Regional and temporal variability of mineral dust concentration over West Africa monitored by the AMMA Sahelian Dust Transect and simulated with CHIMERE-Dust

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Main questions

- ⇨ **What controls the variability of the mineral dust content over West Africa from the daily to the interannual time scale ?**

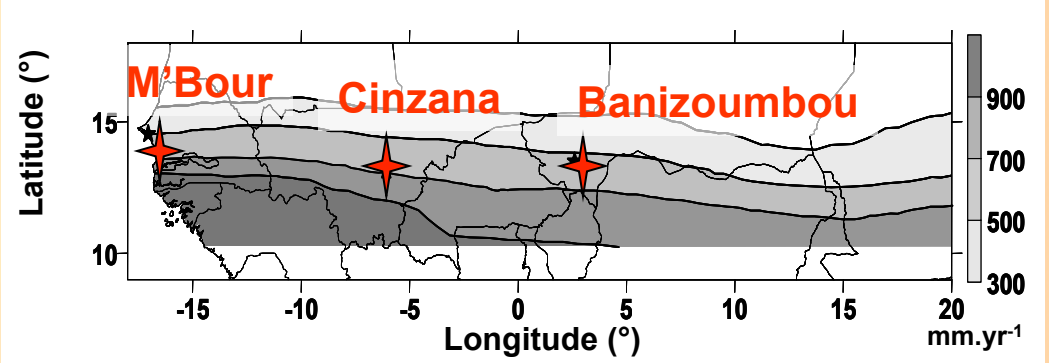
- ⇨ **Is the Sahel a significant source of mineral dust compared to the Sahara ? What about the anthropogenic contribution ?**

Strategy

⇨ Long term and intensive field measurements

Banizoumbou (Niger) Super site

The Sahelian Dust Transect

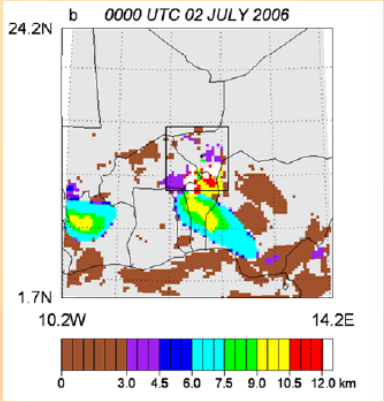


⇨ Continental to local scale modelling

Daily to annual scale

Chemistry and Transport Model

ChimereDUST



Case studies (2-3 days)

Meso-scale meteorological model RAMS-Dust

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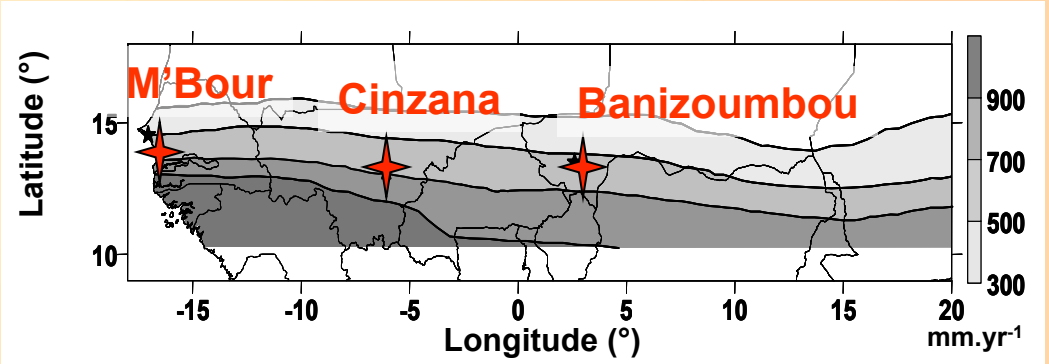

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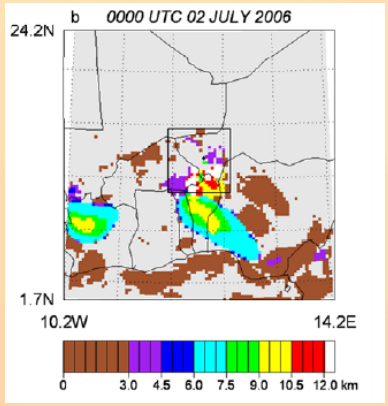


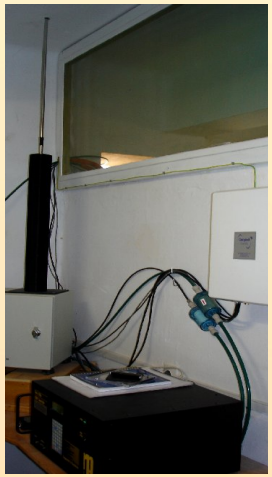
Case studies (2-3 days)

Meso-scale meteorological model RAMS-Dust

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)

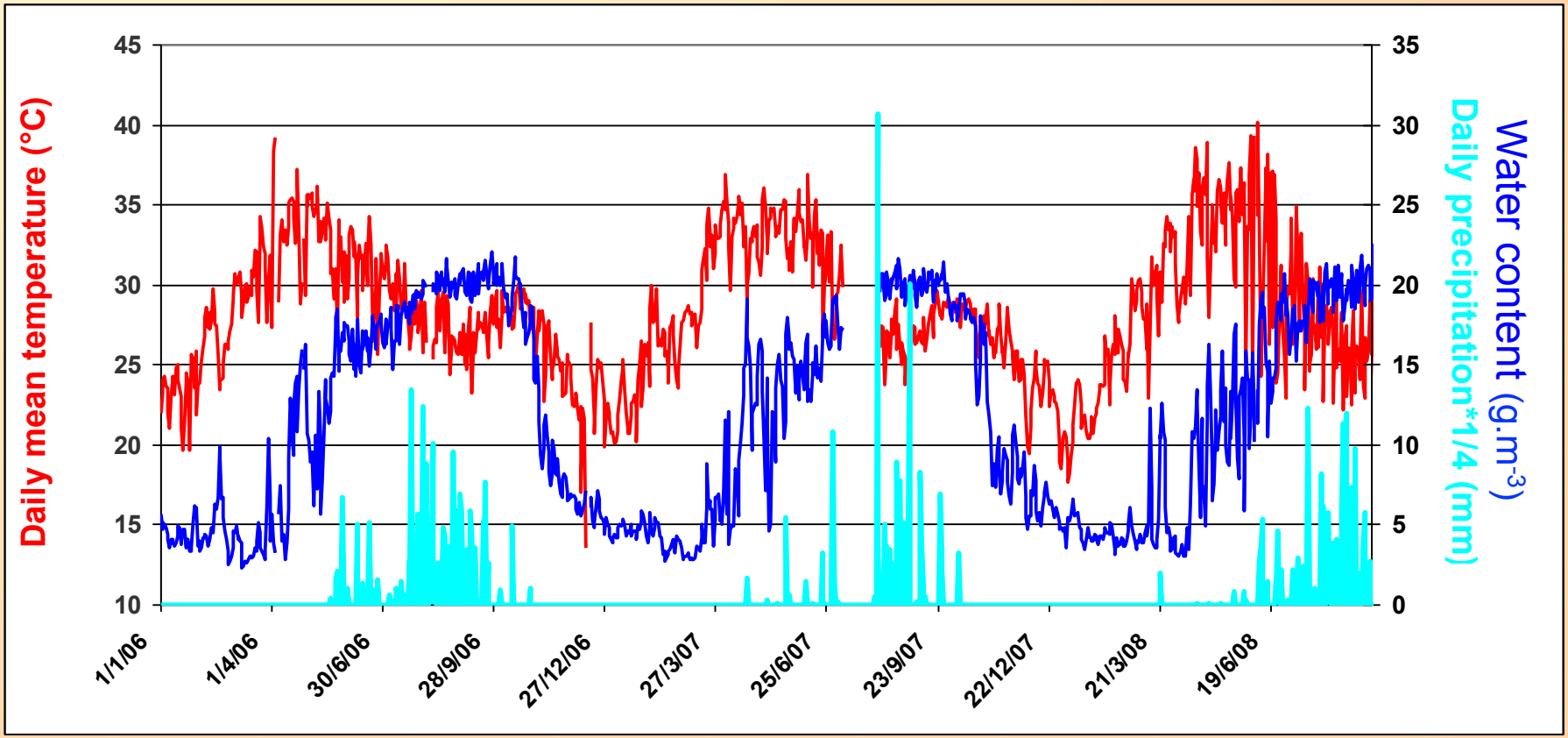
- **Wind velocity**
- **Wind direction**
- **Temperature**
- **Relative humidity**

Total and wet deposition
(Week to event)

Aerosol Optical Depth
AERONET/PHOTONS
sunphotometer

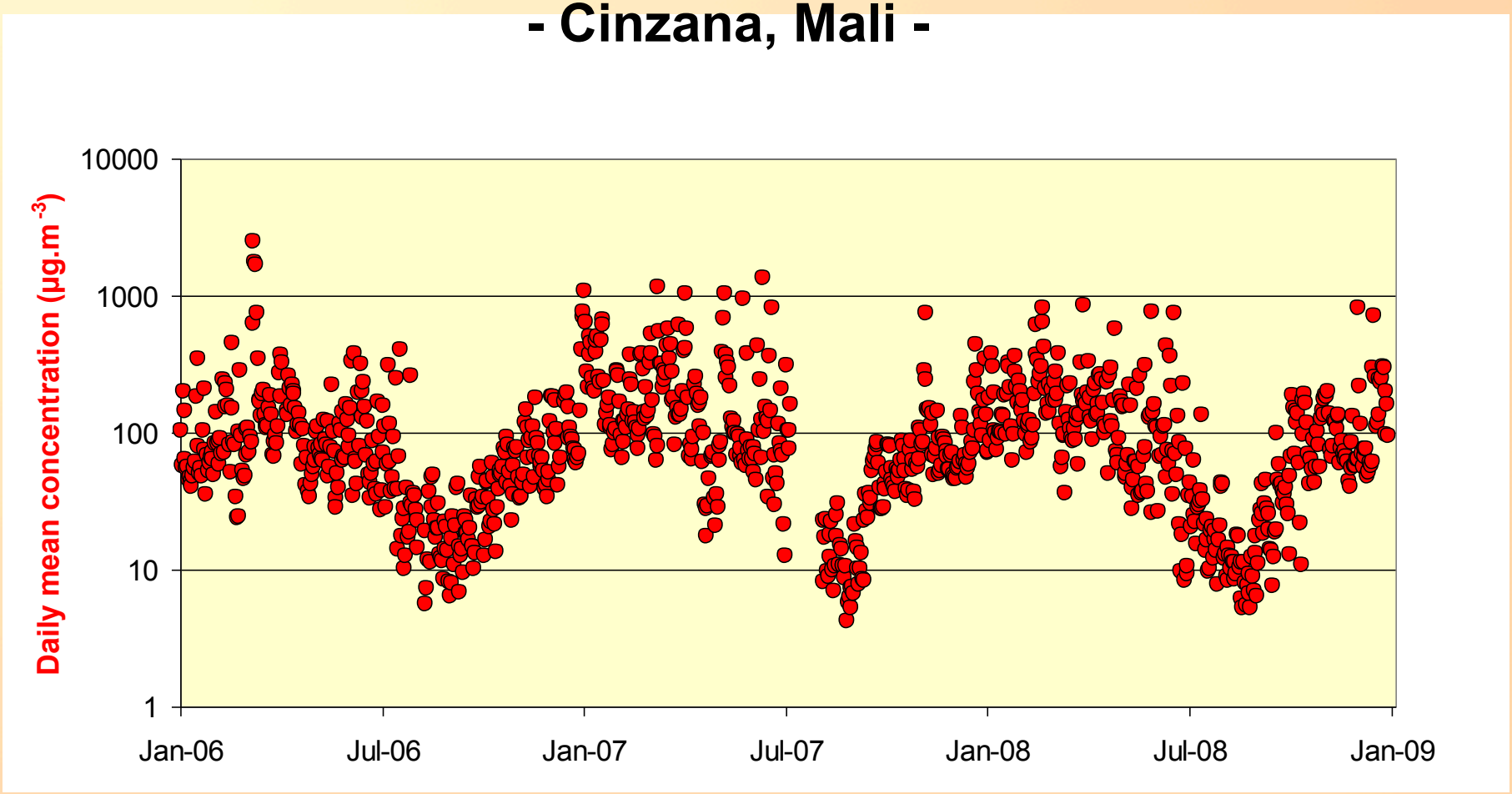
Meteorological conditions

- Cinzana, Mali -

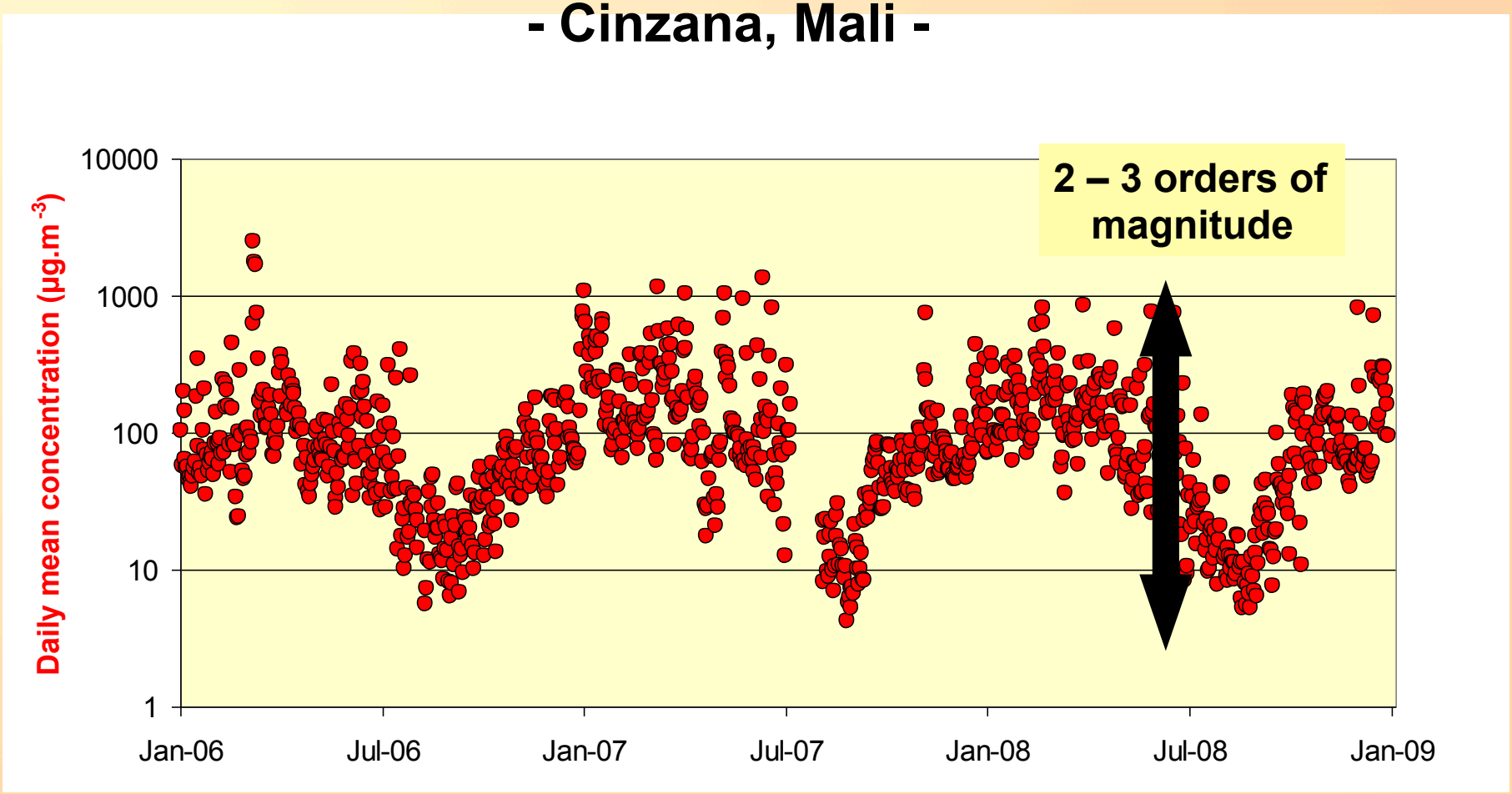


⇨ **Typical seasonal pattern, succession of Harmattan and Monsoon flow**

Dust concentrations : annual features



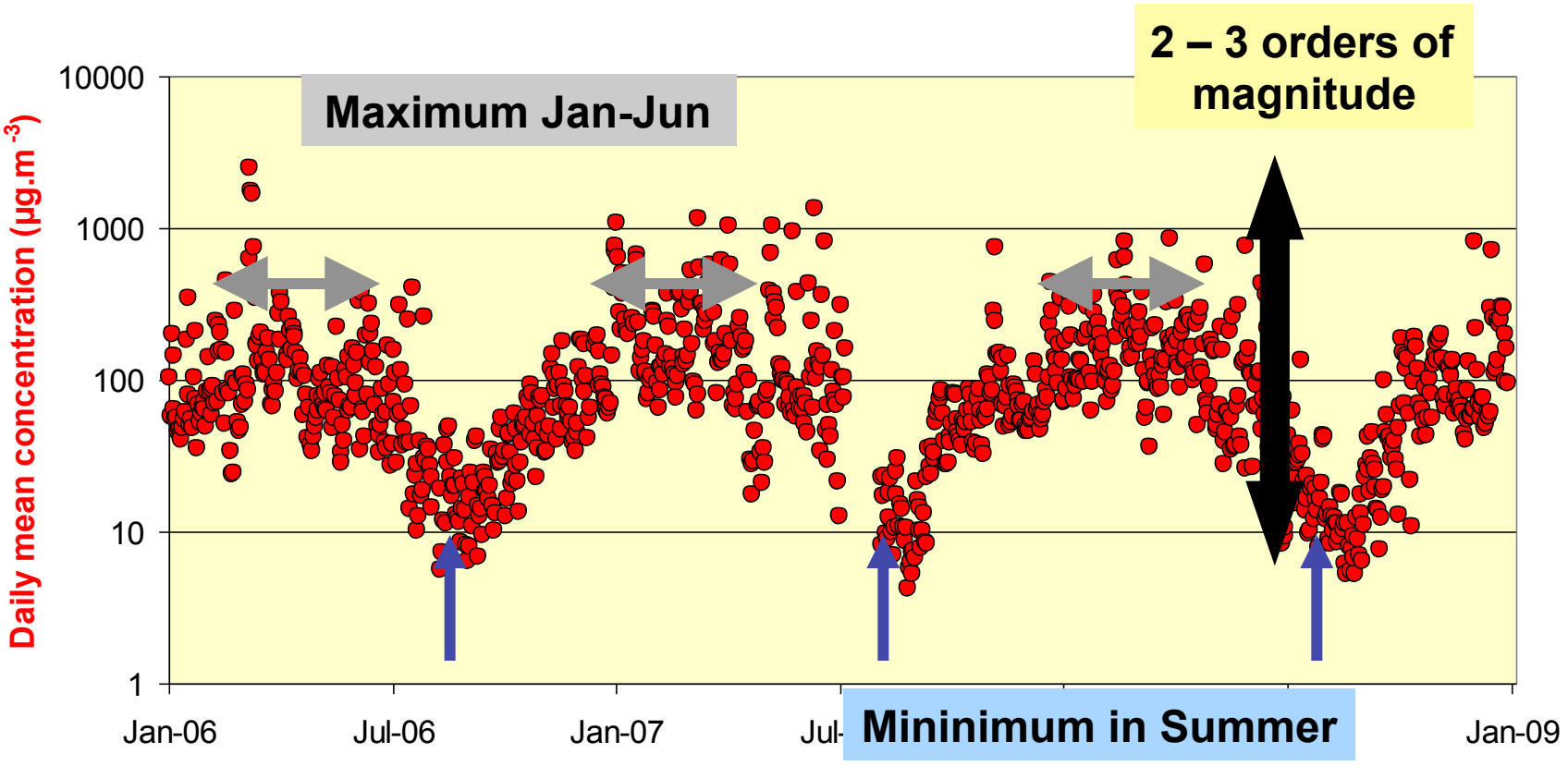
Dust concentrations : annual features



⇨A very large range of concentrations

Dust concentrations : annual features

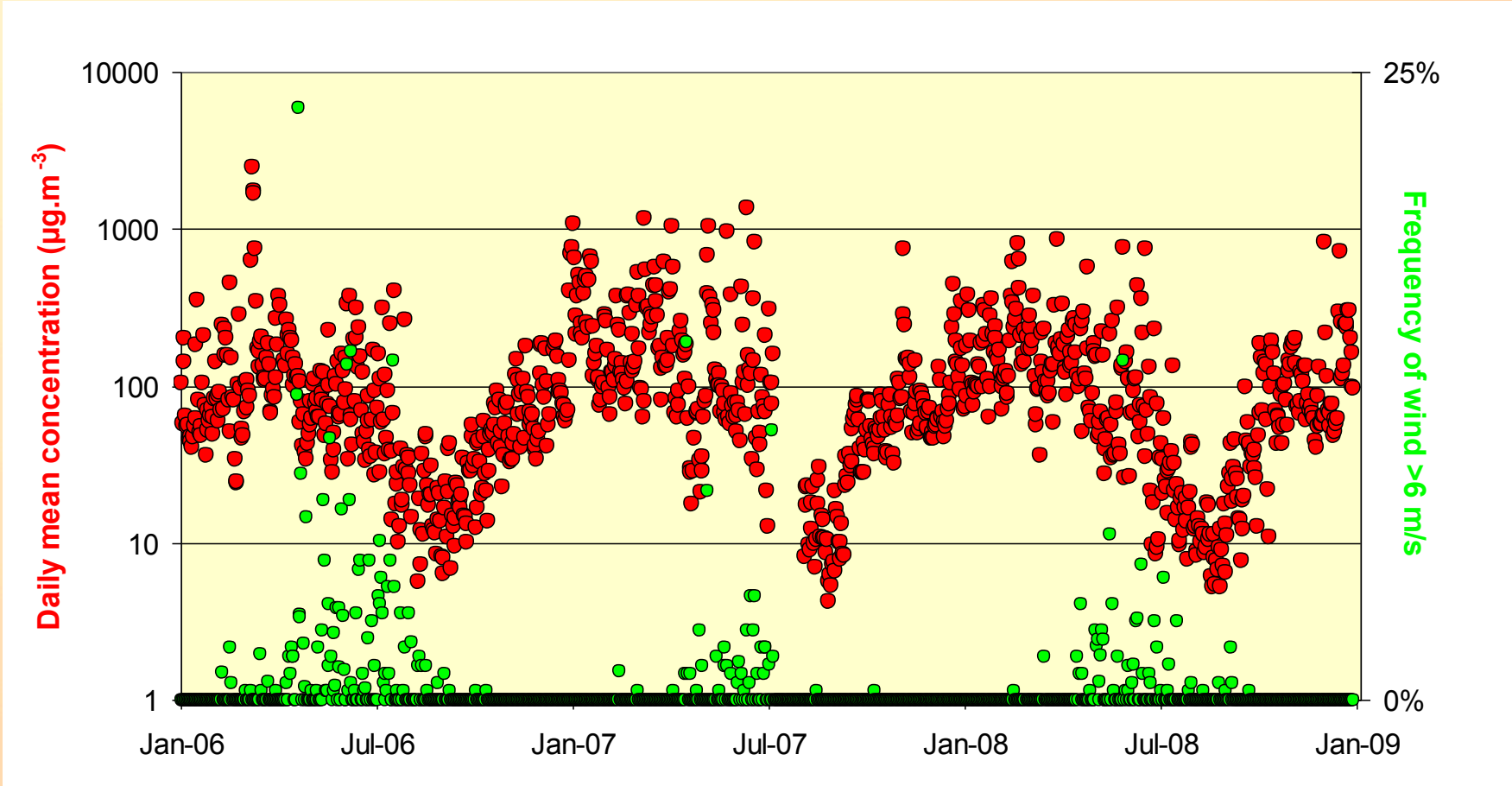
- Cinzana, Mali -



⇨**A very large range of concentrations**
⇨**A clear seasonal cycle**

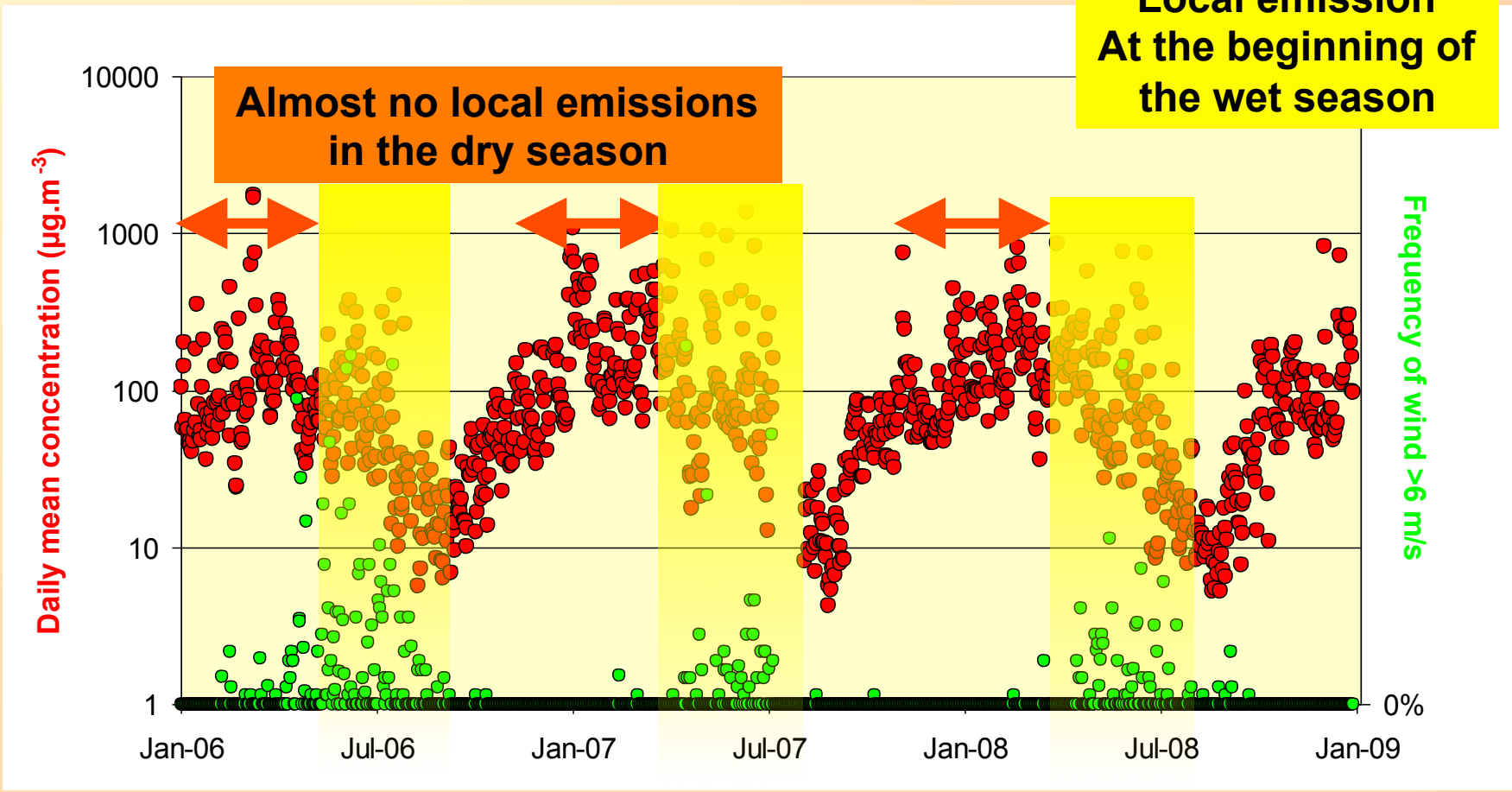
Dust concentrations and local emissions

- Cinzana, Mali -



Dust concentrations and local emissions

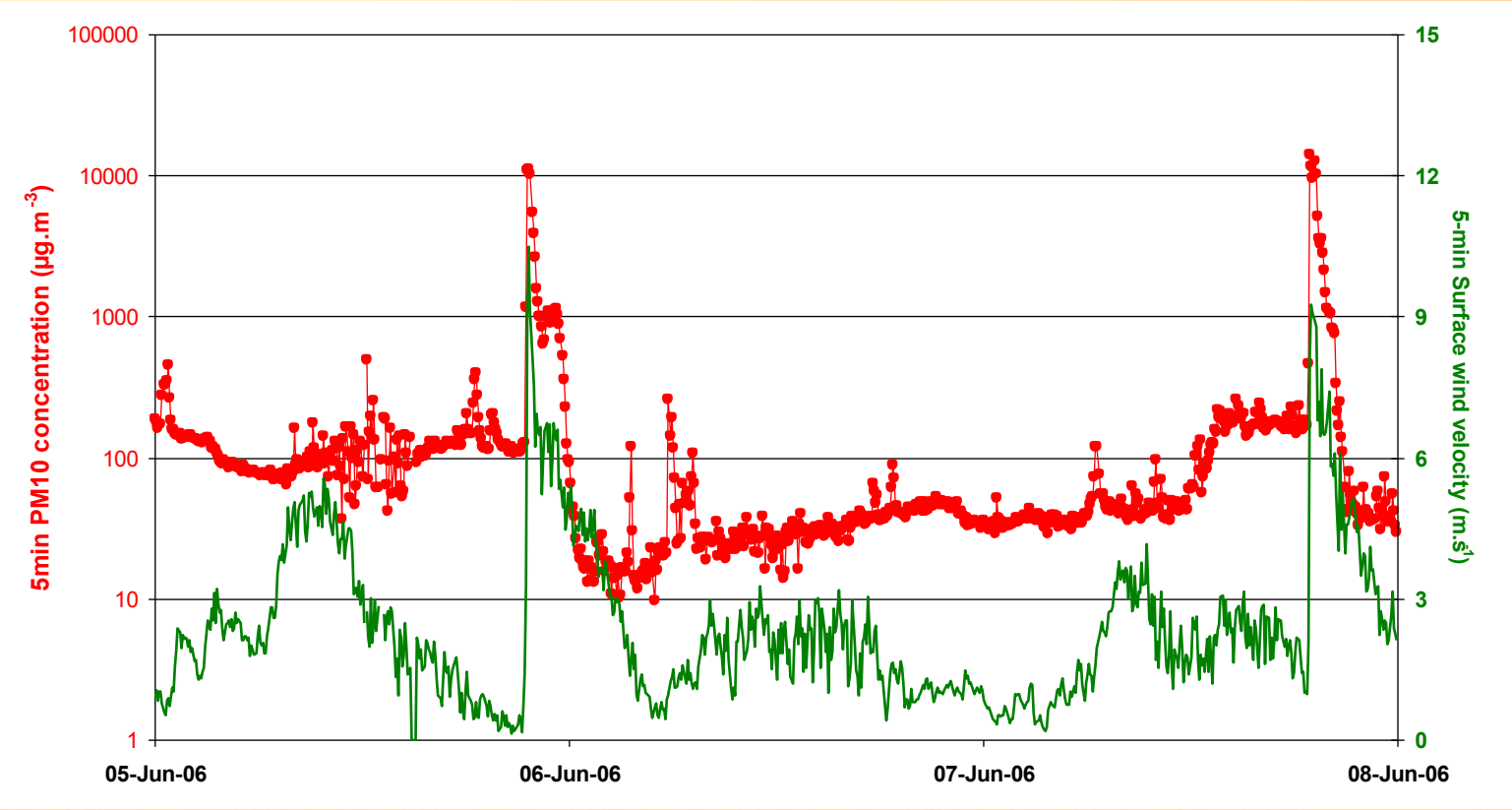
- Cinzana, Mali -



⇨ **The spring maximum is due to transport from the Sahara (low level) but local dust emissions can occur at the beginning of the wet season** ***(confirmed by local erosion measurements in Banizoumbou)***

Dust emissions by convective systems

Dust concentration and surface winds (Cinzana, Mali)



Dust emissions by convective systems

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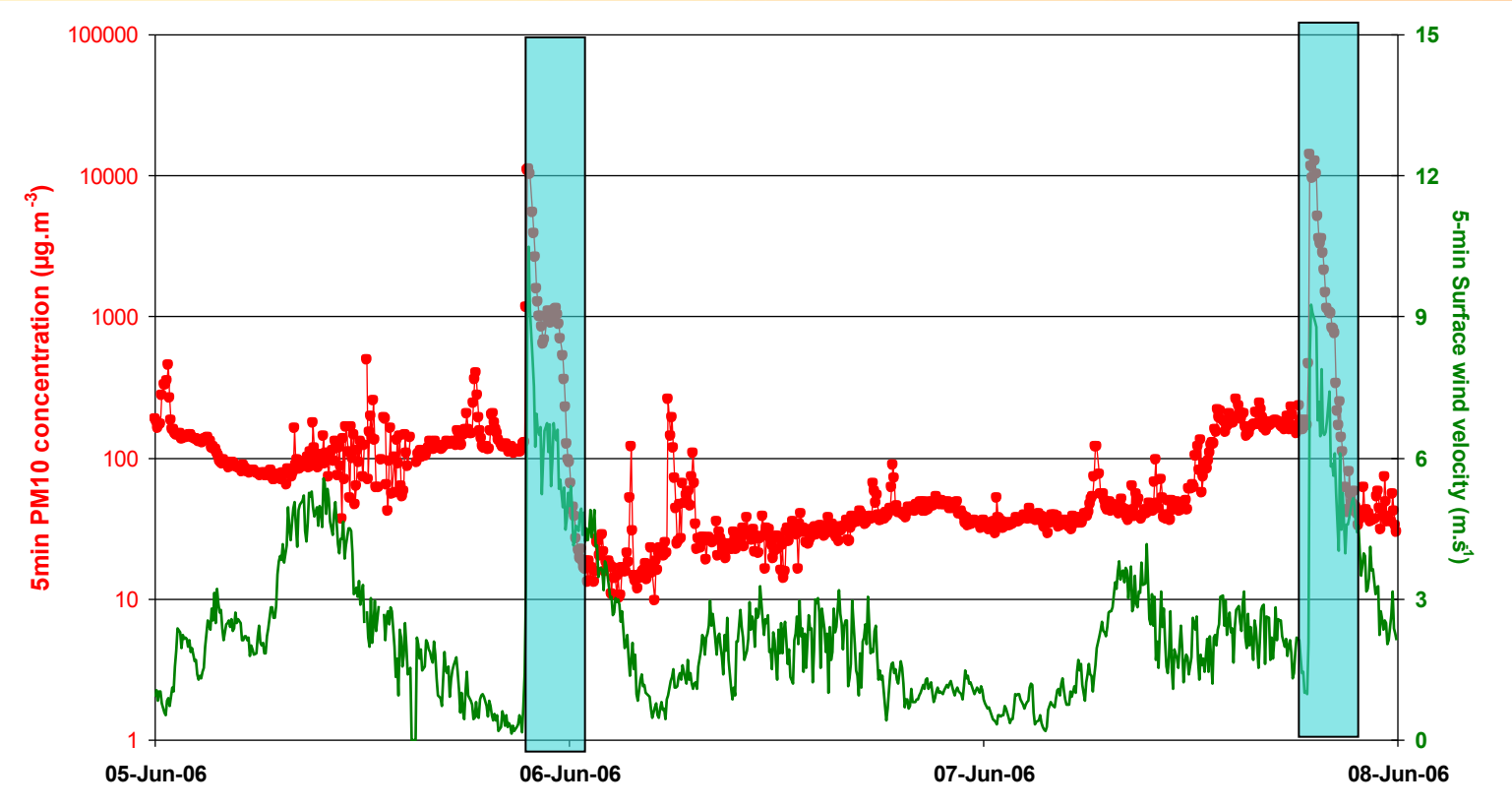
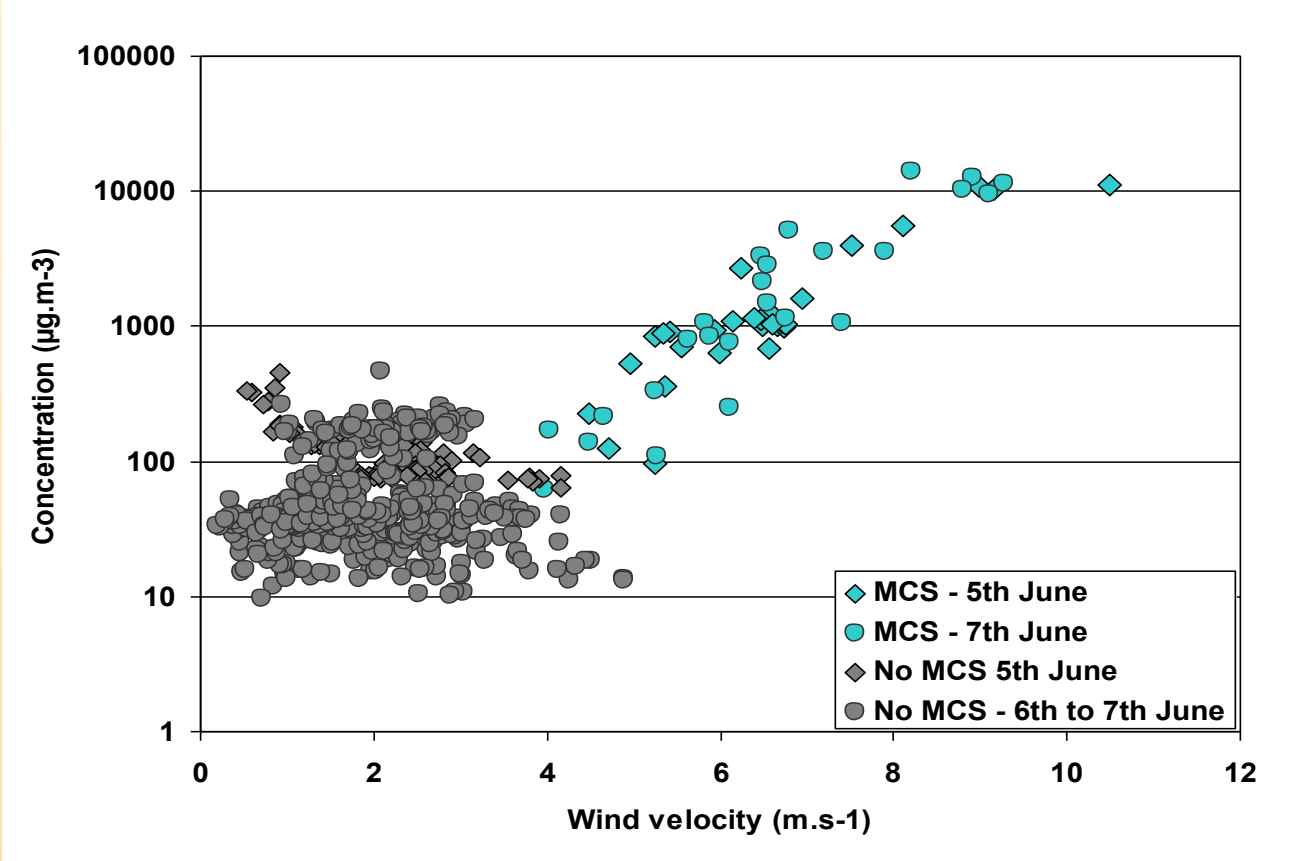


⇨ **Synchronous increase of surface winds and dust concentration (two orders of magnitude in 10 min)**

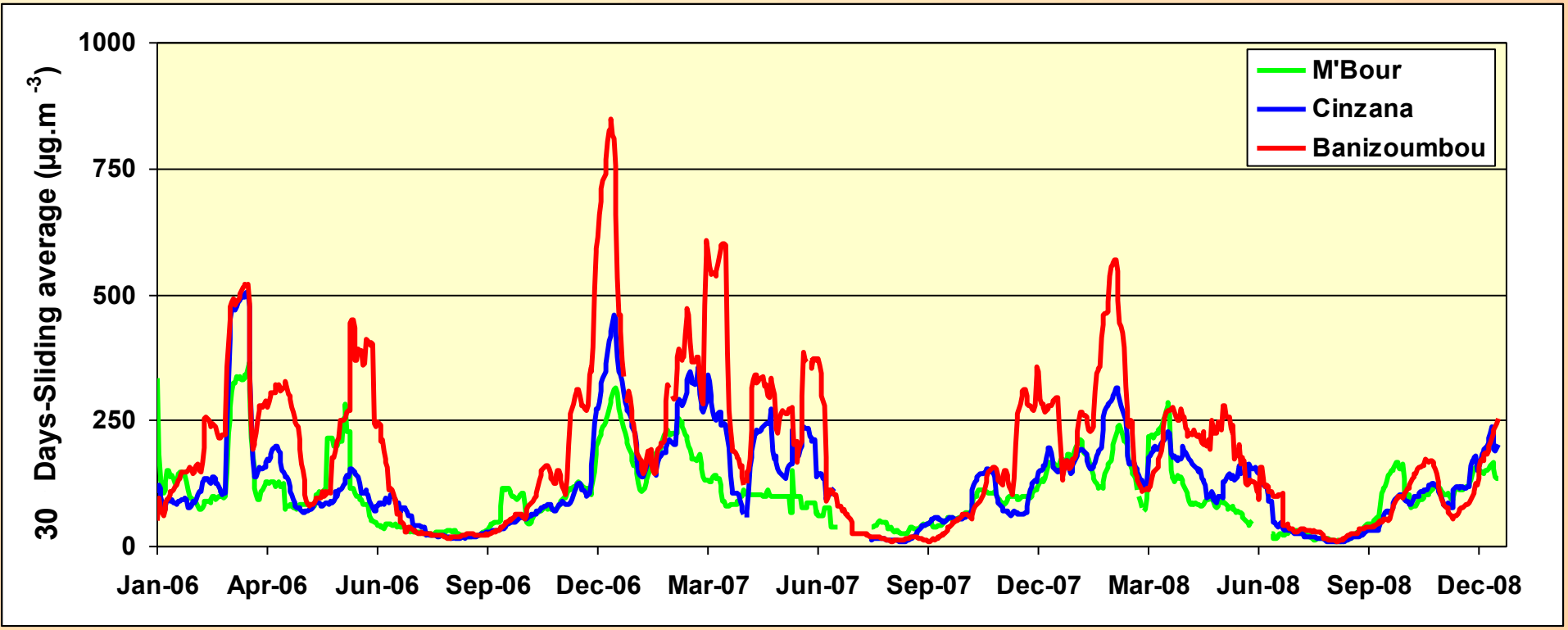
Dust emissions by convective systems

Dust concentration and surface winds (Cinzana, Mali)



⇨ **Local dust emissions due to the passage of mesoscale convective system**

Dust concentrations : regional trend



⇨**A similar seasonal cycle : an East-West gradient of concentration**

The Chimere-Dust model

A Chemistry and Transport Model with no chemistry but dust …

Dust Emission :

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

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

⇒ distributed on 20 log. Bins

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

North Atlantic, North Africa, Arabian Peninsula

Model outputs

-Dust 4D fields in μg/m3 for each bin
-Optical thickness, deposition fluxes

Simulation domains:

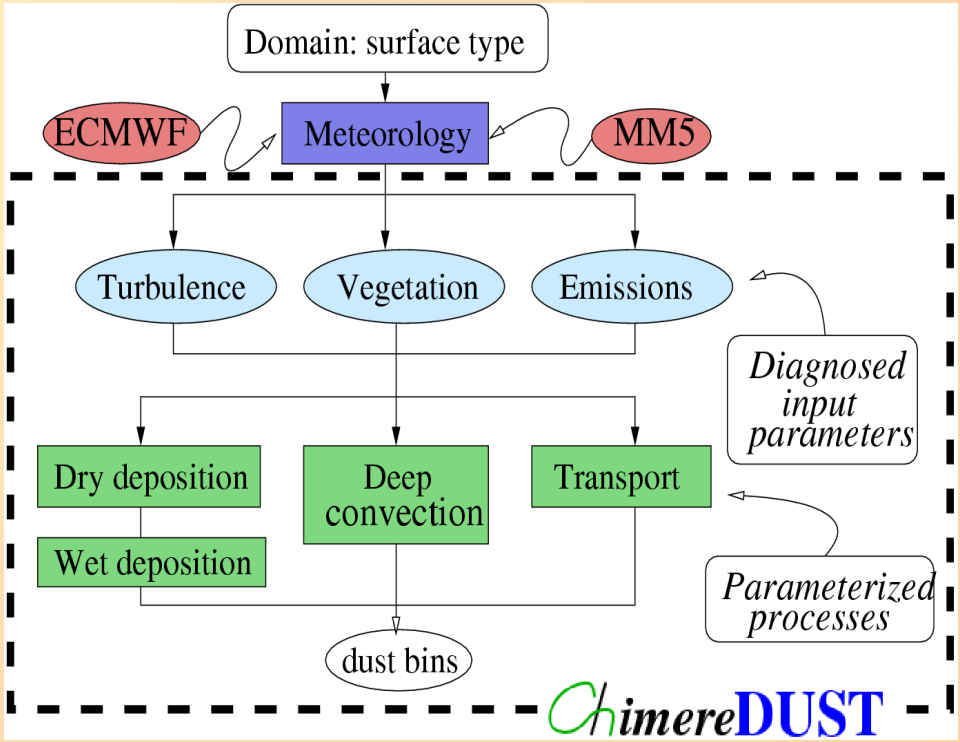
- Horizontally: (1x1 degrees)
-Vertical mesh 15 to levels (up to 200hPa)

Meteorological forcing

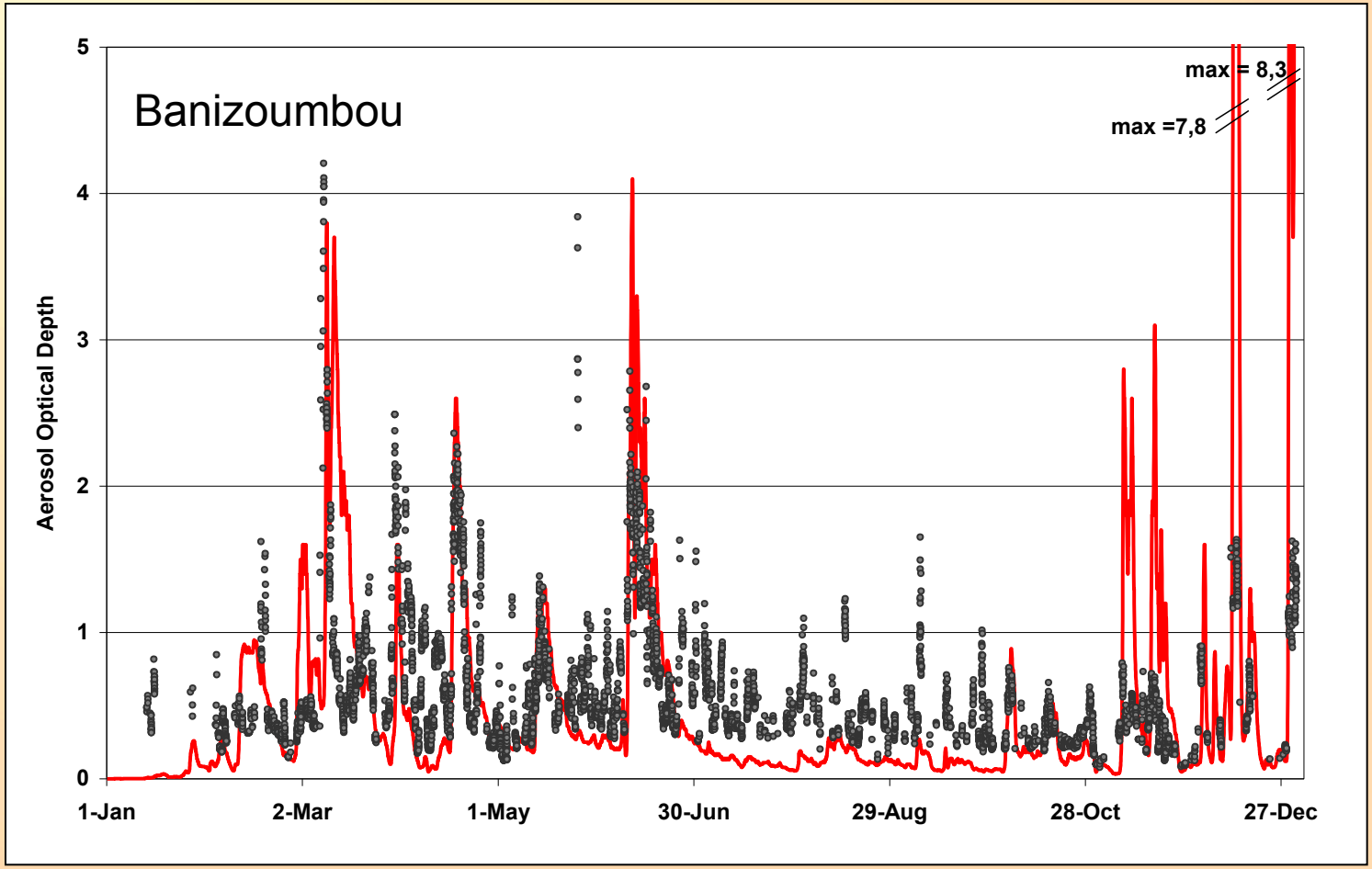
-ECMWF Operational products + empirical correction of surface winds in the Bodélé Depression

Aerosol Optical Depth @550nm

Refractive Index =1.5 - 0.005i ; (Moulin et al., 2001)



Simulated hourly aerosol optical depth (2006)

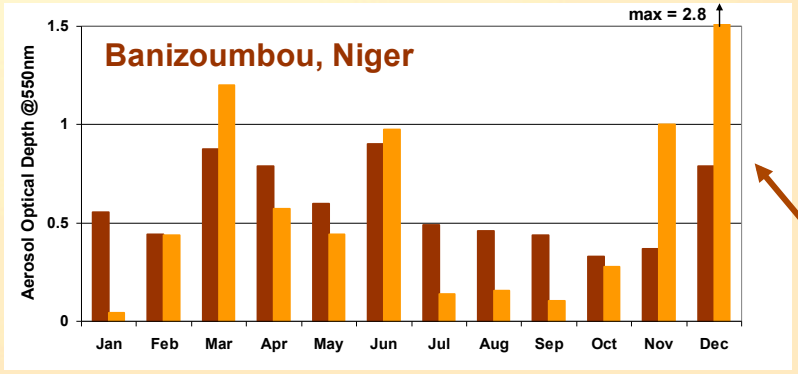


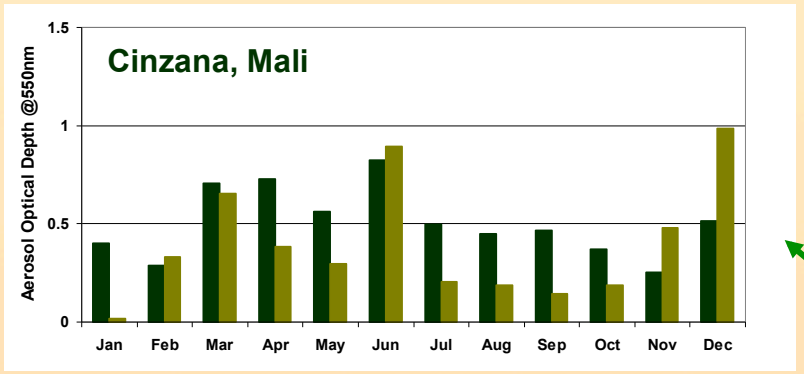
(Level 2 AODs with α>0.4)

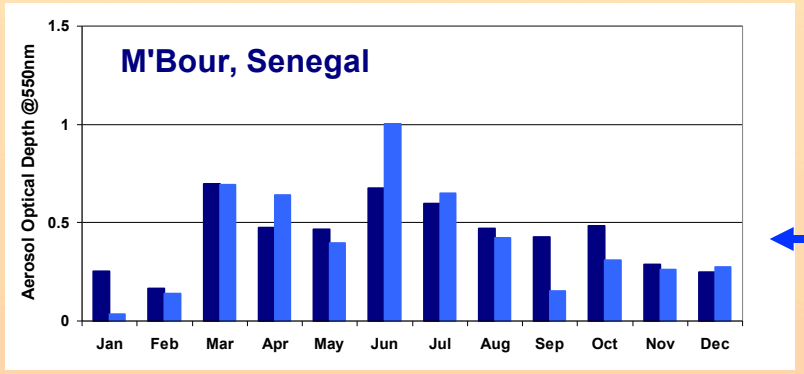
⇨ **Most of the dust events are retrieved in terms of timing and intensity**

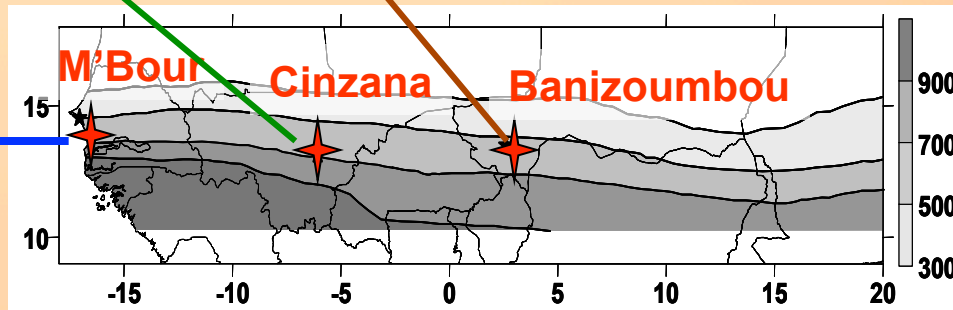
Simulated monthly aerosol optical depth (2006)

ChimereDUST



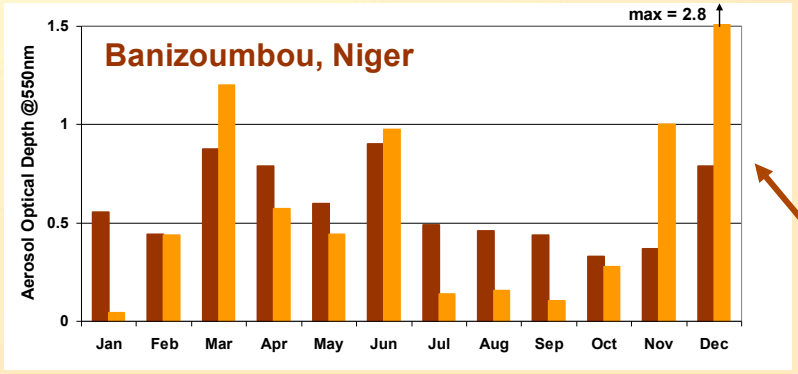


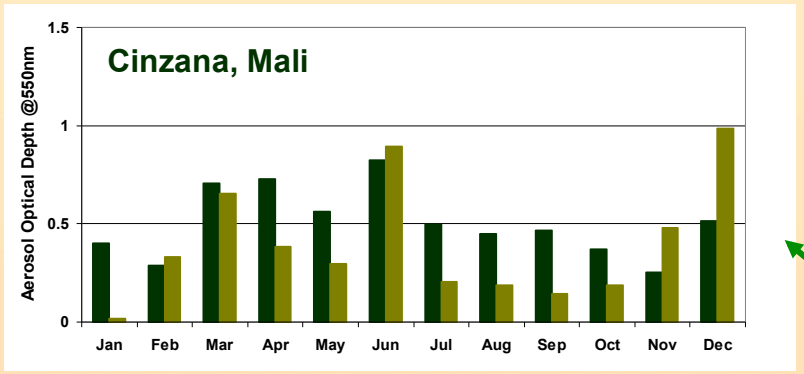


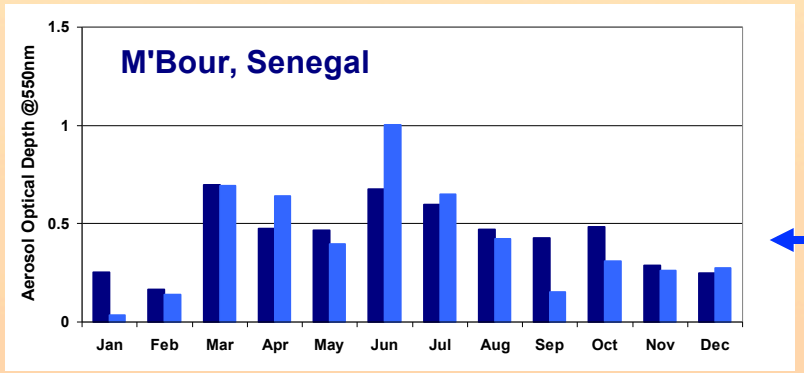


(Observed : dark color; Simulated : light color)

Simulated monthly aerosol optical depth (2006)







(Observed : dark color; Simulated : light color)

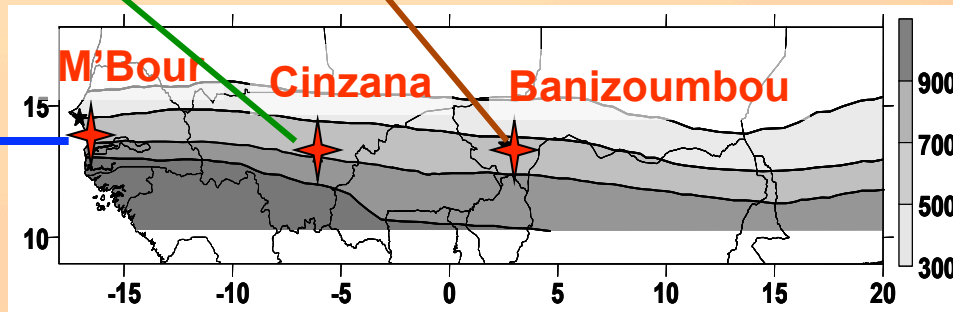
ChimereDUST

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

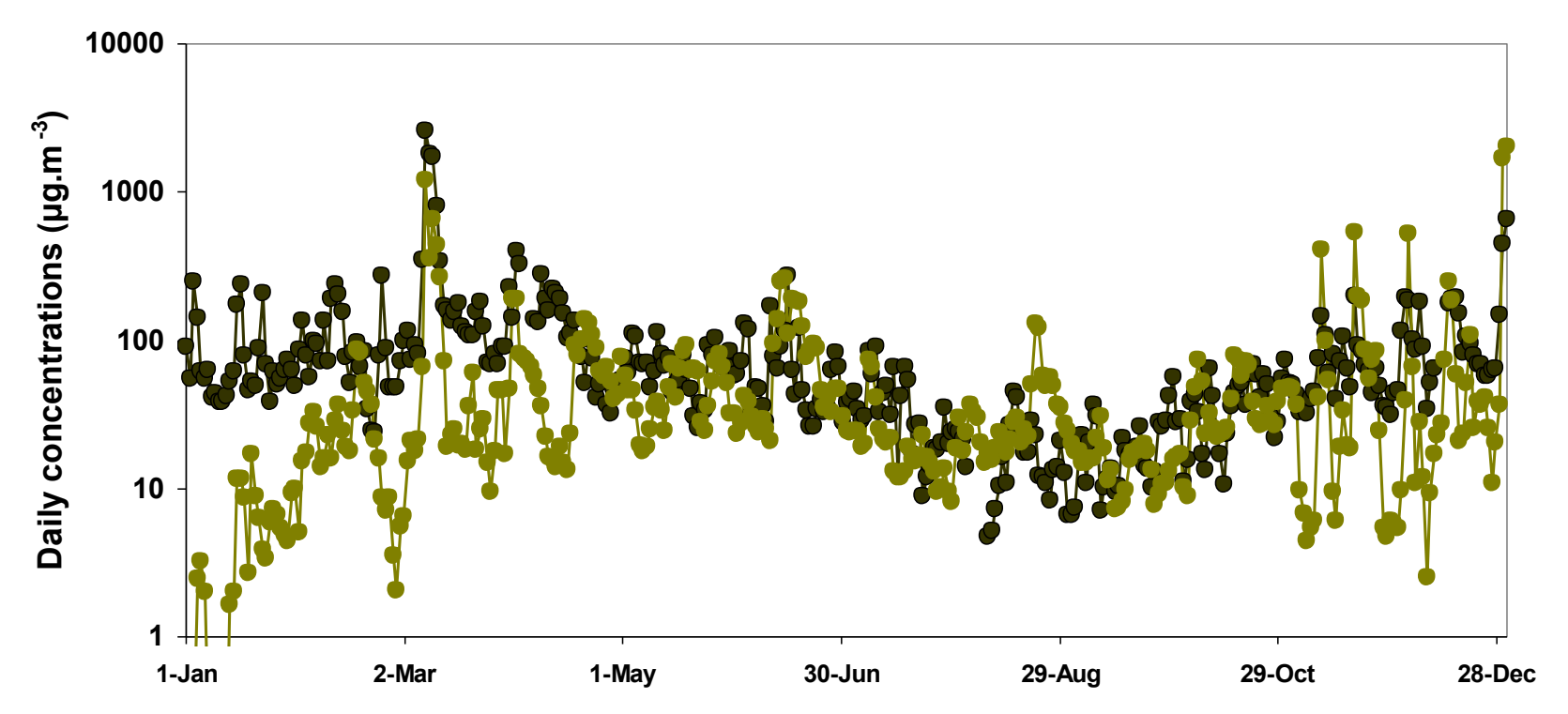
⇨ **A similar seasonal cycle is reproduced at the three stations**

⇨ **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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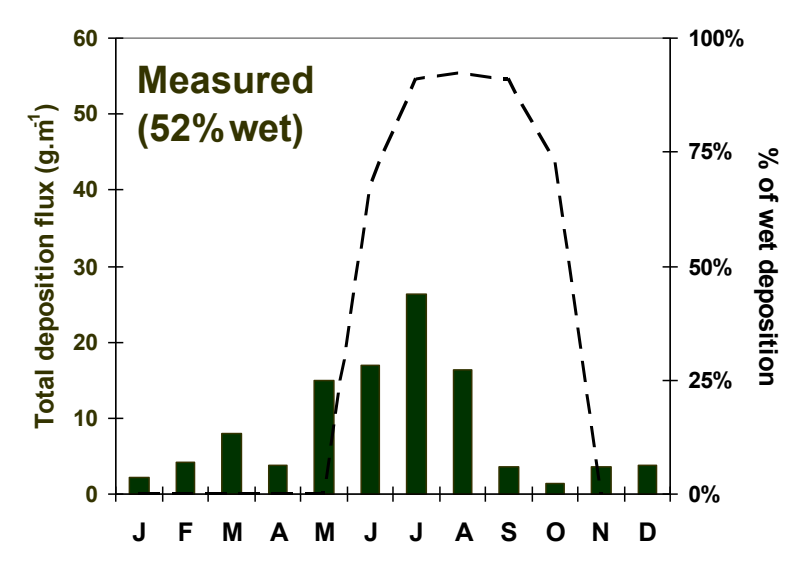
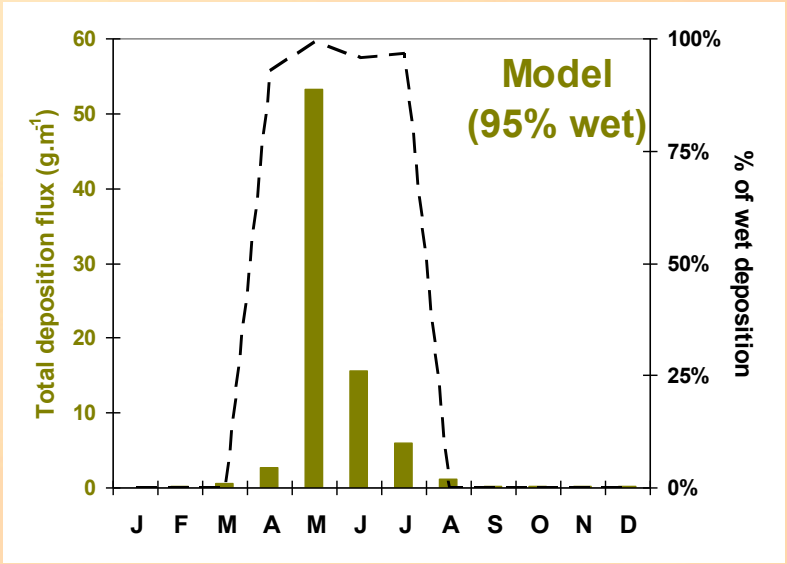
- Cinzana -





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

Conclusion and perspectives

For present conditions (precipitation, wind), the Sahel does not appear as an intense dust source, but changes in precipitation (rates and pattern) and land-use can significantly increase local dust emissions

Further investigations for drier conditions and different land-use conditions are required

Saharan dust transport events are the main responsible for the variability of the mineral dust load over West Africa

A systematic analysis of the meteorological situations associated with high dust load must be performed to understand the causes of this variability

Conclusion and perspectives

Constraining the DUST MASS BUDGET at the regional scale is the PRIORITY

- dust size distribution
- vertical distribution
- deposition fluxes

from recent field experiments (AMMA, SAMUM, FENNEC..) and satellite products

Special thanks to :

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Thank you for your attention …