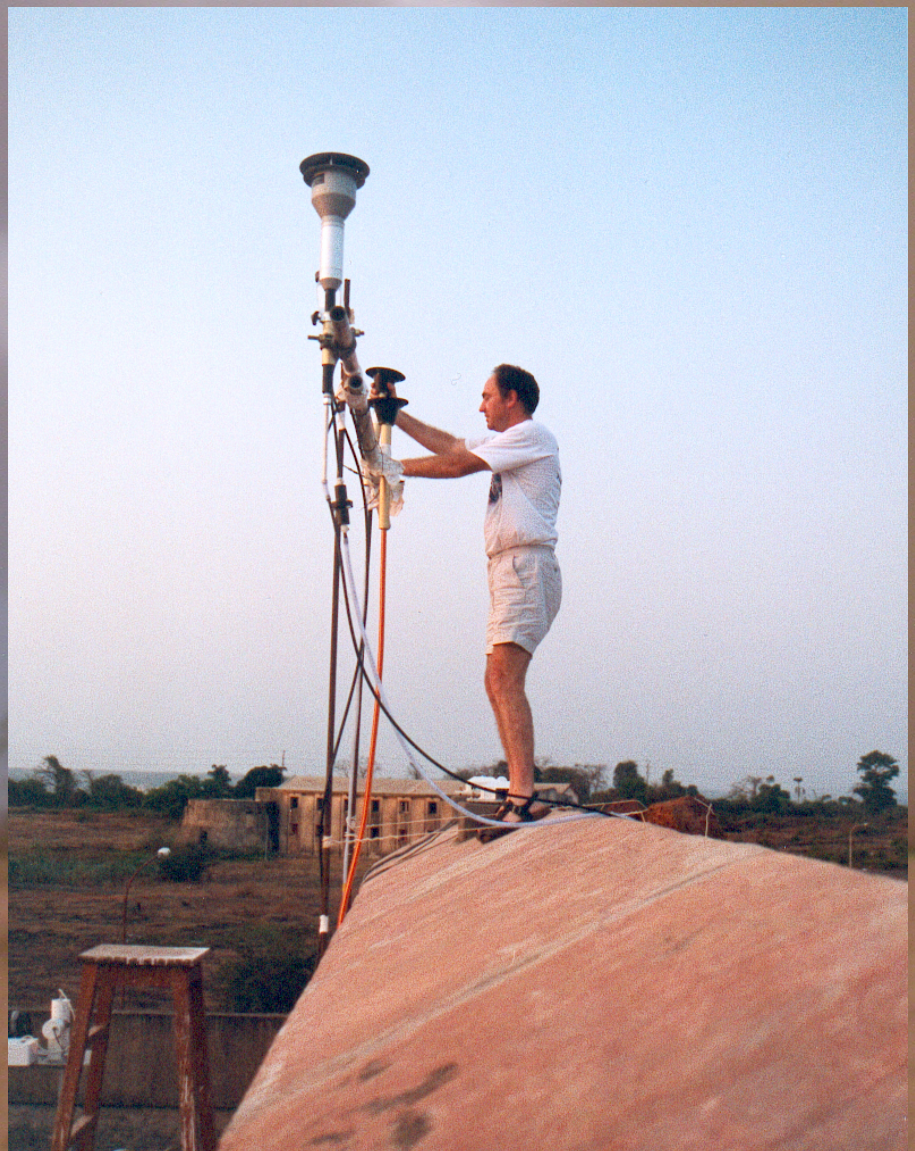
Une pensée pour Laurent Gomes…



Comparison between the mineral dust content simulated over Western Africa with the CHIMERE-DUST model and surface observations from the Sahelian Dust Transect

Catherine Schmechtig [(1)] , Béatrice Marticorena [(1)] ,, Bernadette Chatenet [(1)] , Gilles Bergametti [(1)], Jean Louis Rajot [(1,2)] , and Adriana Coman [(1)]

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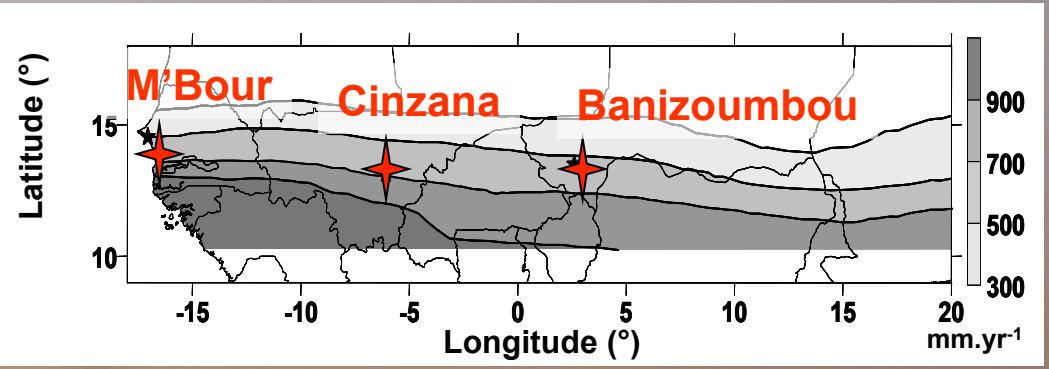
Main questions

- ⇨ **How intense is the mineral dust direct radiative effect ? What are the Saharan and Sahelian dust optical properties, horizontal and vertical distribution ?**
- ⇨ **To what extend does African dust contribute to iron deposition over Ocean ? What is the iron solubility of Saharan and Sahelian dust in or close to source regions ?**
- ⇨ **Is the Sahel a significant source of mineral dust compared to the Sahara ? What about the anthropogenic contribution ?**
- ⇨ **What controls the variability of the mineral dust content over West Africa from the daily to the interannual time scale ?**

Strategy

⇨ Regional and long term field measurements

The Sahelian Dust Transect



⇨ Continental scale modelling

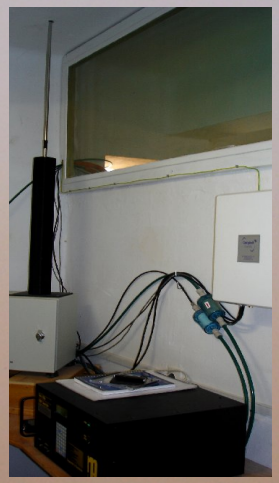
Chemistry and Transport Model

ChimereDUST

The Sahelian Dust transect : Instrumentation

Selection : simplicity and resistance to severe dust and meteorological conditions

TEOM



Mass concentration
(5 min)

PM10 inlet

Basic Meteorology
(5 min)

- **Wind velocity**
- **Wind direction**
- **Temperature**
- **Relative humidity**

Total and wet deposition
(Week to event)

Aerosol Optical Depth
AERONET/PHOTONS
sunphotometer

(Marticorena et al. ACP, 2010)

The Chimere-Dust model

Dust Emission :

⇒ Dust emissions fluxes (Marticorena and Bergametti, 1995); Surface data base (Marticorena et al., 1997)

⇒ Dust size-distribution (Alfaro and Gomes, 2001)

⇒ distributed on 20 log. Bins

Meteorological forcing

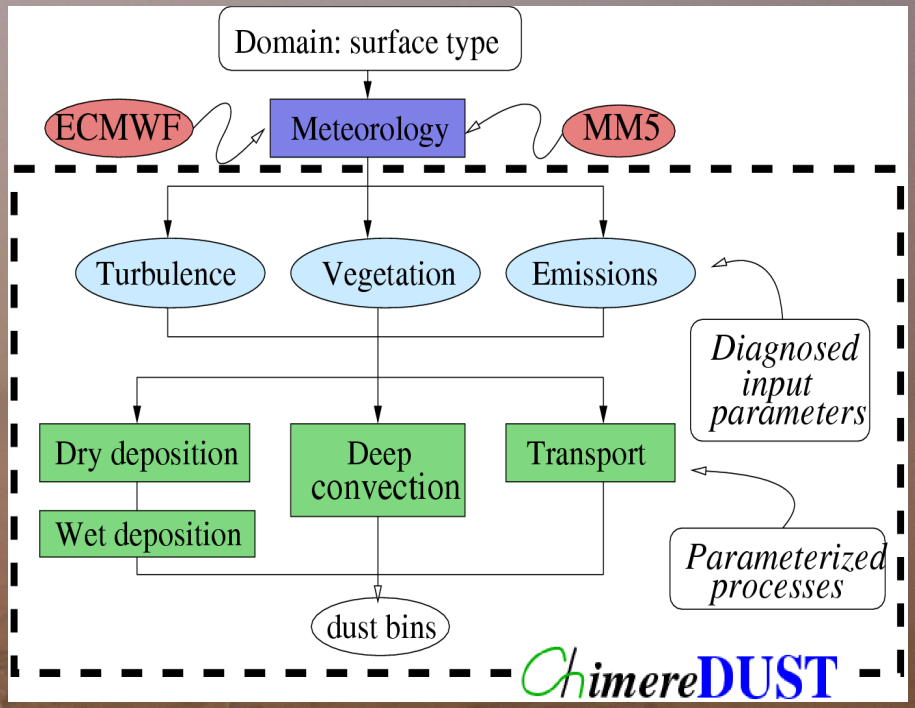
-ECMWF Operational products + empirical correction of surface winds in the Bodélé Depression

Domain : 10S-60N, 90W-90E

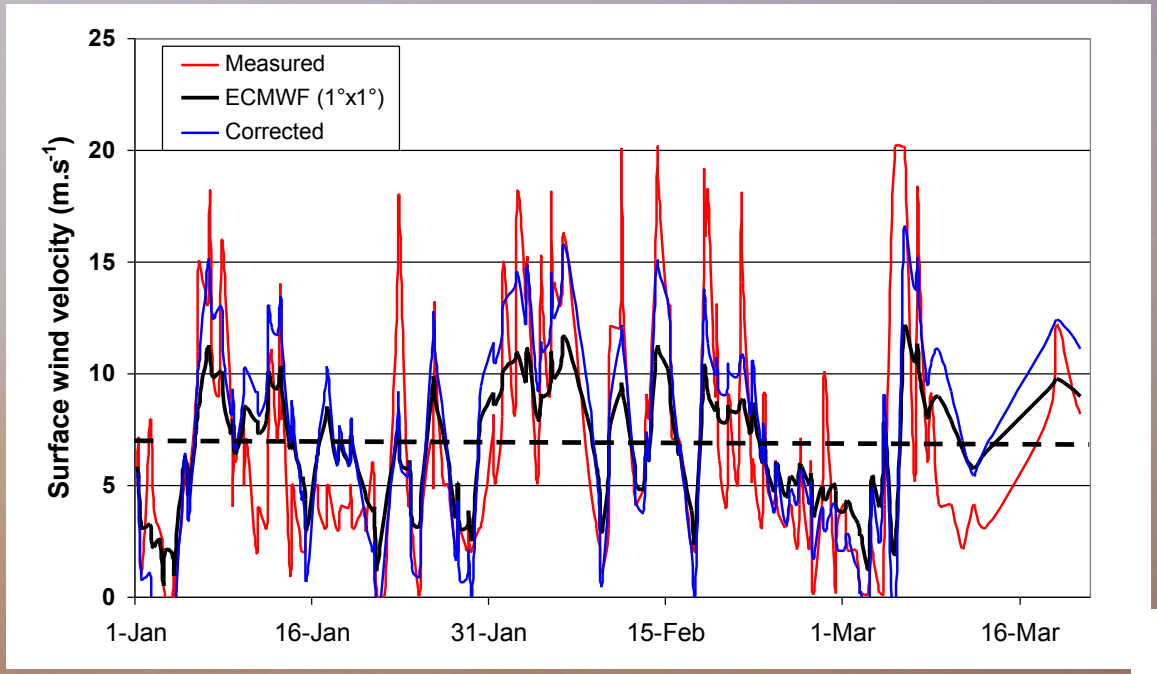
North Atlantic, North Africa, Arabian Peninsul

Resolution
- Horizontally: (1x1 degrees)
-Vertical mesh 15 to levels (up to 200hPa)
-1 h time step

Model outputs
-Dust concentration
-Optical thickness @550 nm
(Refractive Index =1.5 - 0.005i ; (Moulin et al., 200
- deposition fluxes



Correction of the surface wind in the Bodélé Depression

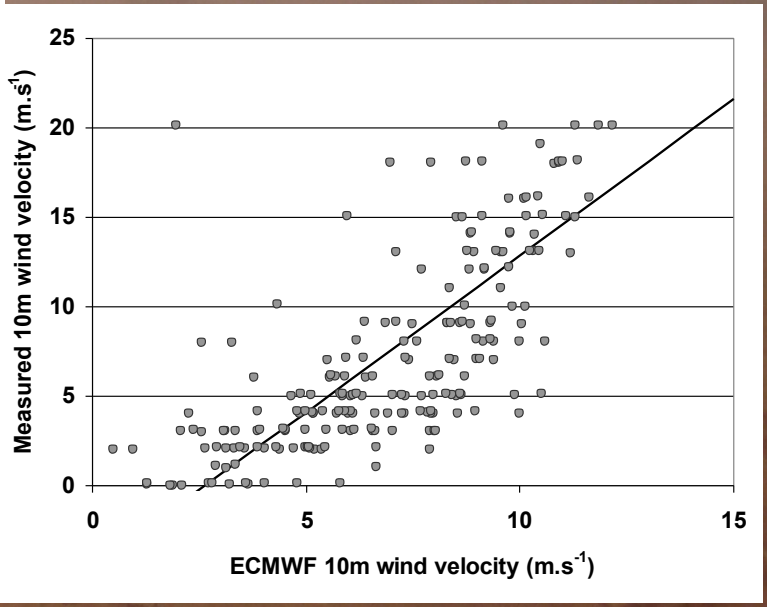


ECMWF surface winds are underestimated by ~a factor 2 (Faya-Largeau; 2004)

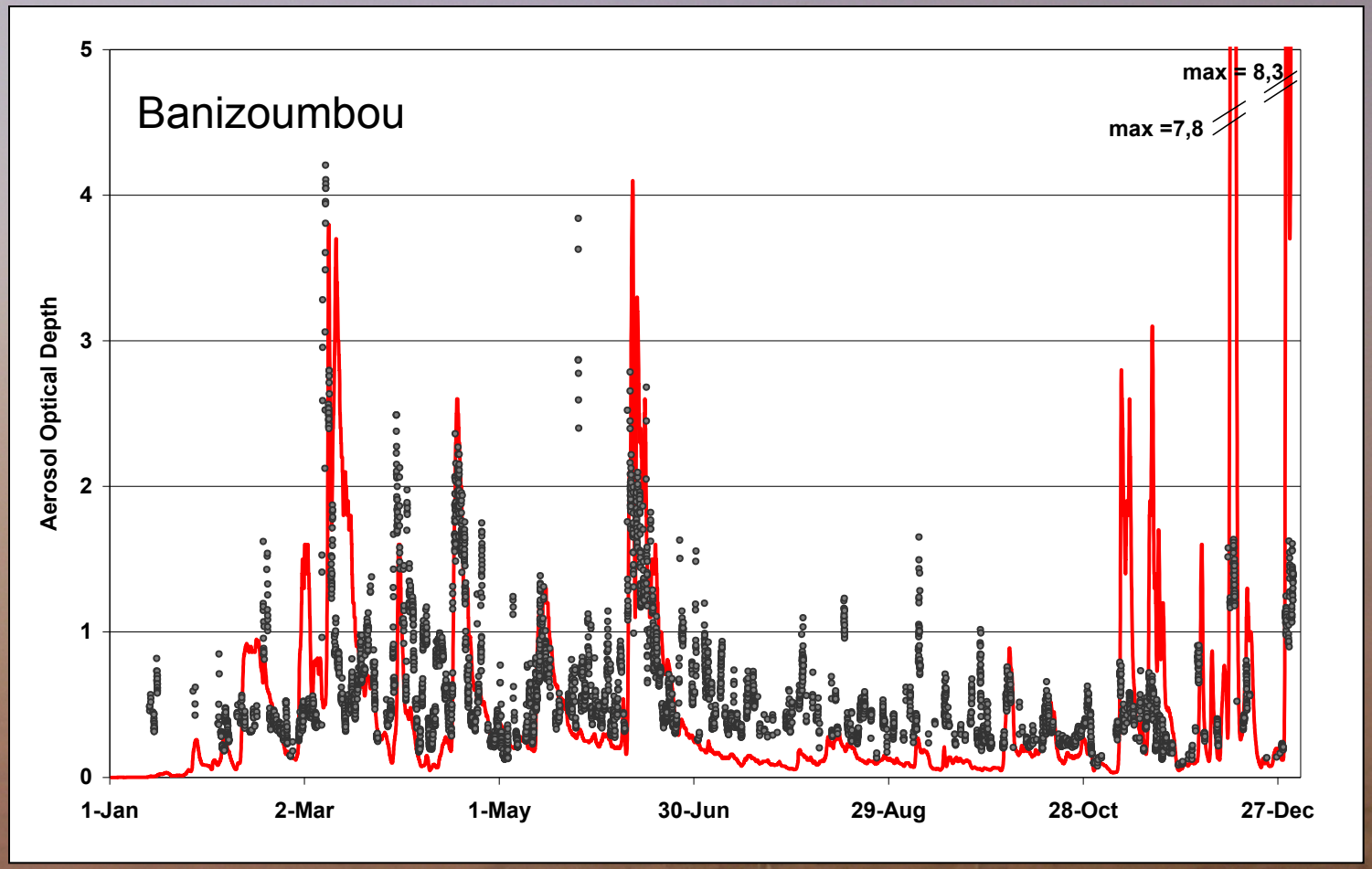
(Schmechtig et al. ACP, 2011)

A crude correction : linear relationship Measured-Model wind speed in a box (15-19°N; 15-20°E) including the Bodélé Depression

$$10m\ WindSpeed_{corrected} = -4{,}62 + 1{,}75 \times 10m\ WindSpeed_{ECMWF}$$



Simulated hourly aerosol optical depth (2006)

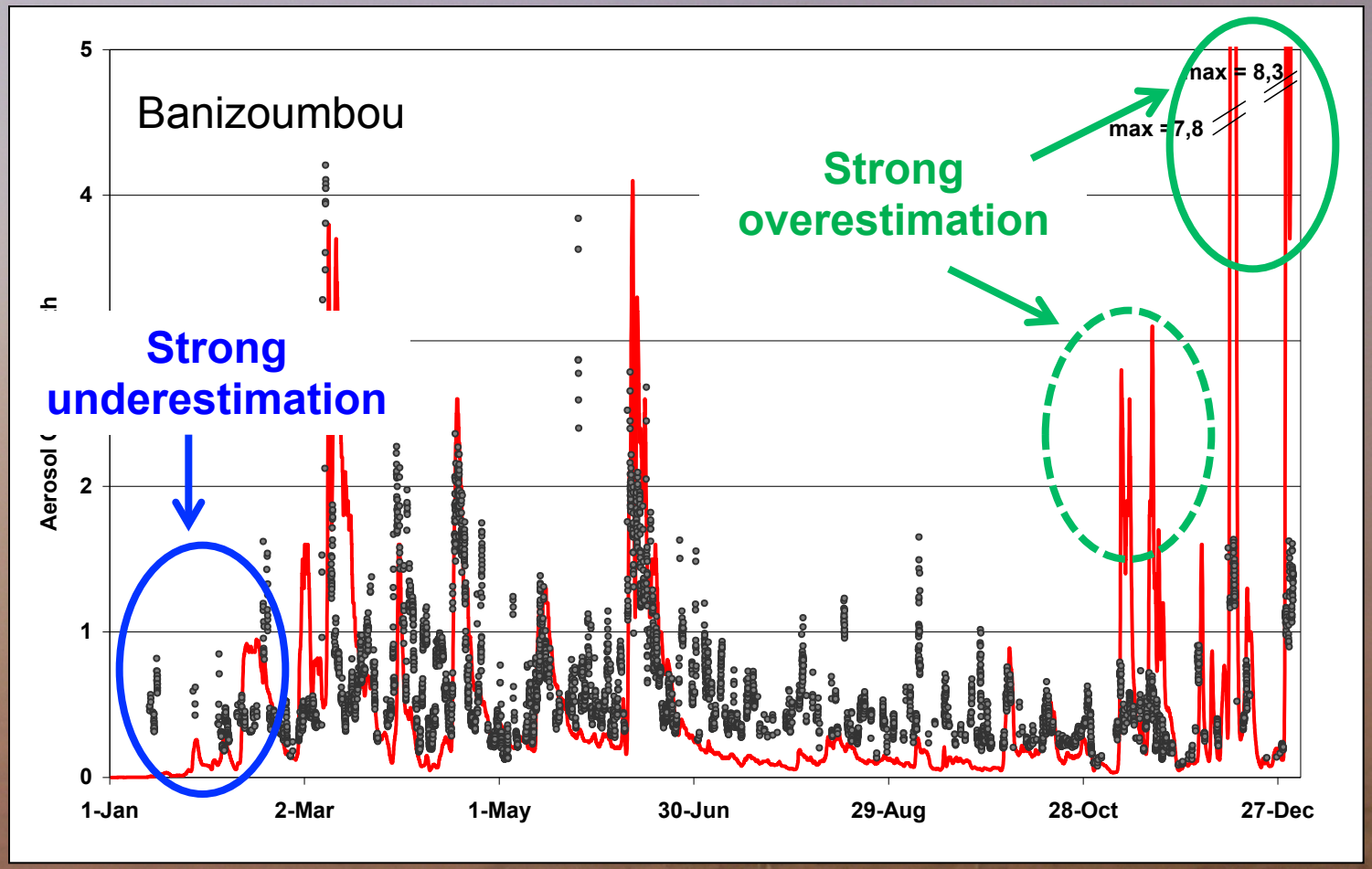


(Level 2 AODs with α>0.4)

⇨ **Most of the dust events are retrieved in terms of timing and intensity**

(Schmechtig et al. ACP, 2011)

Simulated hourly aerosol optical depth (2006)



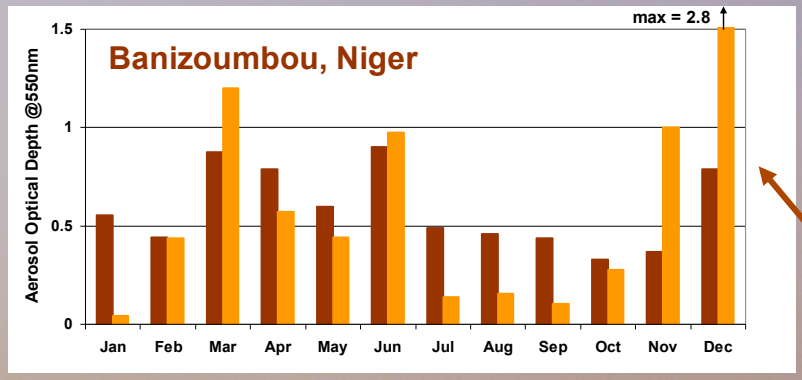
(Level 2 AODs with α>0.4)

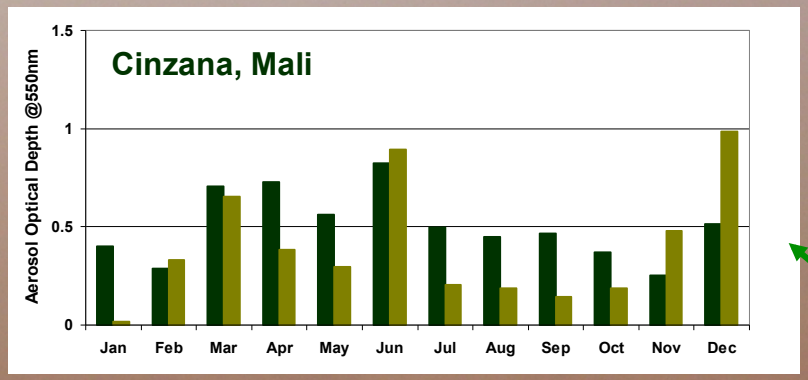
⇨ **Still problems with emissions from the Bodélé Depression !!**

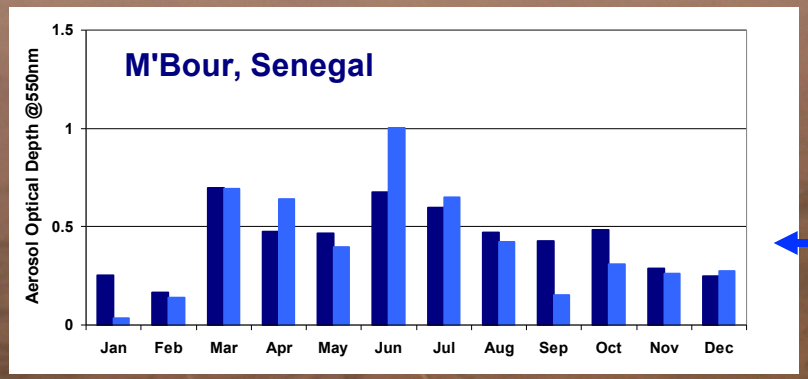
(Schmechtig et al. ACP, 2011)

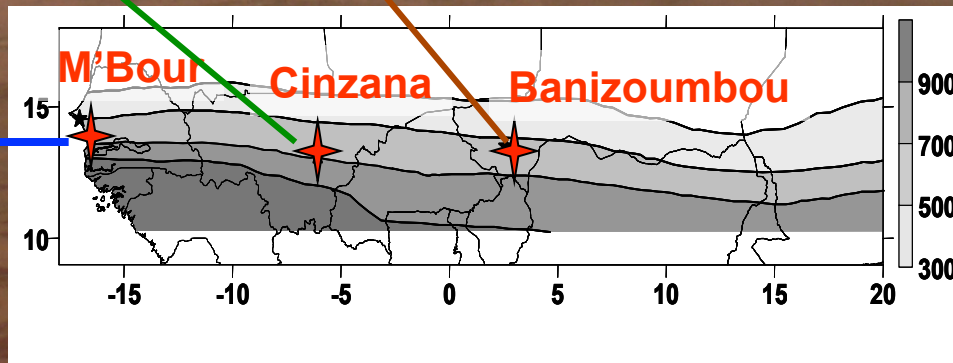
Simulated monthly aerosol optical depth (2006)

ChimereDUST



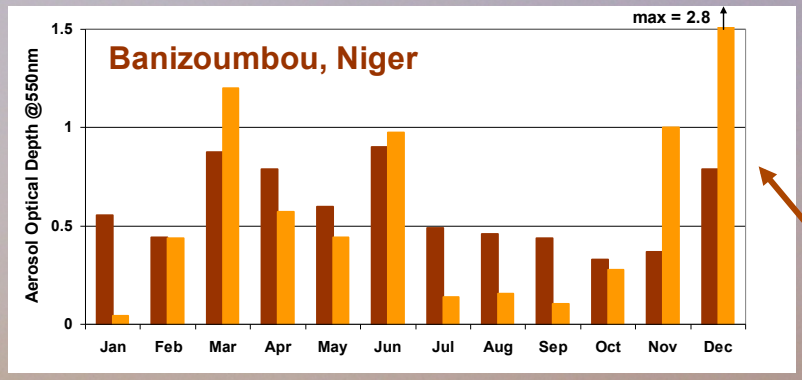


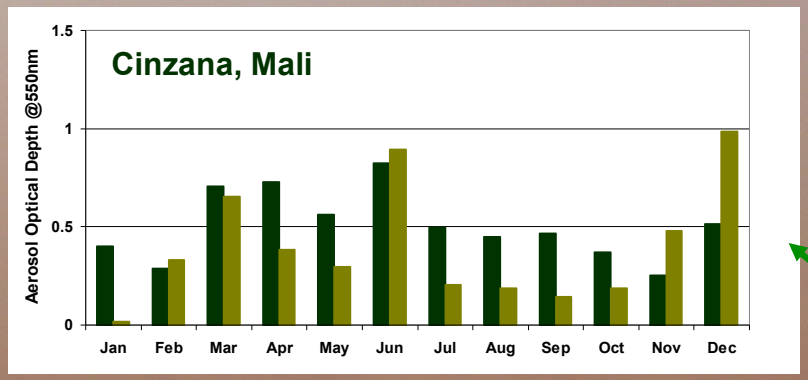


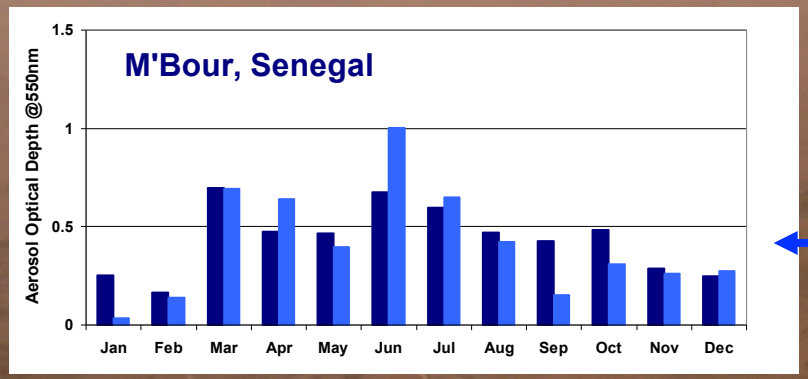


(Observed : dark color; Simulated : light color)

Simulated monthly aerosol optical depth (2006)







(Observed : dark color; Simulated : light color)

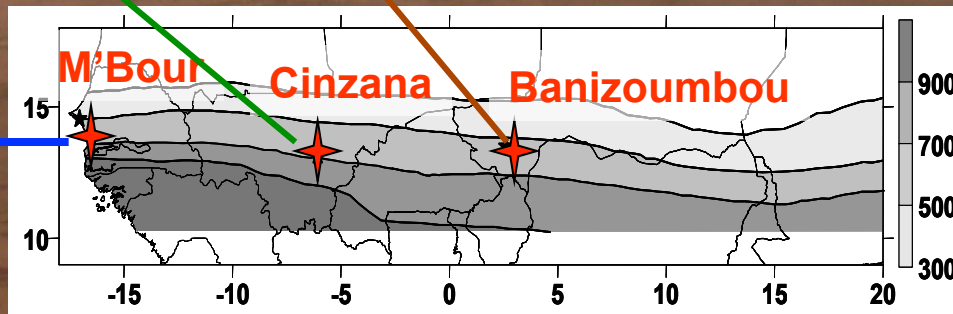
ChimereDUST

⇨ **The magnitude of the observed AOD is well simulated (except jan., dec.)**

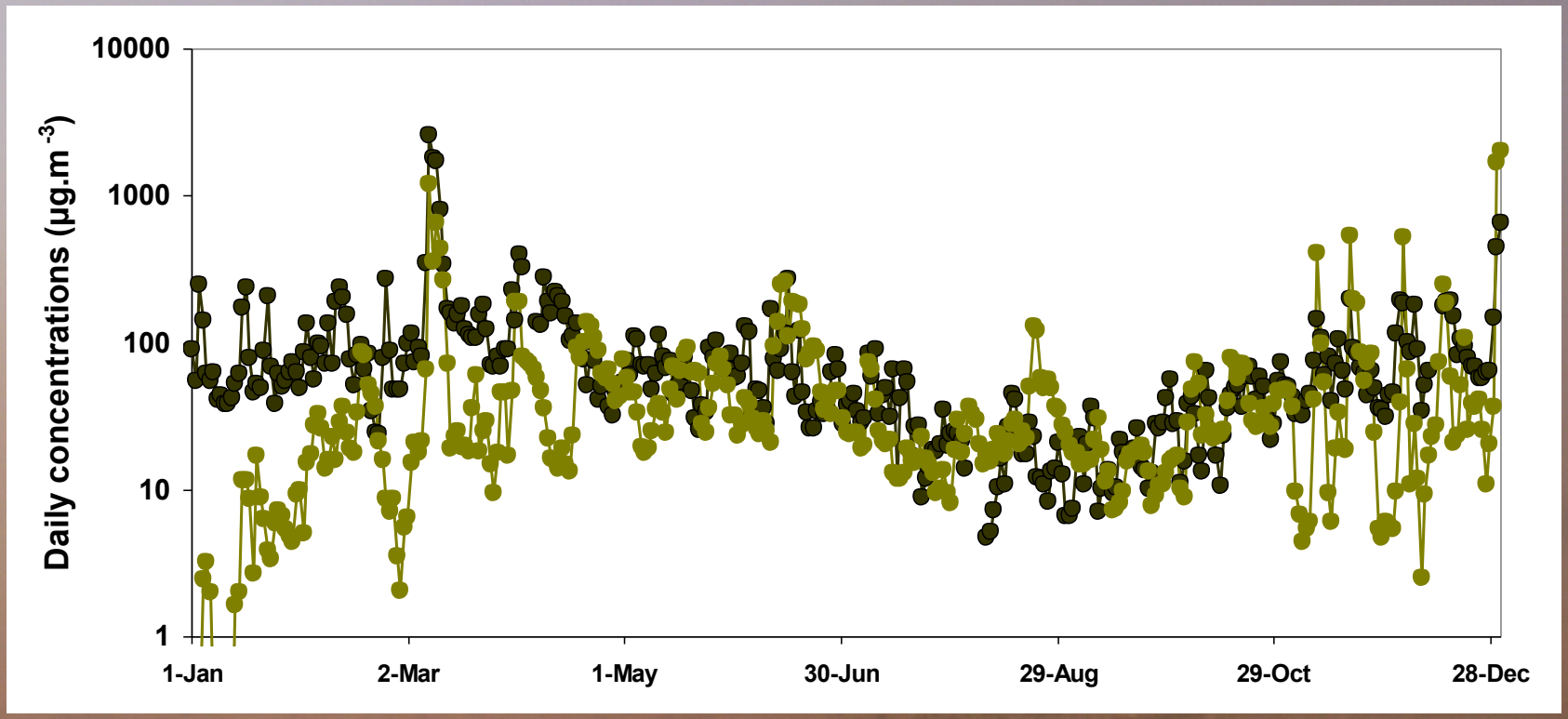
⇨ **A similar seasonal cycle is reproduced at the three stations**

⇨ **The west to East gradient is correctly retrieved**

⇨ **The observed and simulated AODs are significantly correlated (n=36; r=0.53)**



Simulated daily surface concentrations (2006)



(Observed : dark color; Simulated : light color)

- ⇨ **The order of magnitude of the surface concentrations is retrieved**
- ⇨ **The seasonal cycle is well reproduced at the three stations**
- ⇨ **The level of agreement with observations is similar than for air quality PM models (NME = 75%; NMB = -36 %)**

(Schmechtig et al. ACP, 2011)

Simulated deposition fluxes (2006)

Year 2006	Total deposition (µg.m^{-2})	
	Measured	Simulated
M'Bour	83,2	59.6
Cinzana	105	80.2
Banizoumbou	127,7	42.8

⇨ **Annual total deposition fluxes are reasonable but underestimated**

⇨ **The observed Est-West gradient is not reproduced**

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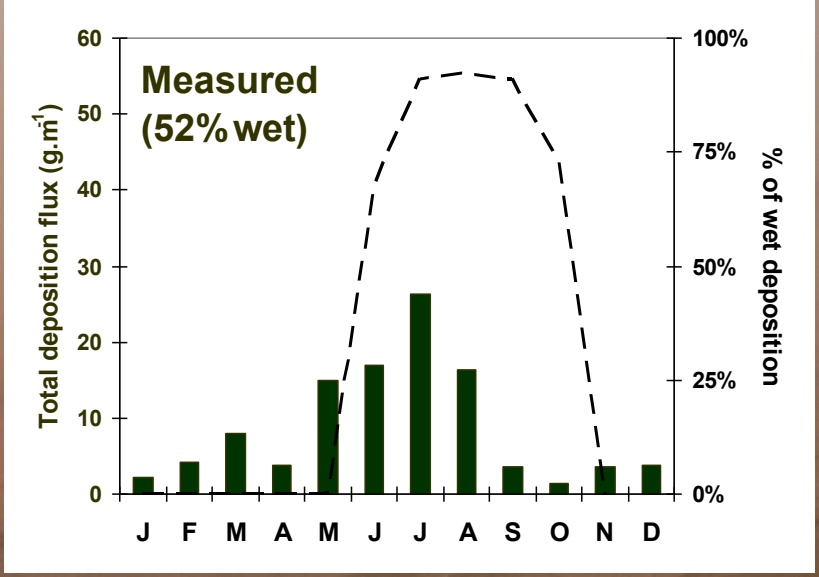
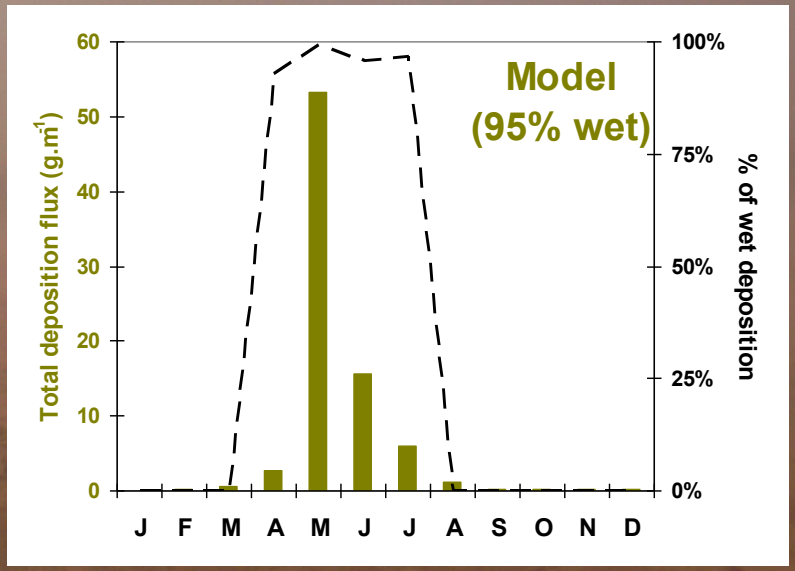
- Cinzana -





⇨ **Significant underestimation of the dry deposition ?**
⇨ **Significant bias due to precipitation spatial and temporal distribution**

Conclusion and perspectives

→The CHIMERE-Dust model correctly retrieve the measured AOD and surface concentrations
- order or magnitude
- seasonality
- Regional pattern

→ Deposition fluxes are reasonably simulated in terms of magnitude, but not in terms of regional pattern and proportion of wet and dry deposition

→ This agreement is obtained with quite (too ?) simulated dust emissions (~2300 Mt ; 0 >D>40 µm)

Conclusion and perspectives

► Bias in the meteorological forcing (surface winds; precipitation) must be assessed and corrected (as a function of space and time)

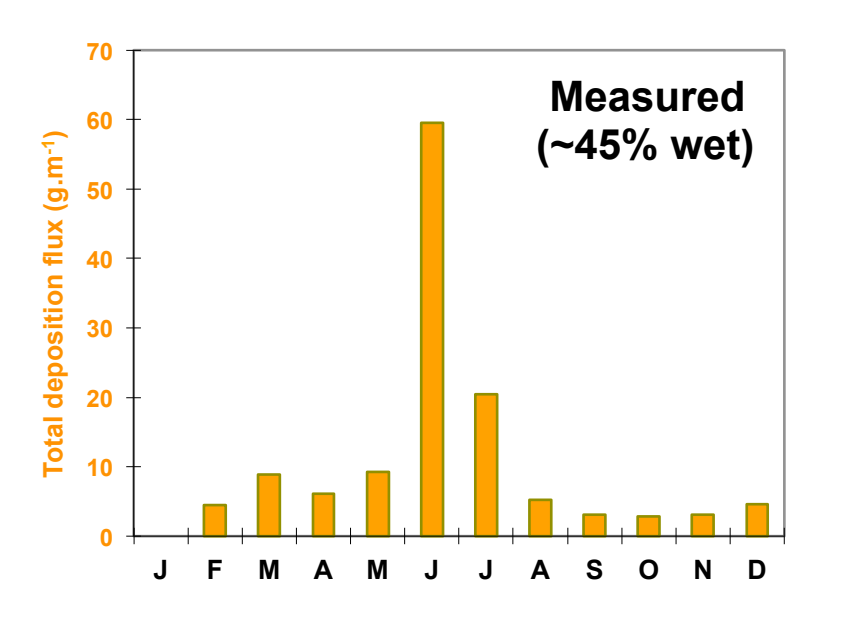
► The simulated dust mass budget is still underconstrained

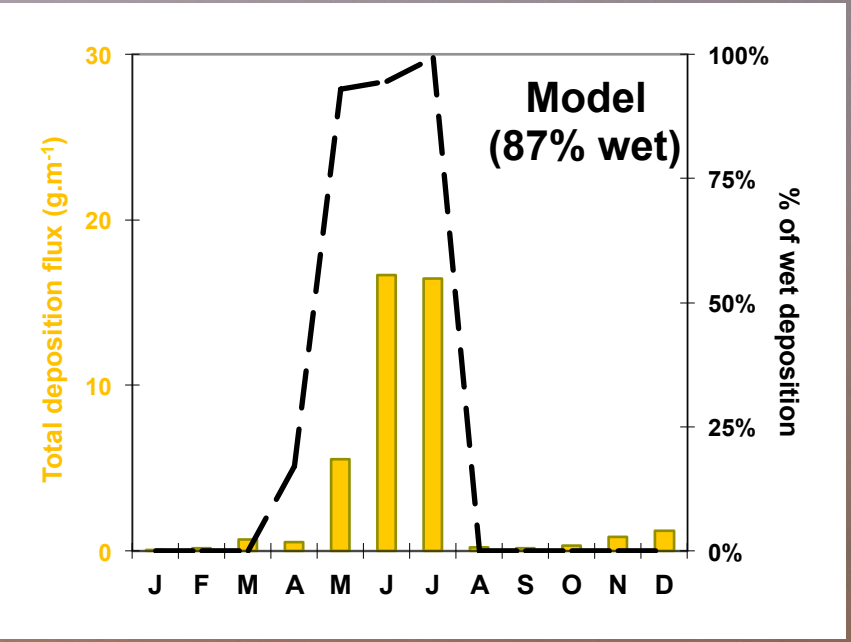
- Comparison with measured dust size distributions ; numerical tests

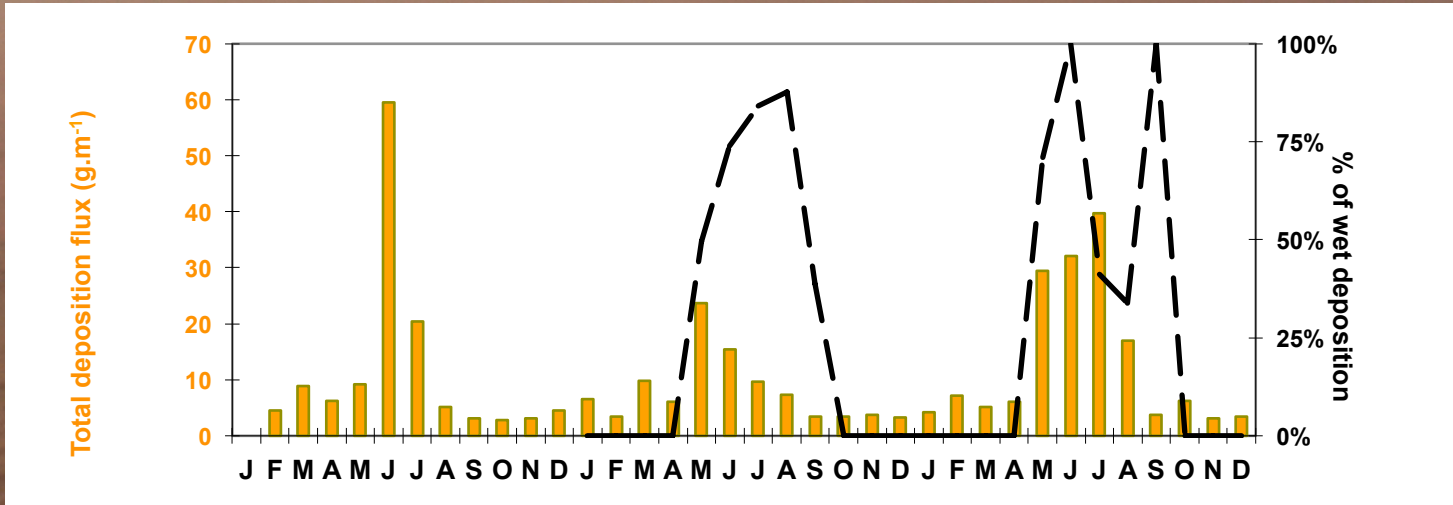
-Test on deposition fluxes (deposition velocity; precipitation pattern, etc ..)

Measured and simulated deposition fluxes

Banizoumbou, Niger

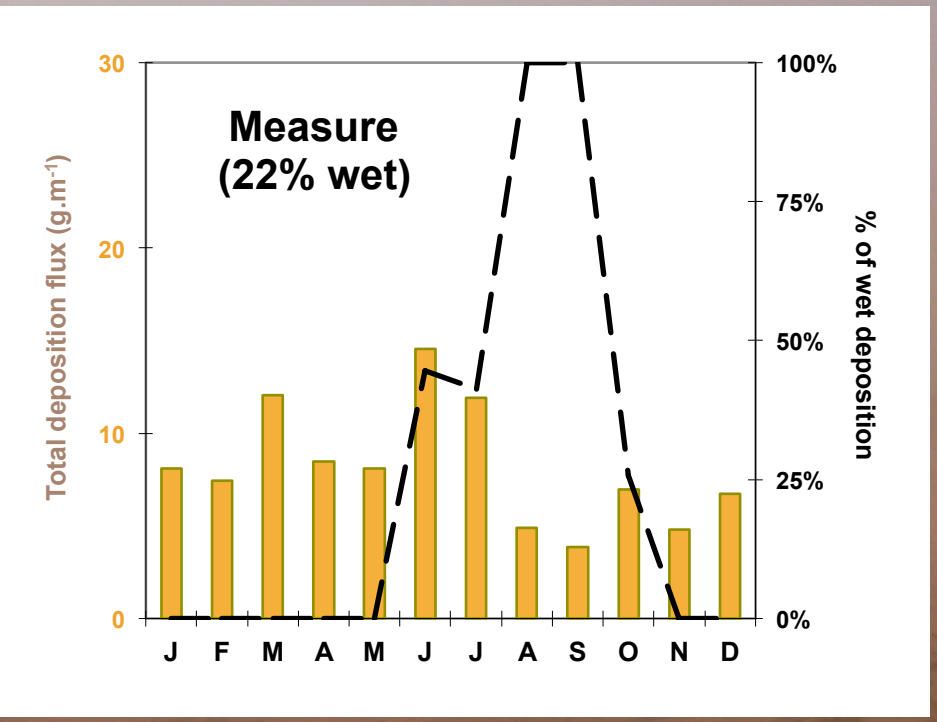


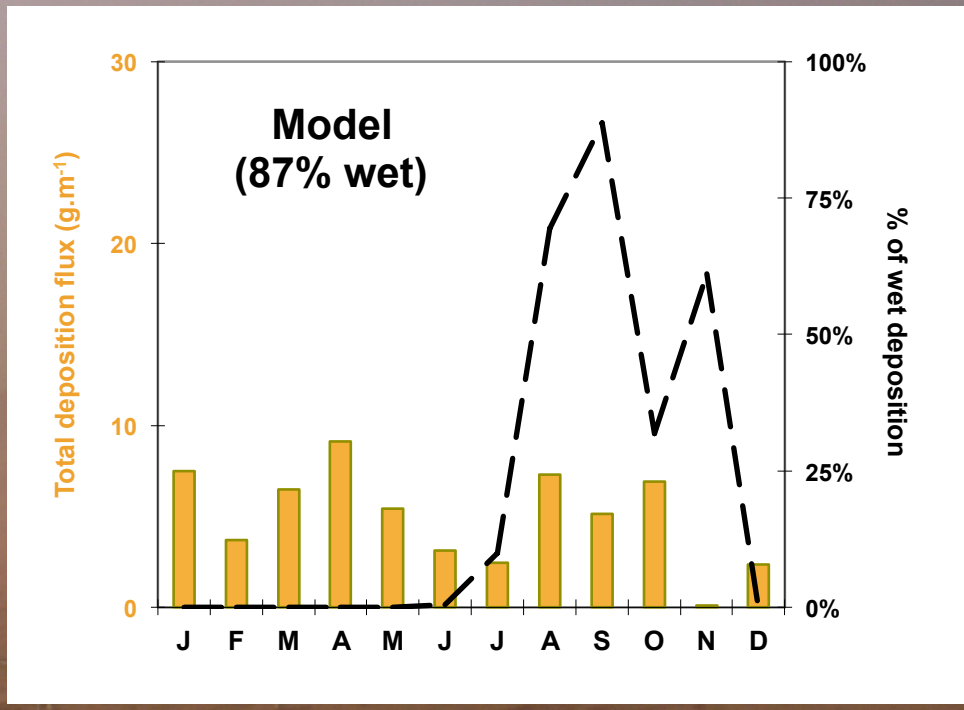


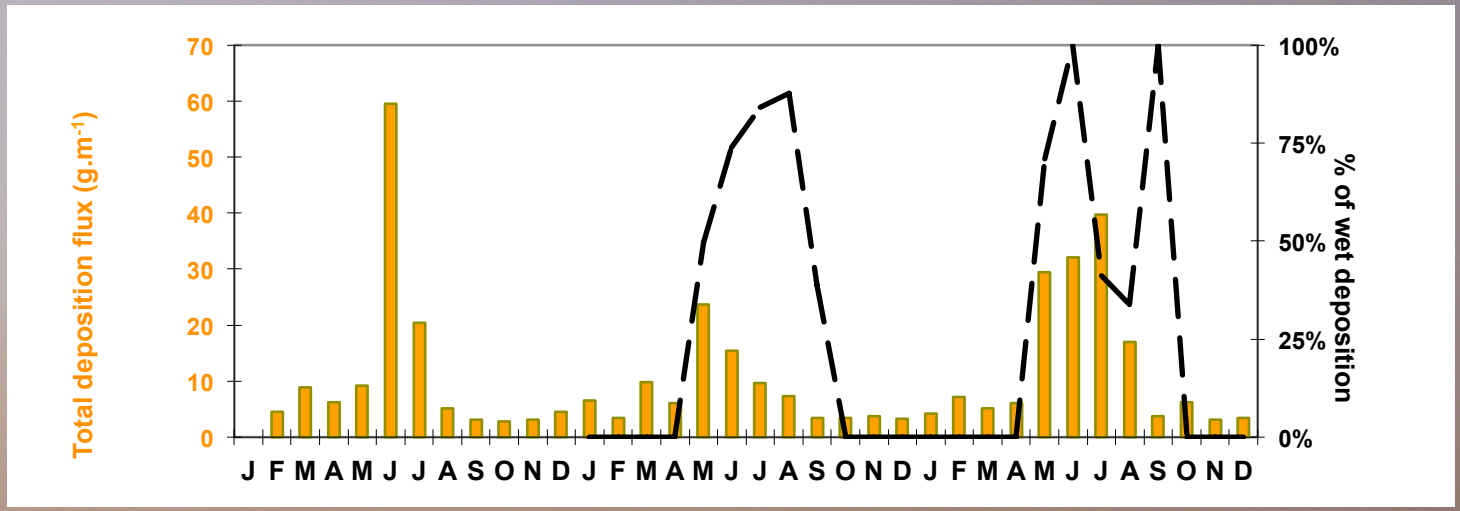


Measured and simulated deposition fluxes

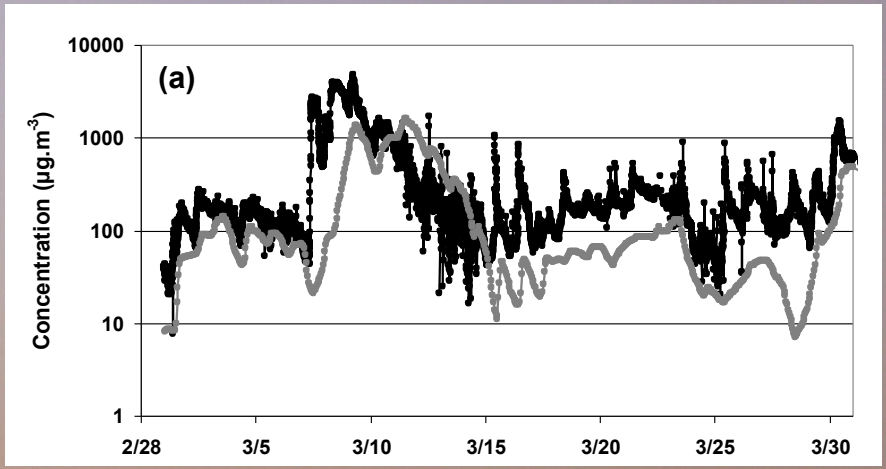
M'Bour, Senegal

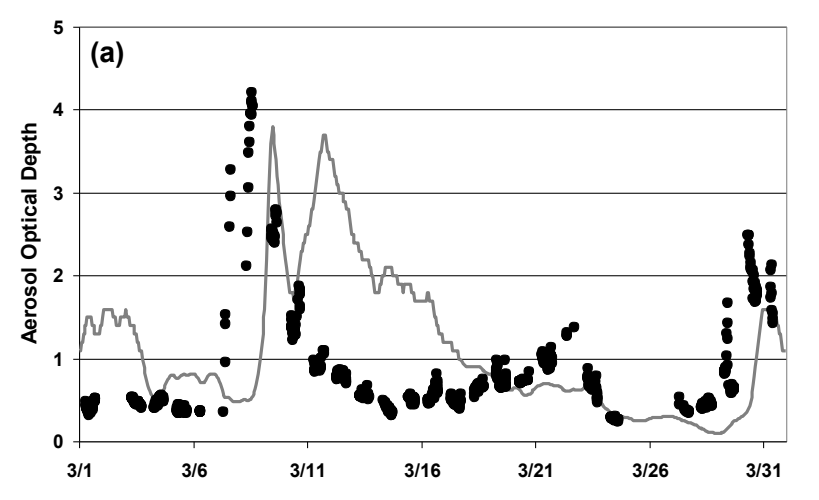


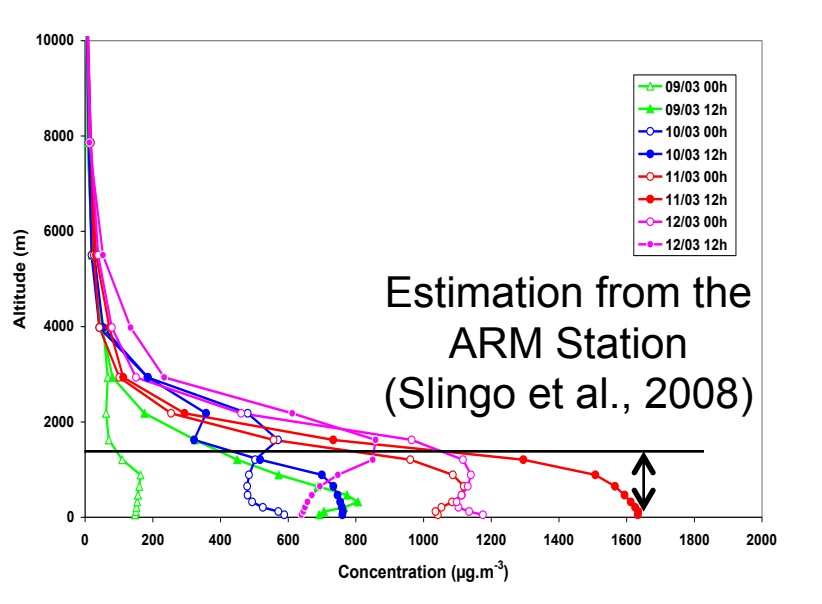



Total deposition flux (g.m-1)
70
60
50
40
30
20
10
0
100%
75%
50%
25%
0%
% of wet deposition
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D

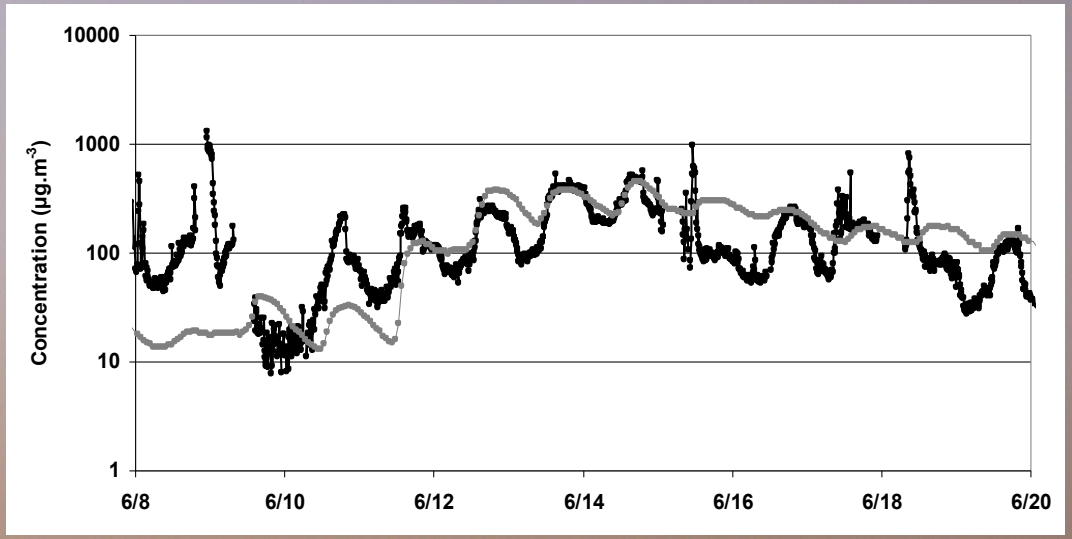
A low layer dust event (March 2006)

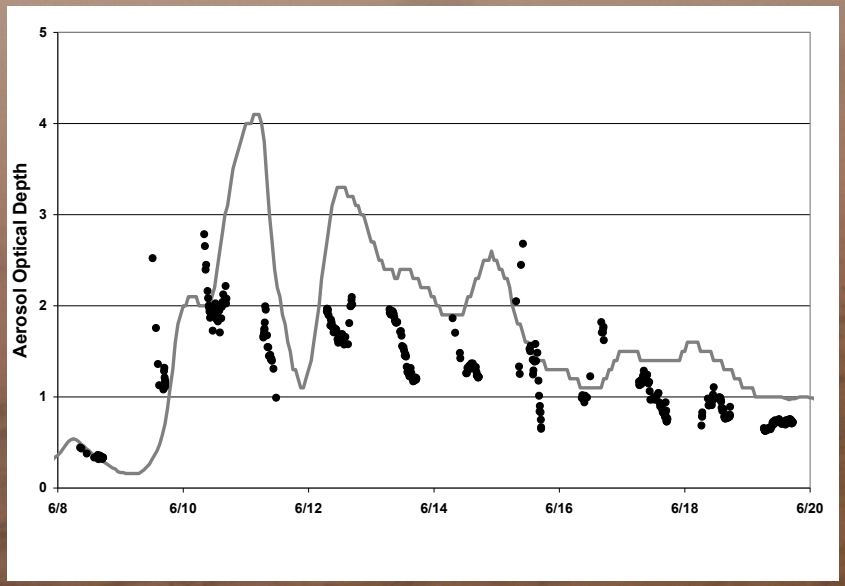


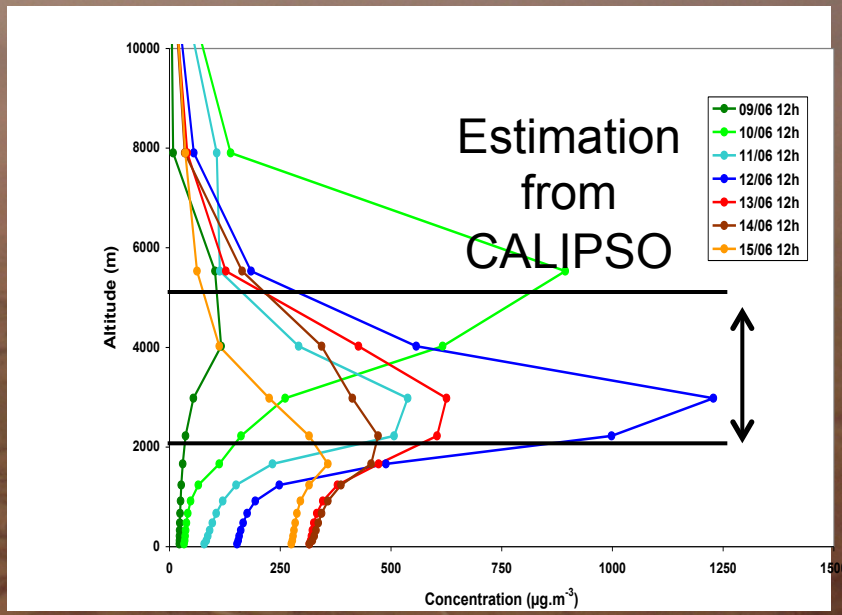




An elevated summer dust event (June 2006)

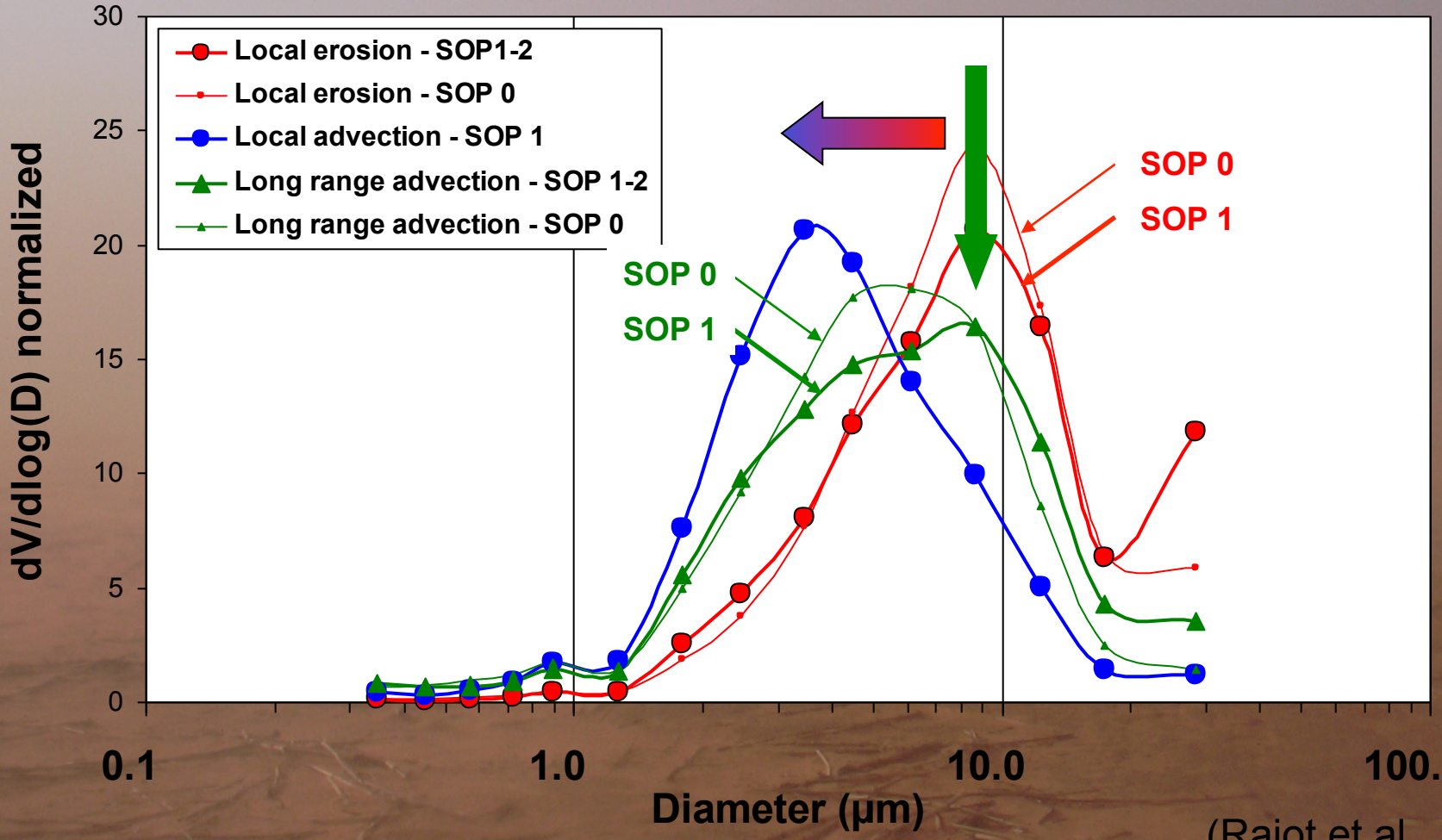






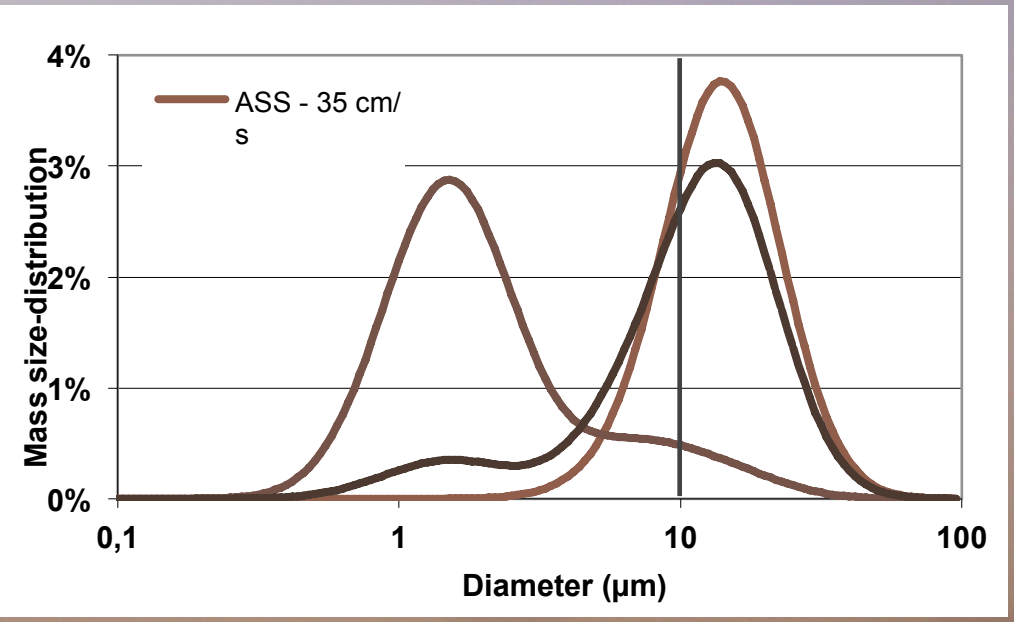
Measured dust size distribution

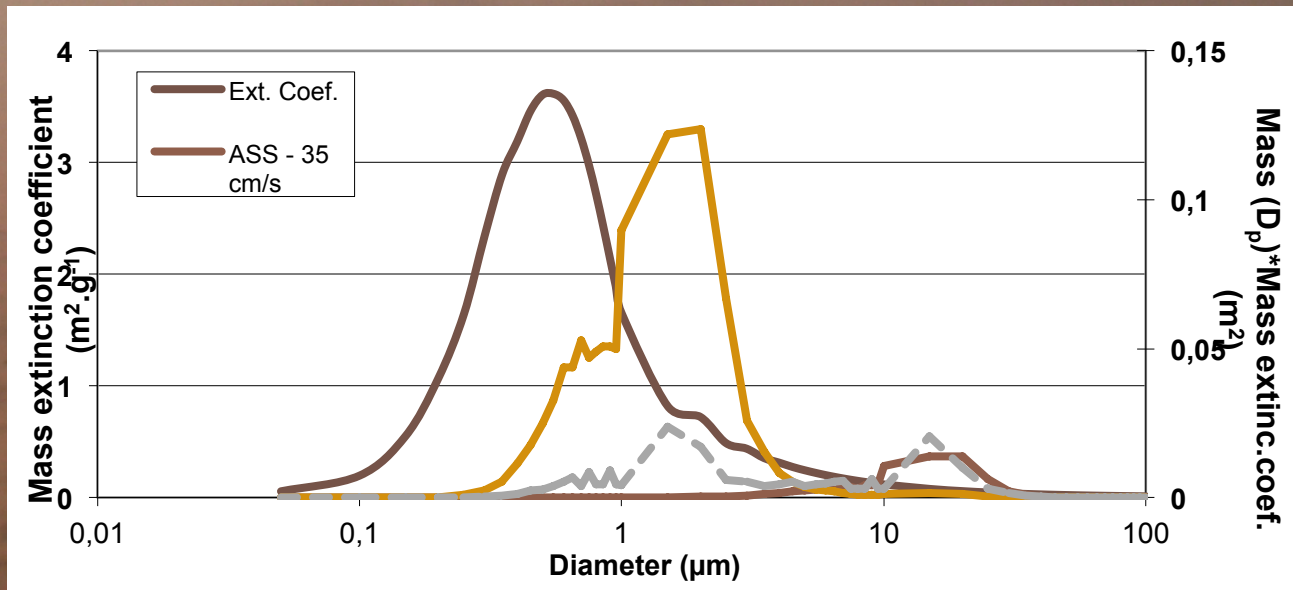
- ✓ Shift between local erosion and local advection (decrease of coarse modes)
- ✓ Coarse mode within the long range transport
- ✓ Local erosion and Long range advection similar within dry and wet season



(Rajot et al., in prep.)

Modelled emitted dust size distribution



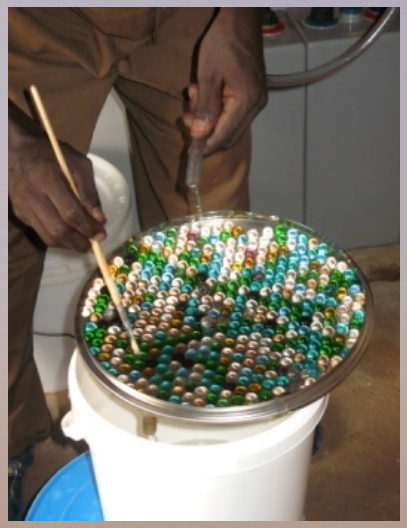


Total deposition sampler

The sampler is an inverted « frisbee » trap equipped with a flow deflector ring (Wiggs et al. 2002) and filled with marbles. Wind tunnel experiments shows that this device has the highest efficiency (Sow et al., 2006) .

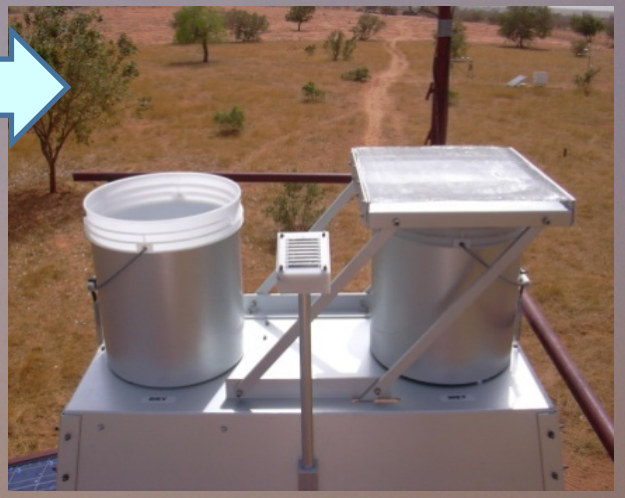
Deposition samples are collected weekly since January 2006 (i.e., ~900 samples in 6 years).

Sample collection



Samples are collected with water, three to four decantation cycles of ~6 hours are performed before the removal of the excess water. The sample is then dried at 50°C. The collected mass is weighted three times..

Wet deposition sampler



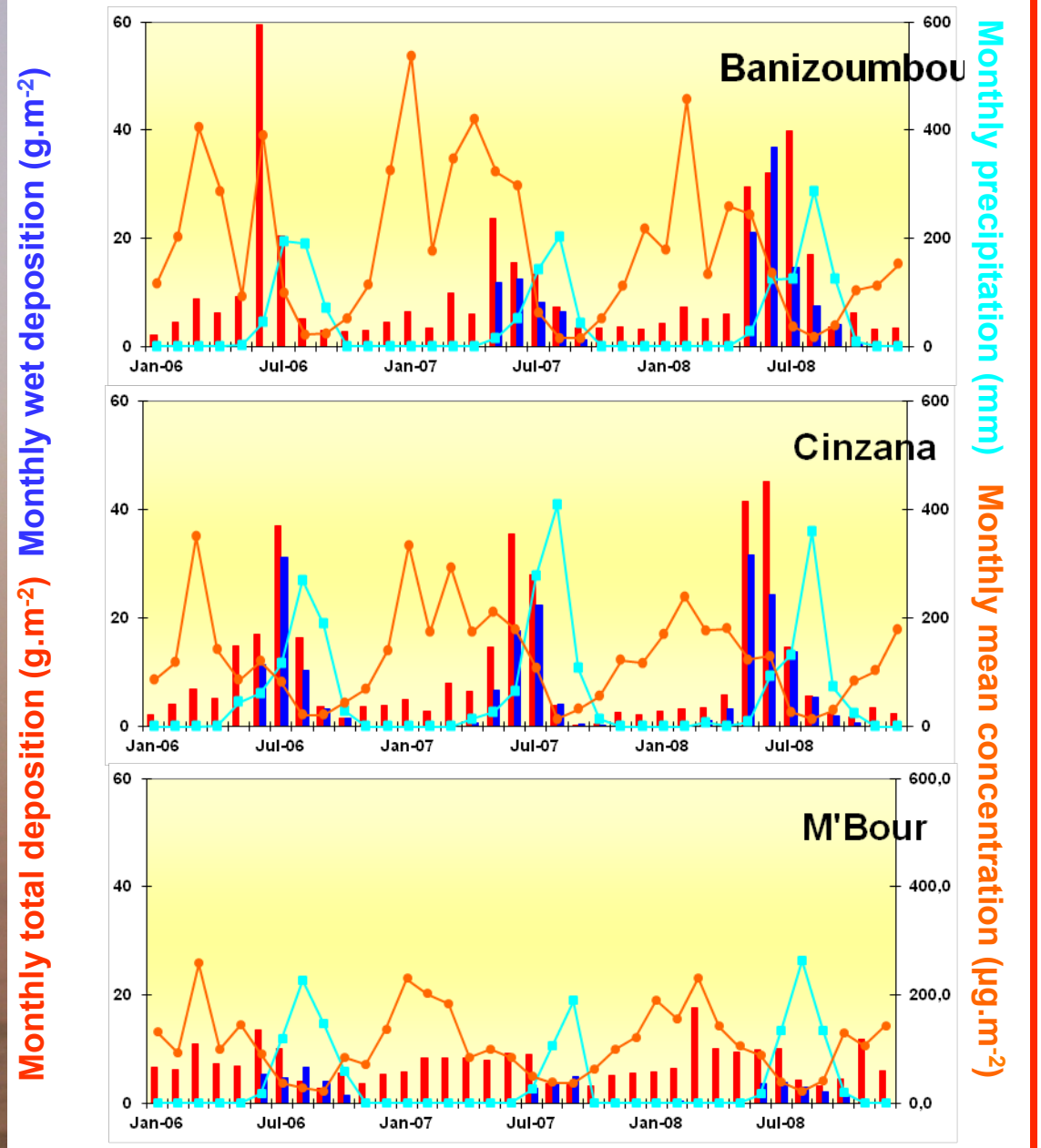
Wet deposition is collected using an automatic tip bucket system. A precipitation sensor, allows the wet deposition collector to get open when precipitation starts and to close when precipitation stops.

Wet deposition samples are collected for each rain event (i.e., ~700 samples in 6 years).

Annual deposition fluxes measured along the three stations of the SDT

ANNUAL TOTAL DEPOSITION FLUXES

Annual deposition fluxes measured over the North of Africa and in the Mediterranean basin ((2) O'Hara et al. (2006); (3) Breuning-Madsen and Awadzi (2005); (4) Avila et al. (1997), Bergametti et al. (1989), Kubilay et al. (2000) ; Mattson and Nehlen (1996))



Monthly total and wet deposition fluxes, precipitations and mean atmospheric dust concentrations at the three stations of the STD from 2006 to 2008 (note that wet deposition measurements are not available for the wet season 2006 in Banizoumbou)

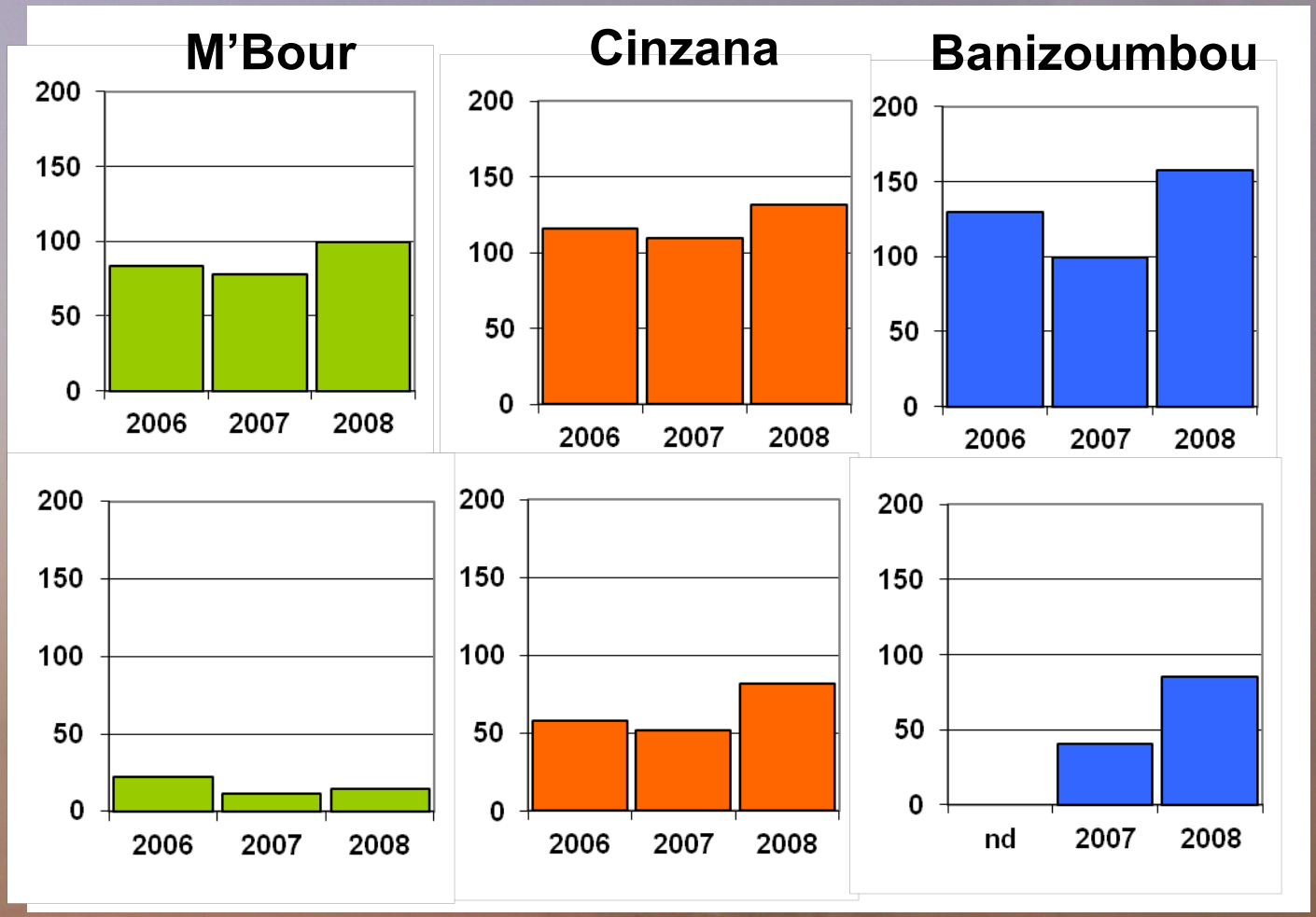
Total deposition fluxes exhibit a clear seasonal cycle in Banizoumbou and Cinzana. The highest values are recorded at the beginning of the rainy season, when precipitation occurs while atmospheric dust concentrations are still high.

The seasonal cycle in M'Bour is mainly driven by dry deposition occuring in spring and summer.

Whatever the stations, there is no clear and simple link between dust concentrations and total deposition fluxes in the dry season at the monthly scale.

Total Deposition flux ($g.m^{-2}.yr^{-1}$)

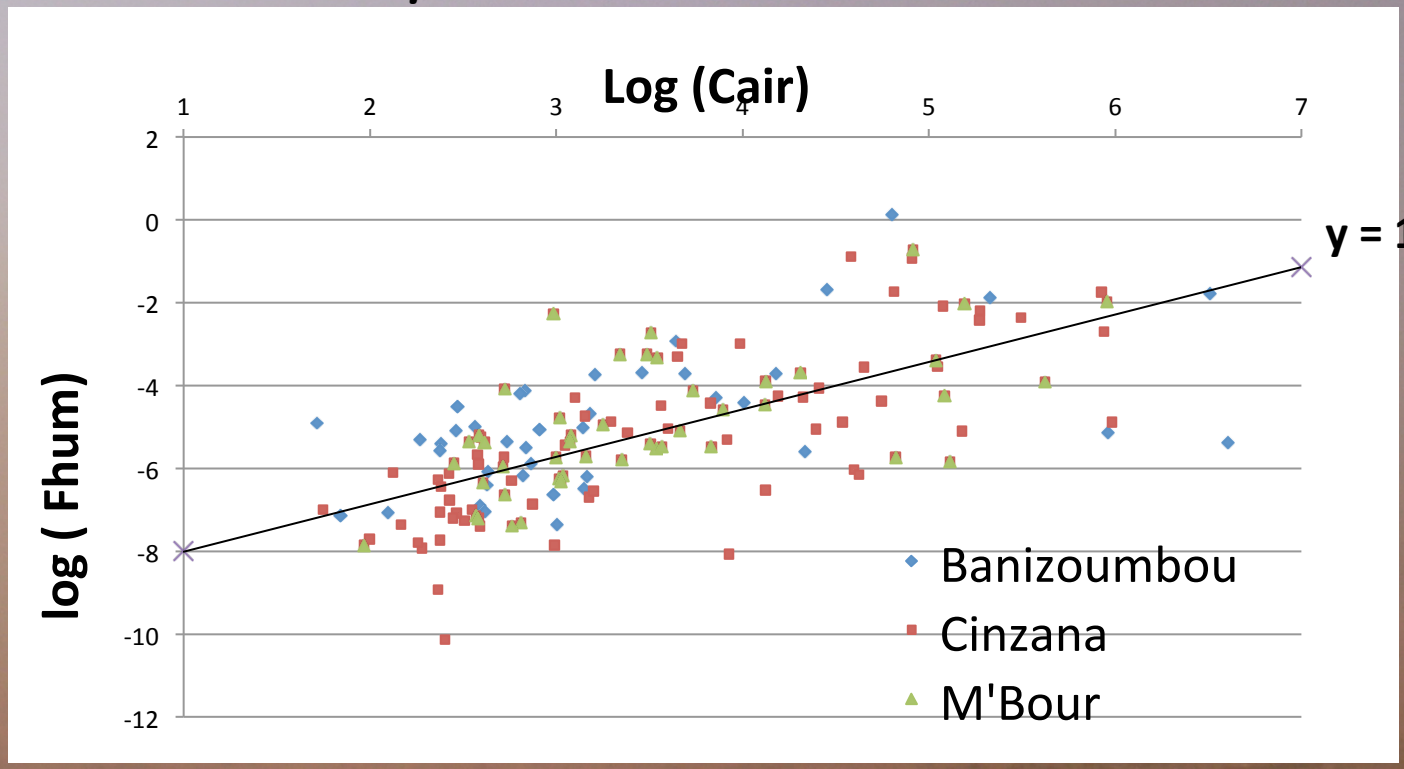
Wet Deposition flux ($g.m^{-2}.yr^{-1}$)



Annual total deposition fluxes ranges from 78 (M'Bour in 2007) to 158 $g.m^{-2}.yr^{-1}$ (Banizoumbou in 2008). The year-to-year variability is low in M'Bour (σ =11%) but a little higher in Banizoumbou and CInzana (σ = 30%). For these two stations, this variability is mainly driven by changes in wet deposition fluxes.

WET DEPOSITION FLUXES

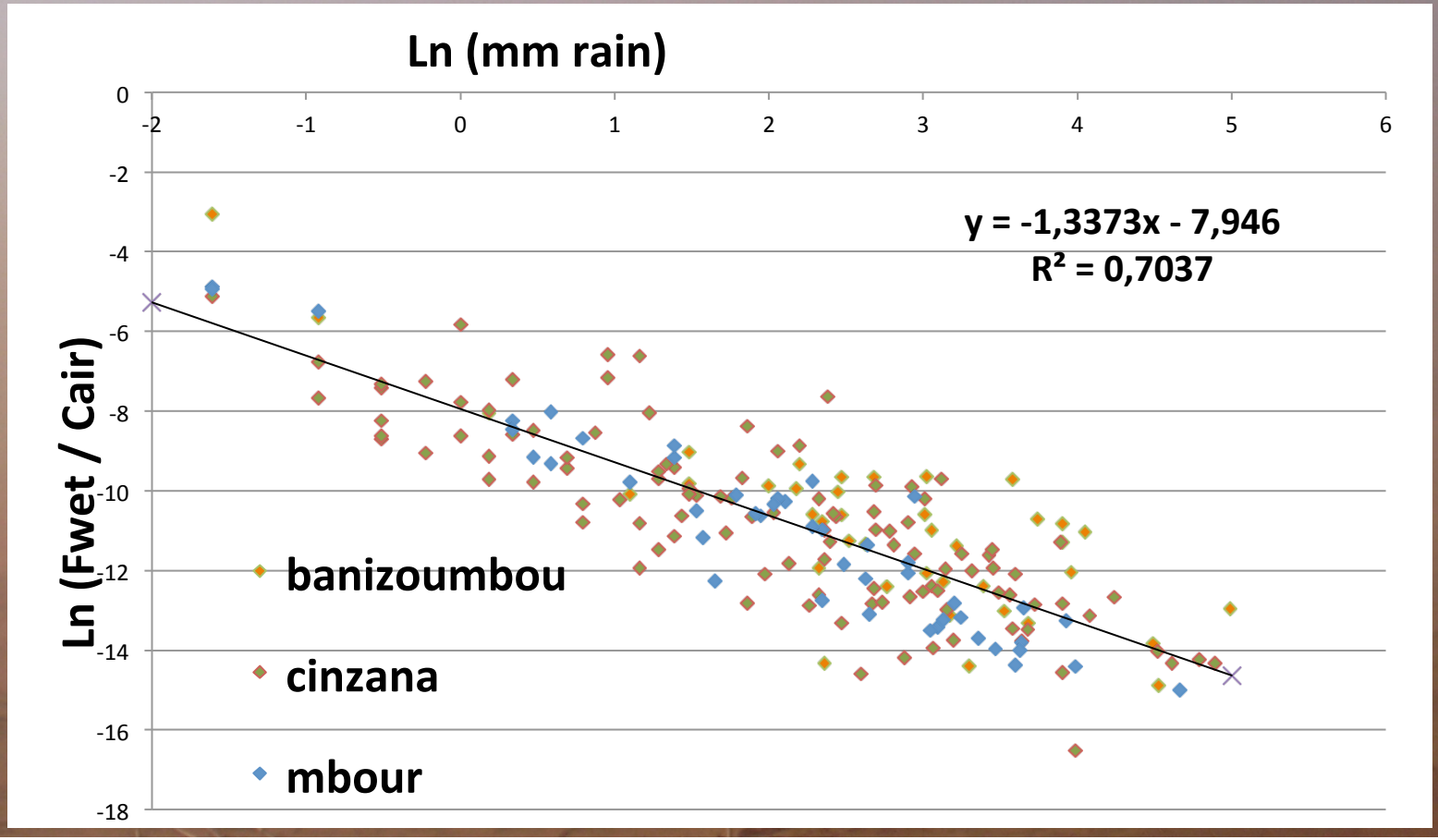
Wet Flux = Λ [Dust]



- *A trend of increasing the wet flux when the dust concentration increases*
- *However, there a large spread in the data*

SCAVENGING EFFICIENCY

Λ = (wet deposition flux)/[Dust] = f(precipitation)



Not constant but decreases with the precipitation amount