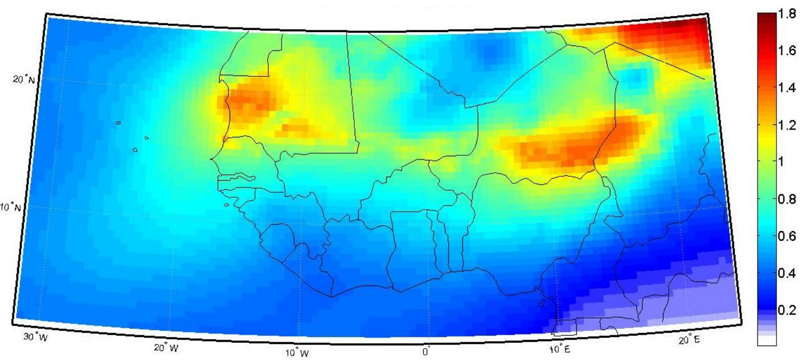
Sea salt

+

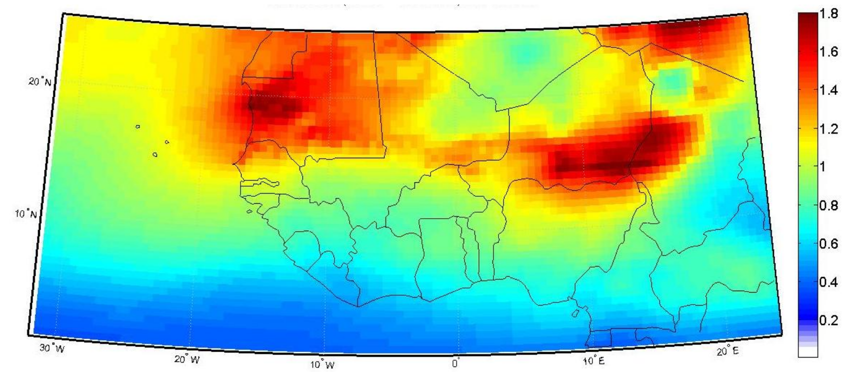
Chemistry

Aerosols modeling and observations

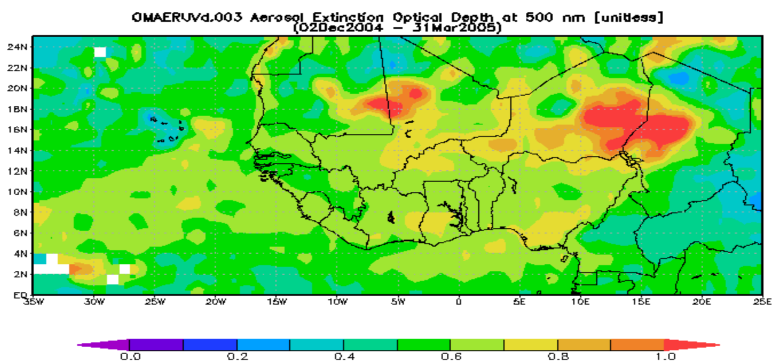
Dust Only



Dust and Biomass



Observations OMI



Taking into account the biomass burning aerosols improve the results

The modele captures well the Bodele source as well as the Lybian one, but sees source at the djouf region that the satellitte doesn't see.

Dust episodes during March 2010 (cont.)

Comparison between Model simulation and AERONET observations

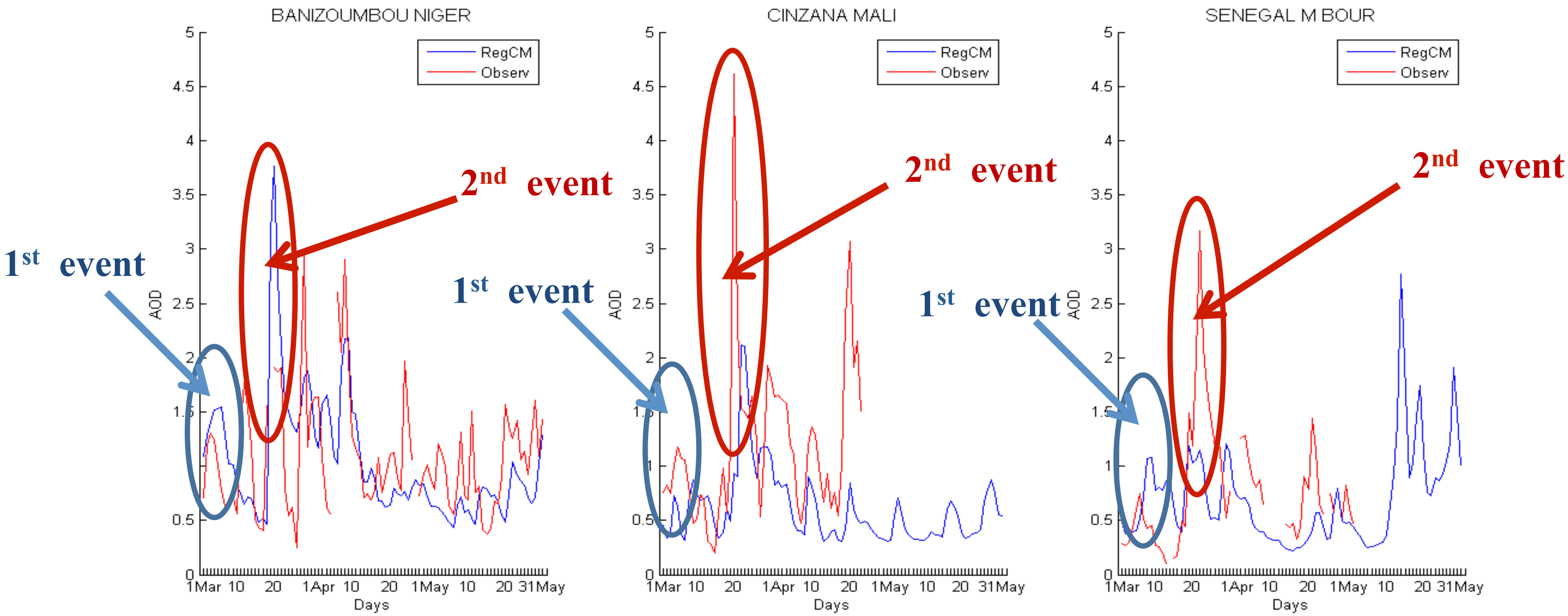


Figure 4: Comparison of AOD values between the RegCM 4.0 simulations and the observations made with the AERONET at 500 nm (from March to May 2010).

AERONET observation at the 3 stations showed 2 dust events in March.

Banizoumba station: first peak in March was captured by RegCM late.

The second event (17th to 21st March) was well captured by RegCM, compared to the first (5th to 8th March) event.

Model AOD values slightly underestimated compared to the AERONET observed values.

Dust episodes during March 2010

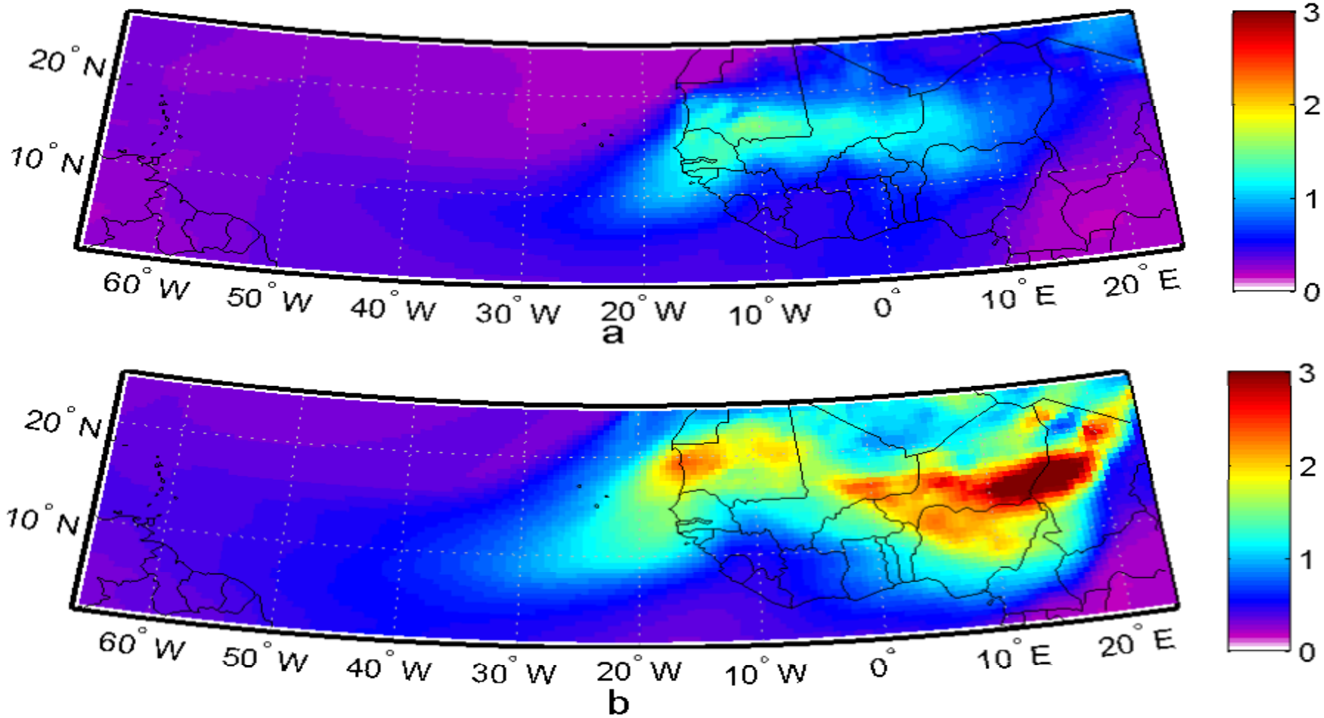


Figure 3 : Mean AOD values during dust episodes simulated with the RegCM 4.0: (a) March 5-8 and (b) March 17-21.

Two major emission events were simulated: First 5th to 8th March. Second : 17th to 21st March

Temporal evolution of dust plumes

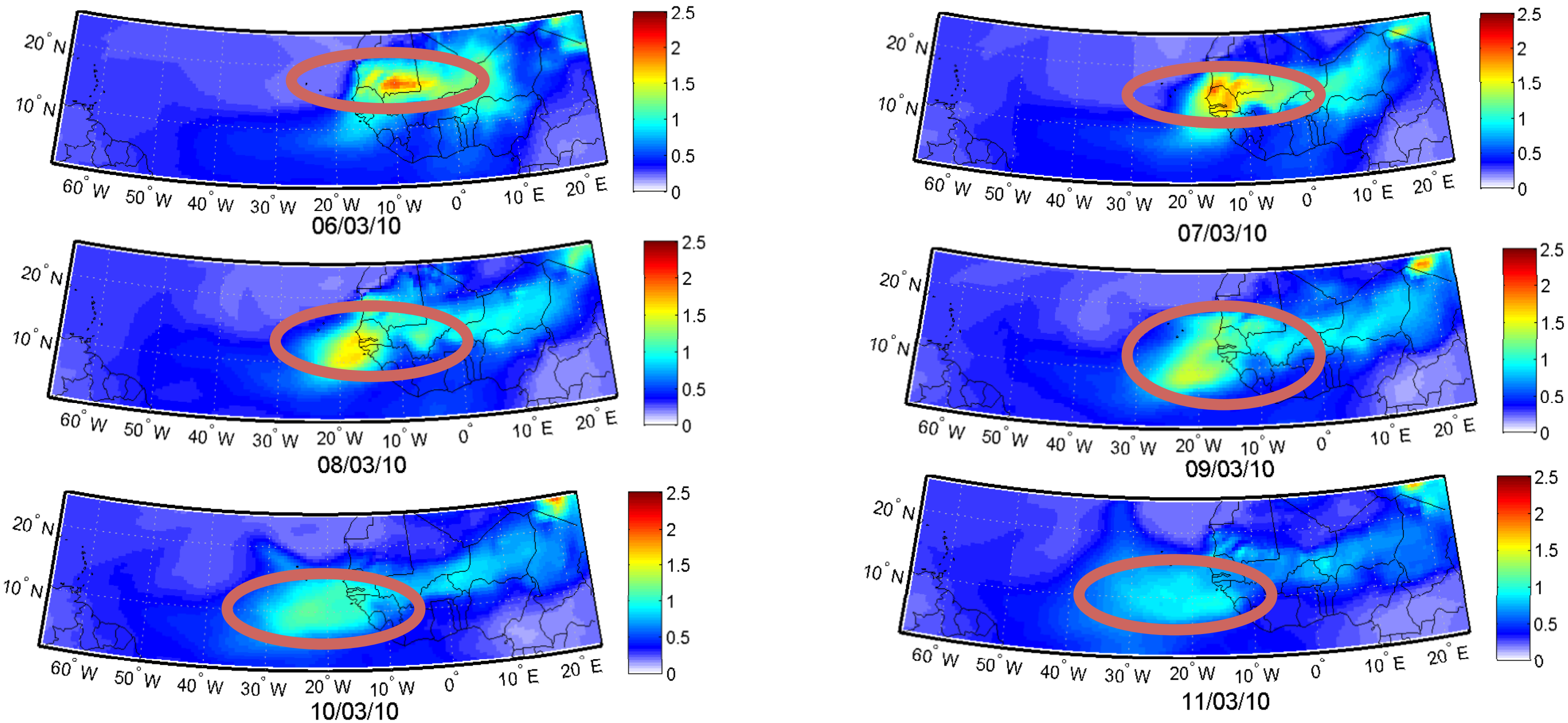


Figure 5 : Evolution of dust particles (episode of March 5-8th simulated with the RegCM 4.0) from the African continent towards the Atlantic Ocean between March 6-11th 2010.

March 6th, dust plumes maximum over Mauritania and Senegal.
March 7th, maximum over Senegal and Gambia.
March 8th, maximum over Ocean beyond the Guinean Coasts.
March 9th, entirely present over the Atlantic Ocean .

Dust plumes spent 3-5 days to pass through the continent to the Atlantic Ocean

Temporal evolution of dust plumes

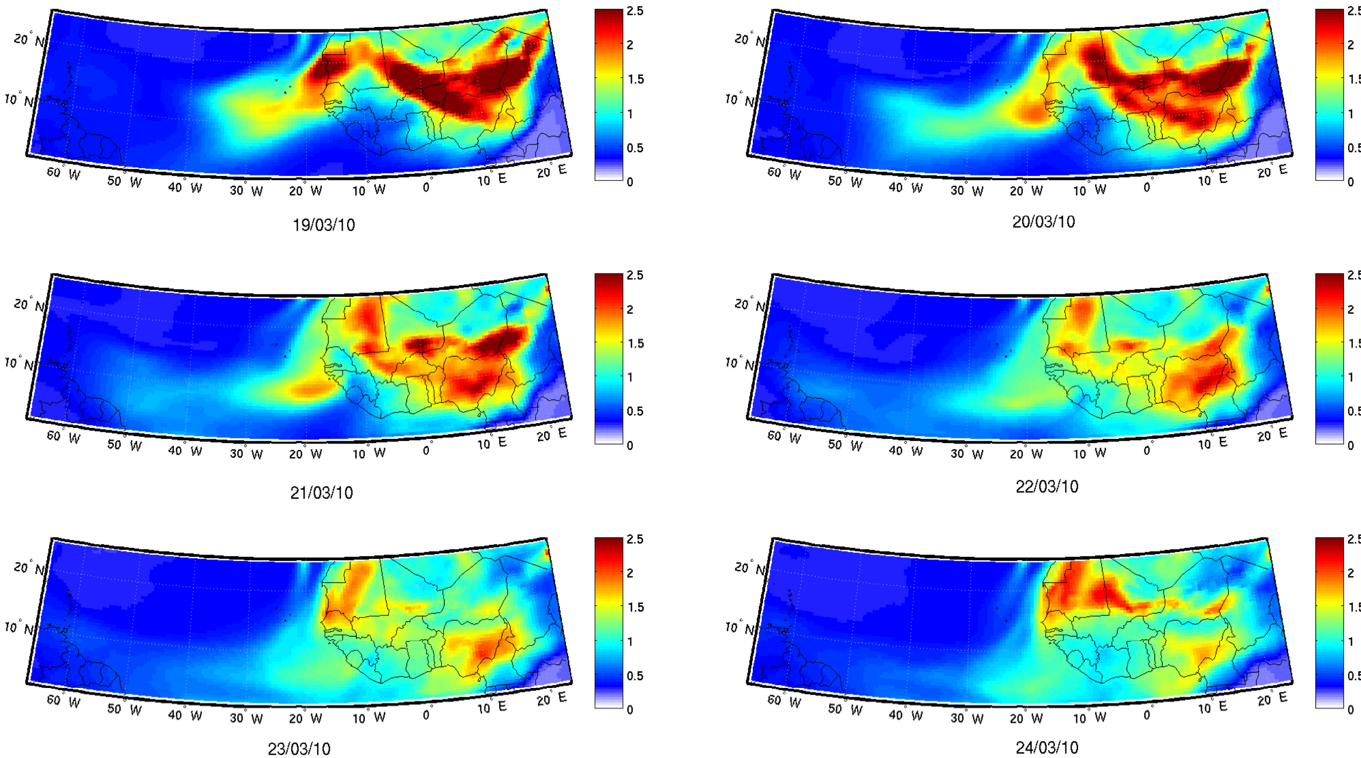


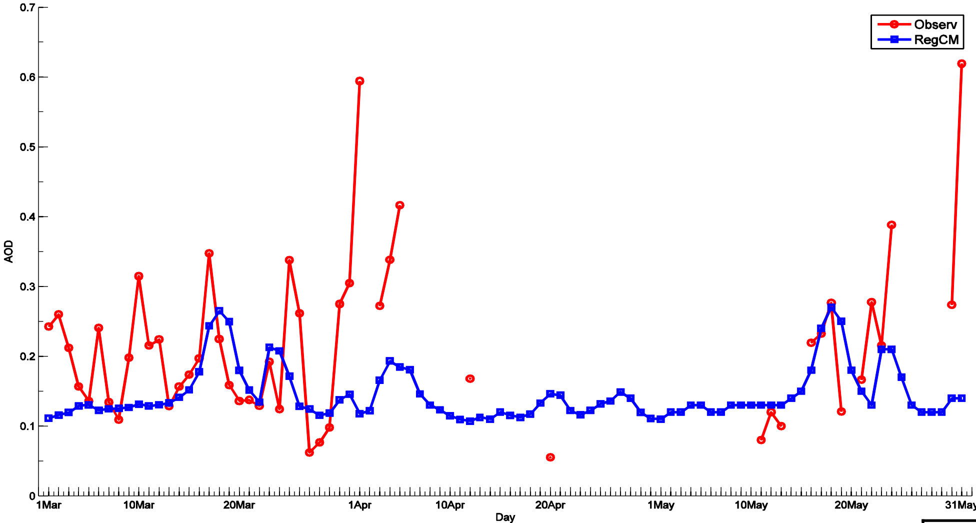
Figure 5 : Evolution of dust particles (episode of March 17-21th simulated with the RegCM 4.0) from the African continent towards the Atlantic Ocean between March 19-24th 2010.

Chad and Niger sources were active simultaneously during the first 3days (19th, 20th and 21st of March).

spatial evolution was more accentuate than the temporal evolution.

Dust plumes spent 3-5 days to pass through the continent to the Atlantic Ocean

Dust detection in Ragged Point during spring 2010



Peaks satisfactorily captured by the model compared to AERONET observations.

March and April AERONET AOD values in 2010 more than doubled of the same months during 2008 and 2009

Figure 6 :Daily simulated AOD values at the Ragged-point station, during March-April-May 2010 with the RegCM 4.0 and observations from AERONET.

dust emissions occurring during the first 10-days of March 2010 were not detected by the model.

		2008	2009	2010
March	RegCM	0.11	0.14	0.21
	Observation	0.09	0.08	**0.19**
April	RegCM	0.15	0.17	0.21
	Observation	0.18	0.09	**0.31**
May	RegCM	0.19	0.22	0.18
	Observation	0.16	0.23	0.24

Zonal and meridian transport of dust

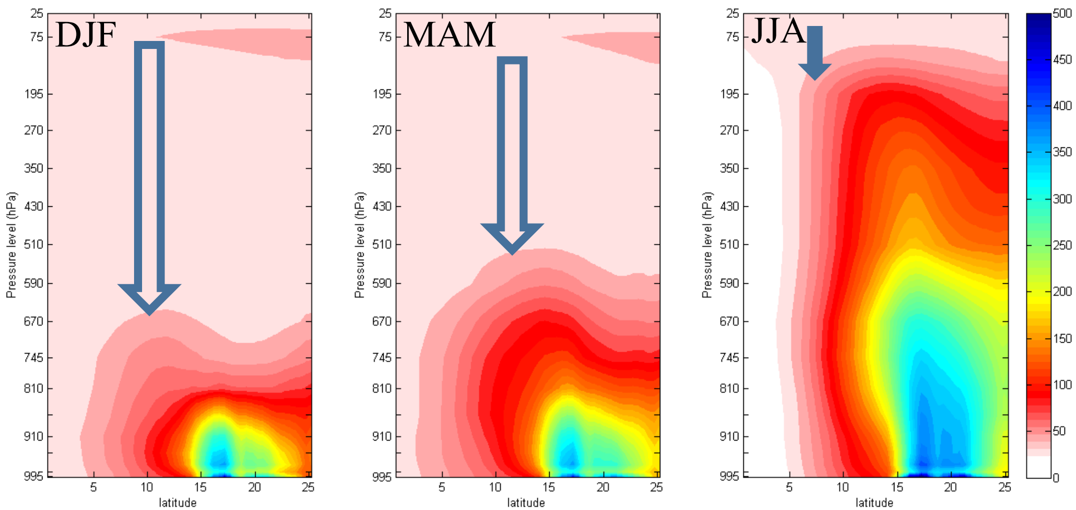


Figure 6: Meridian profile of mean desert dust concentrations in troposphere µg/kg average between 66°W and 23°E for DJF, MAM and JJA.

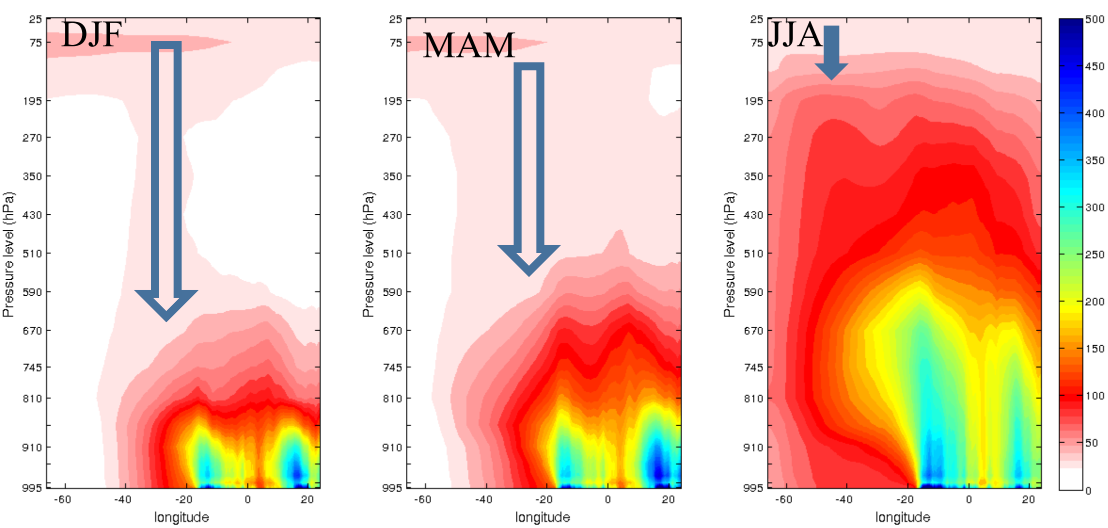


Figure 7: Zonal profile of mean desert dust concentrations in µg/kg in troposphere average between 0°N and 25°N for DJF, MAM and JJA .

Dust sources location: 18º to 22º N

The dust source around 18°N (Bodélé) quasi-continuous activity.

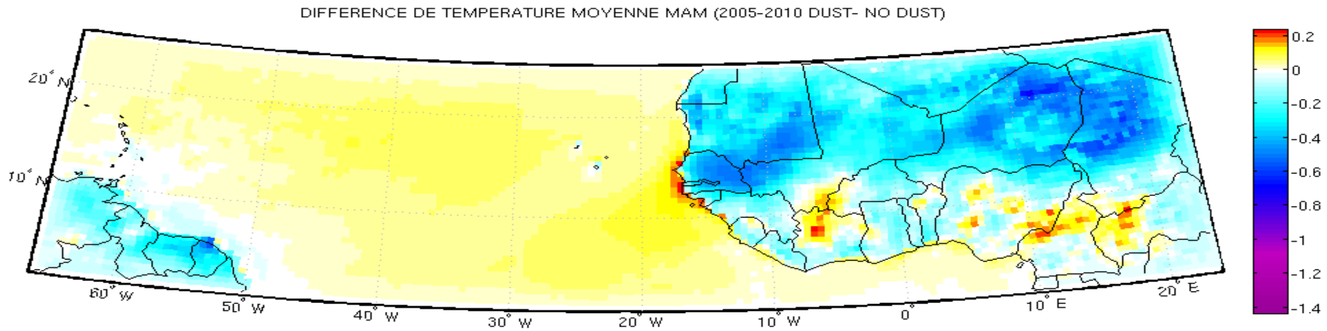
Ascending altitude from DJF to JJA.

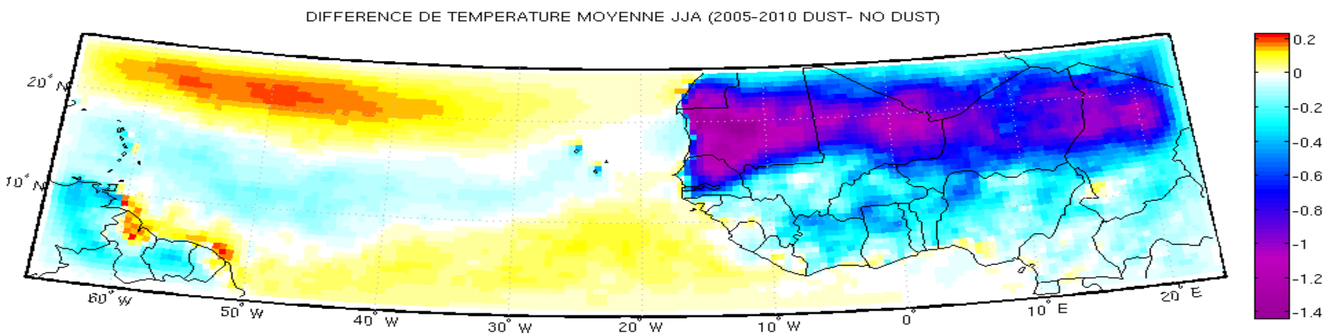
Trajectories linked to altitudes reached by dust plumes.

Dust transport strongly influenced by regional atmospheric dynamic.

DUST IMPACTS ON SURFACE TEMPERATURES

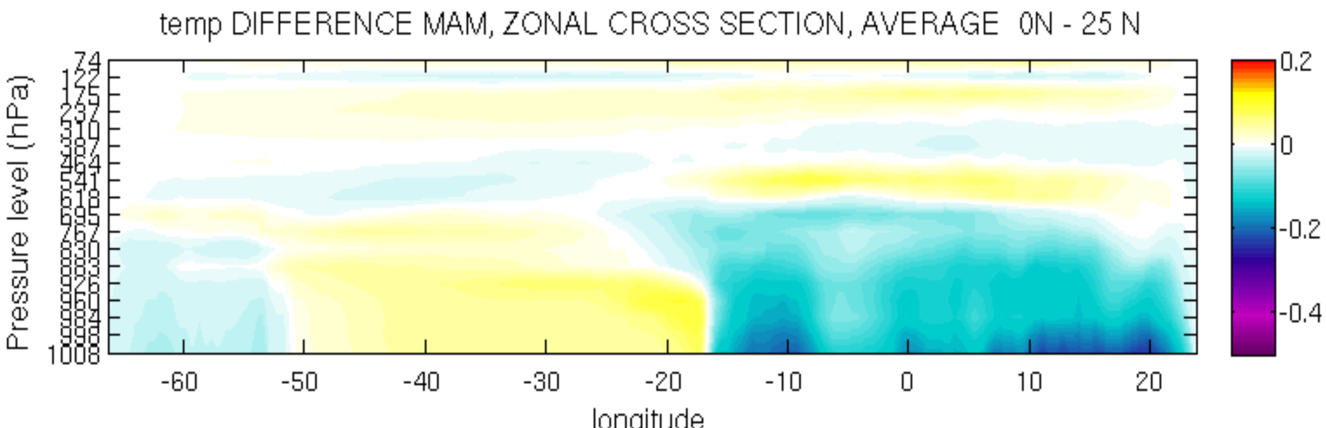
Dust -No Dust

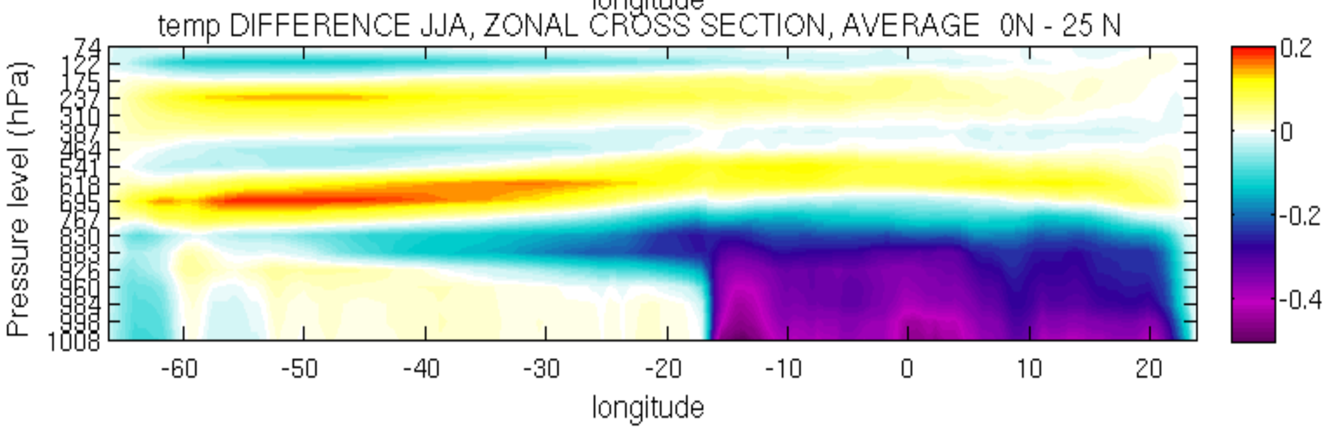




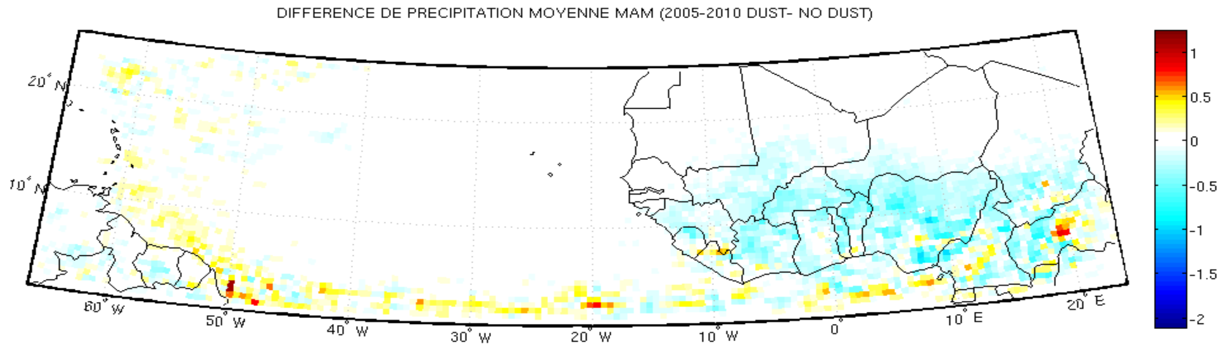
Cooling of the surface, pronounced at source area
Cooling of the SST under the SAL

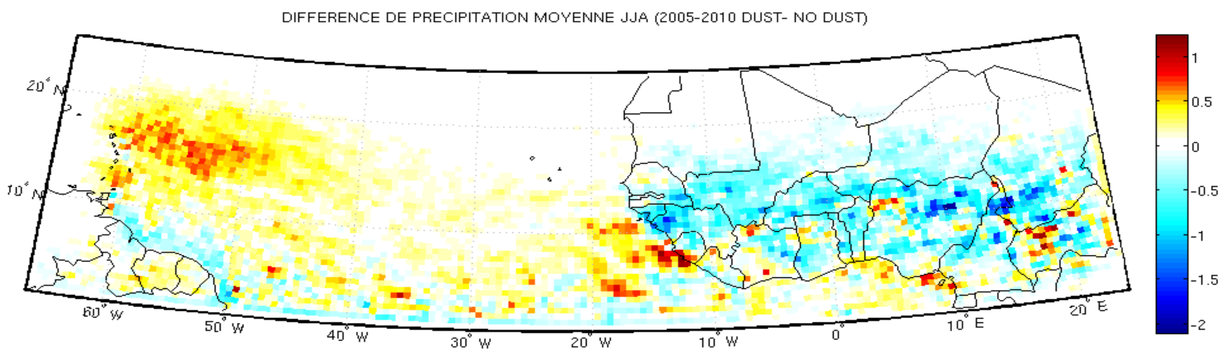
DUST INDUCED ATMOSPHERIC THERMAL VERTICAL PROFILE





DUST IMPACTS ON PRECIPITATIONS





Decrease precipitation over sahel and increase over the ocean

Conclusion

✓Seasonality of trajectories associated with the seasonality of altitudes reached by dusts plumes.

✓Vertical profile of dust concentrations revealed a progressively increase DJF to JJA, with a transition altitude during MAM.

✓RegCM well captured the variability of various episodes at stations Banizoumba, Cinzana and M'Bour AERONET station with underestimation the peaks.

✓Cooling effect in the whole region both during the period MAM and the monsoon period (JJA).

✓However, the extension over the Atlantic Ocean did not modify the results found by these previous studies.

✓Decrease in MAM and JJA precipitations with exception of some zones in Central Africa, West Africa (Southern-Guinea and Northern-Liberia), Caribbean, and South America, where increased in precipitations were observed during MAM.

THANKS FOR YOUR LISTENING