Harmattan dust events over the Western Sahel: synoptic analysis

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Outline

Context: This study is inscribed in the larger effort, supported by the AMMA project, to better understand the role of environmental parameters on meningitis epidemics in West Africa.

Objective: Synoptic circulation associated with harmattan dust events

Data & Method:

- Aerosol data (in situ): - Aeronet: **AOT 440** (level 2) - **PM10**
  Relationships between PM10 and AOT 440
  - at daily timescale
  - comparison of annual cycles

- Climatic data: Daily **Era Interim Reanalysis** data (**u v at 10m**)
  Seasonality in wind speed and direction
  Definition of the harmattan wind condition

➢ Definition of picks of mineral dust (PM10 Extremes >= 90th perc.) in the harmattan (wind direction)
➢ Composite analysis

Results:

Harmattan dust events and:

- Aerosol Index detected by satellite (OMI)
- near surface synoptic conditions (wind 10 m, mslp, Ta2m, SP1000)
- number of dust events

Conclusion:

Summary and future work

Context:

This study is inscribed in the larger effort, supported by the AMMA project, to better understand the role of environmental parameters on meningitis epidemics in West Africa.

Previous findings on the link between the harmattan features and meningitis epidemic dynamics in the western Sahel:

- seasonality : annual peak of the harmattan strength corresponds with the onset of meningitis epidemics in Mali (e.g. Sultan et al. 2005);

- other winter climatic parameters (e.g. relative humidity) are also statistically link to the meningitis dynamics at interannual time scales (e.g. Yaka et al. 2008).

- October and April Aerosol Index (AI-TOMS) is positively related with meningitis incidence anomaly (e.g. Thompson et al. 2006) in Niger, Burkina Faso …;

➢ regional near surface atmospheric conditions during the dry season may play a major role on this disease.

Objective:

➢ to investigate one of the specificity of the harmattan wind namely dust events over the western Sahel.

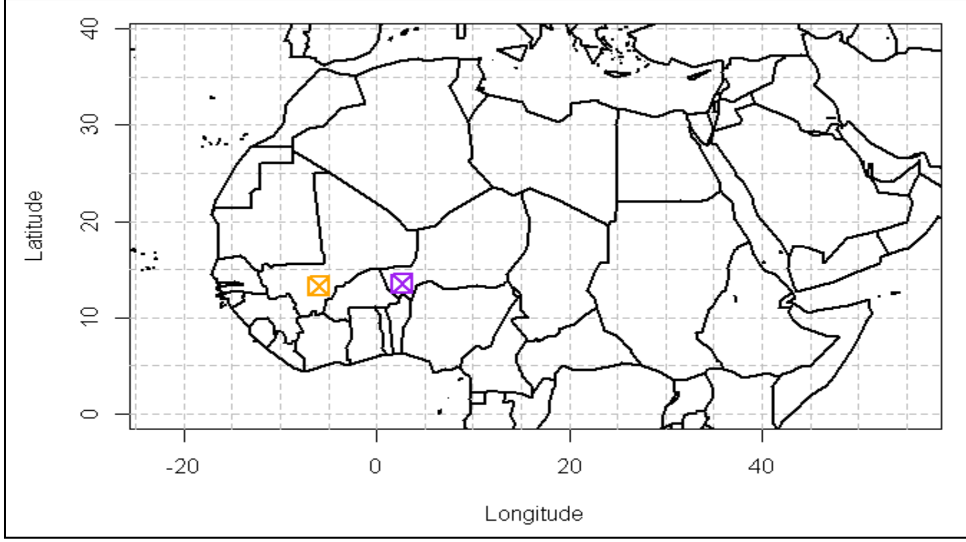
➢ Synoptic circulation associated with harmattan dust events

Aerosol Data

2 stations:

Banizoumbou (Niger)

Cinzana (Mali)



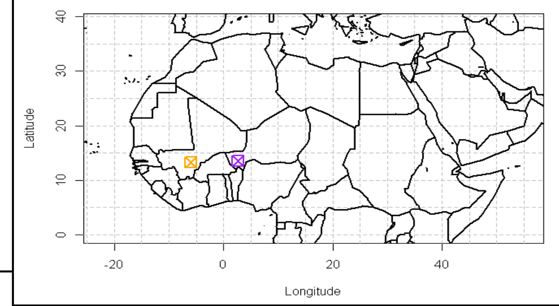
Daily data

- AOT 440 (level 2.0)

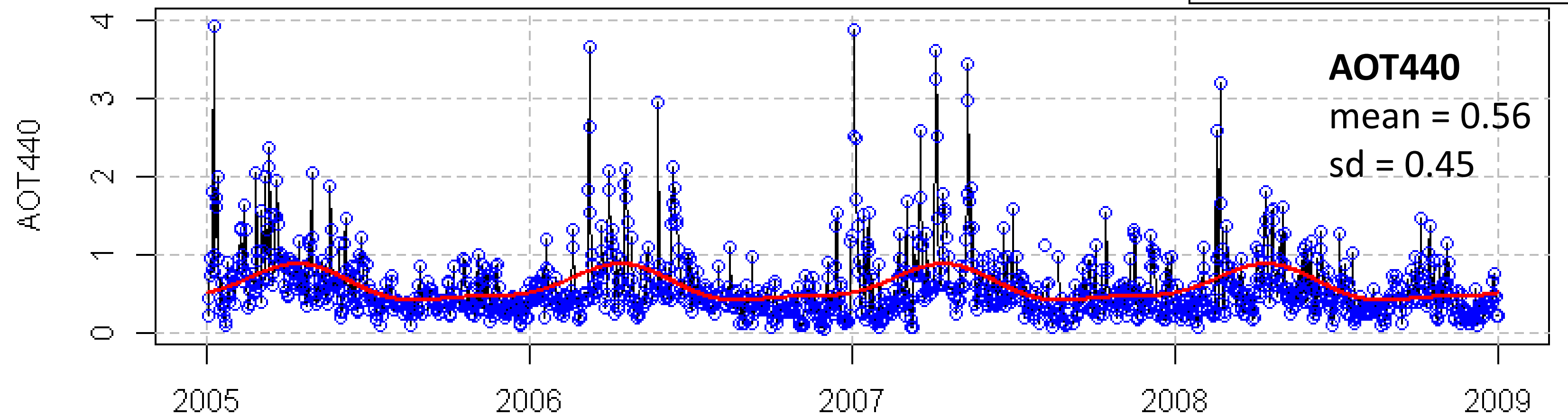
http://aeronet.gsfc.nasa.gov/cgi-bin/type_piece_of_map_opera_v2_new
Holben NB et al. 2001

- PM10 aerosol mass concentration

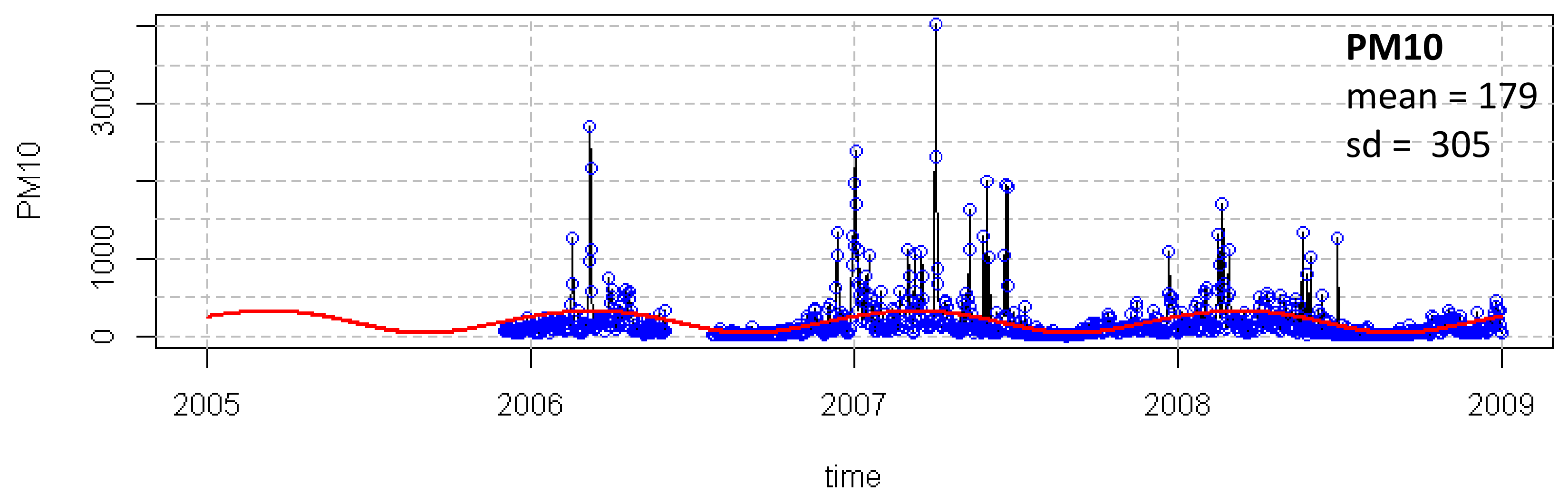
AMMA database (http://database.amma-international.org)
Marticorena B et al. 2010



Banizoumbou (Niger)

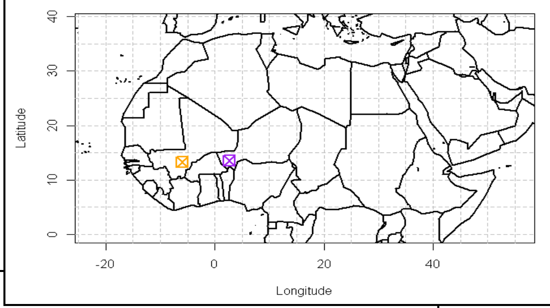


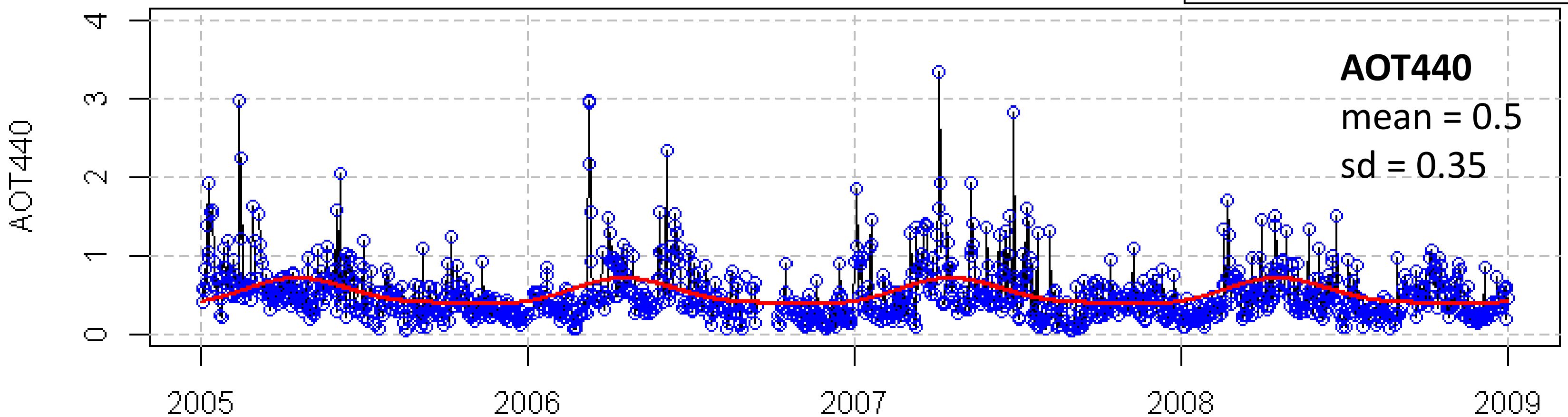
Daily data from the 1st of January 2005 to the 31st of December 2008



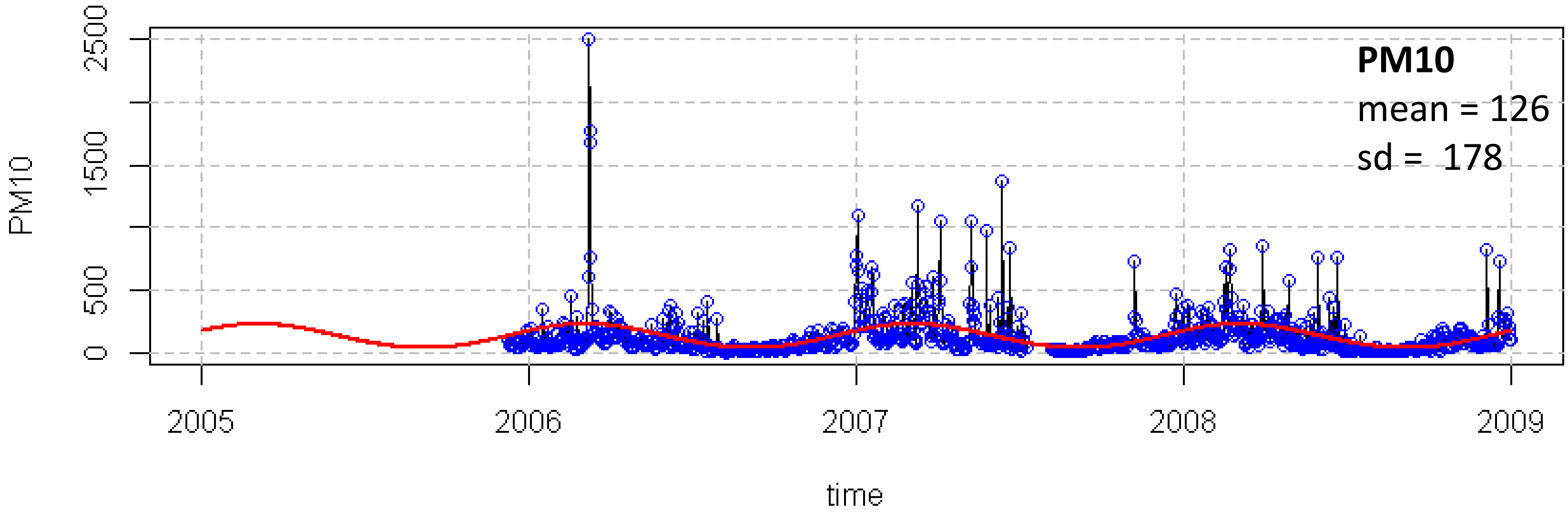
Daily data from the 2nd of December 2005 to the 31st of December 2008

Cinzana (Mali)



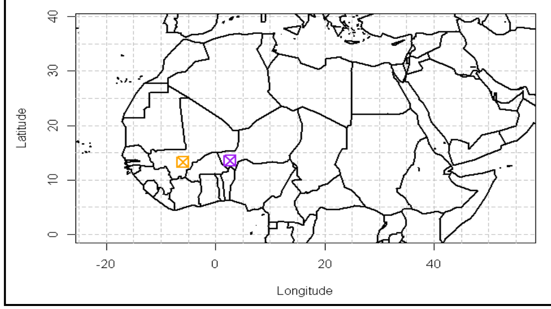


Daily data from the 1st of January 2005 to the 31st of December 2008

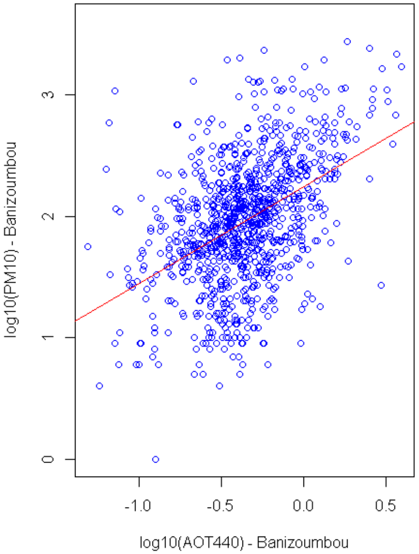


Daily data from the 9th of December 2005 to the 31st of December 2008

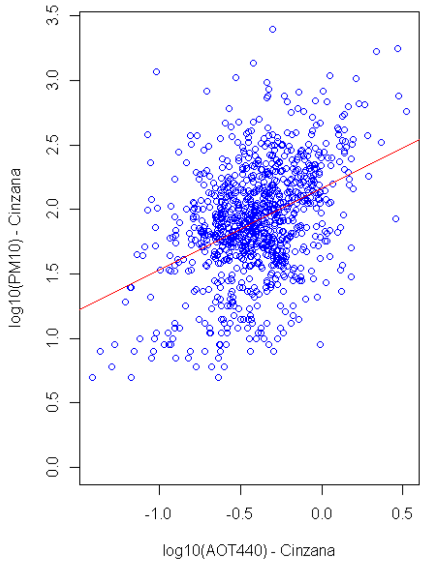
Comparison of daily AOT & PM10



n = 1069 r = 0.46 p.value < 0.01



n = 1084 r = 0.40 p.value < 0.01

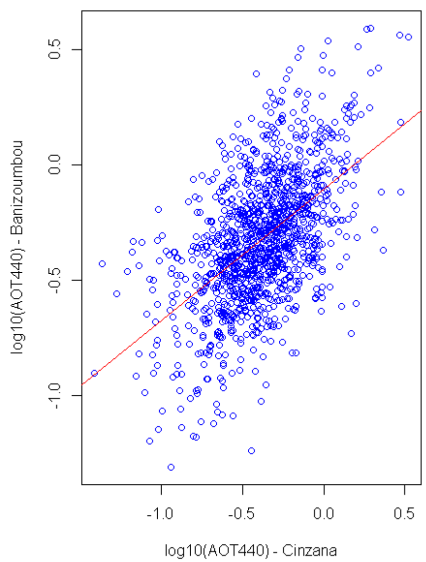


Significant but weak relationship at daily time scale between AOT440 and PM10

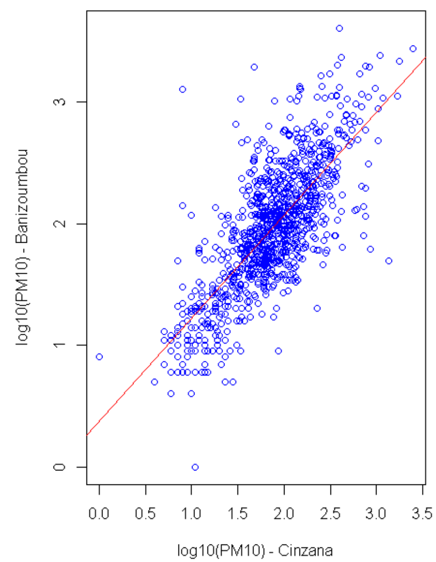
Spatial dependence - daily AOT & PM10

Stronger spatial dependence in PM10 meaning that mineral aerosol concentration varies more synchronically at daily time scale

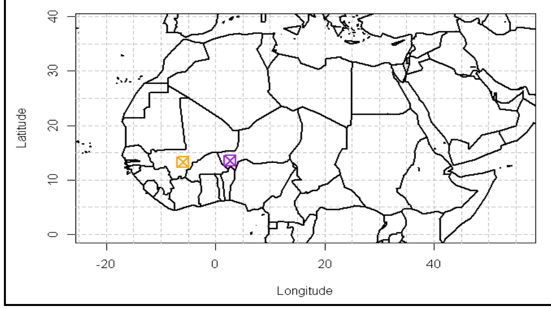
n = 1069 r = 0.54 p.value < 0.01

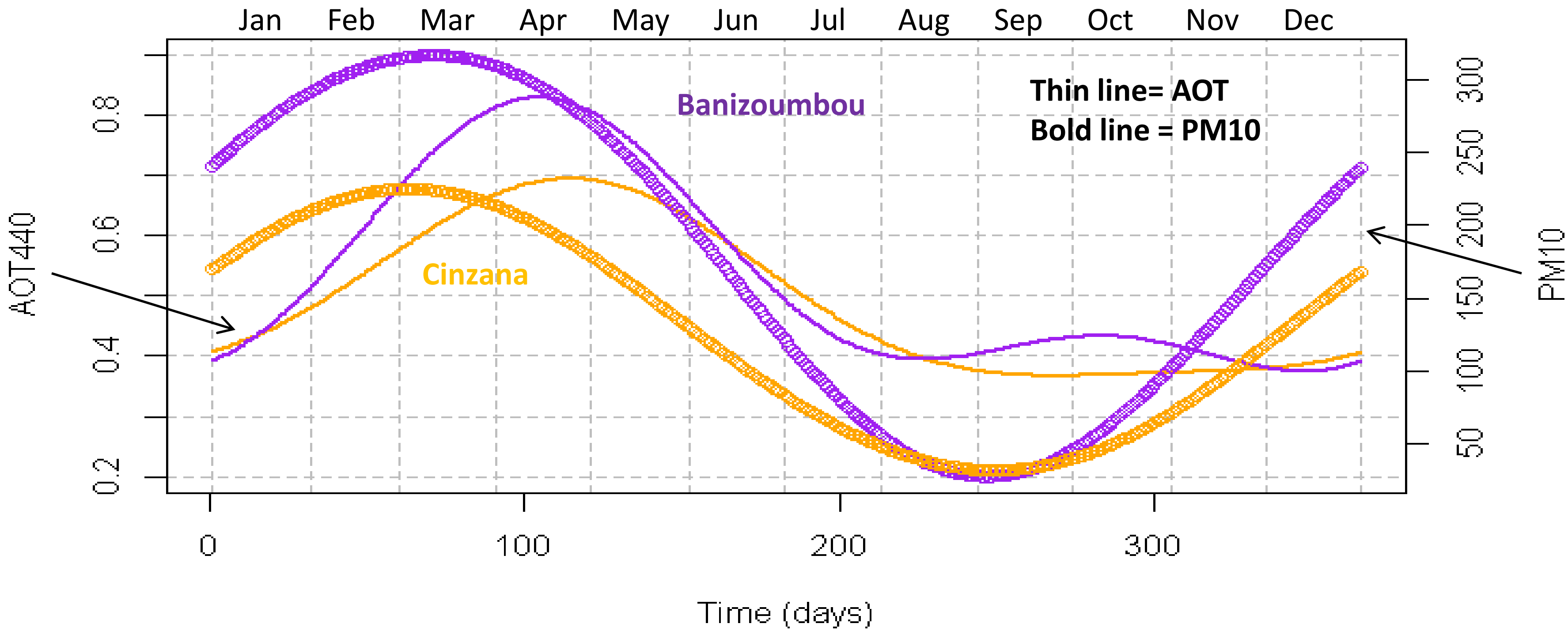


n = 1069 r = 0.75 p.value < 0.01



Annual cycle: PM10 & AOT





At **Banizoumbou** = Annual peak in March for PM10 (~1 month earlier than for AOT 440)

At **Cinzana** = Annual peak between February and March (~1.5 month earlier than for AOT 440)

The dust season is longer and stronger at Banizoumbou than at Cinzana

Wind data

Era Interim Reanalysis

Daily mean u and v at 10 meters

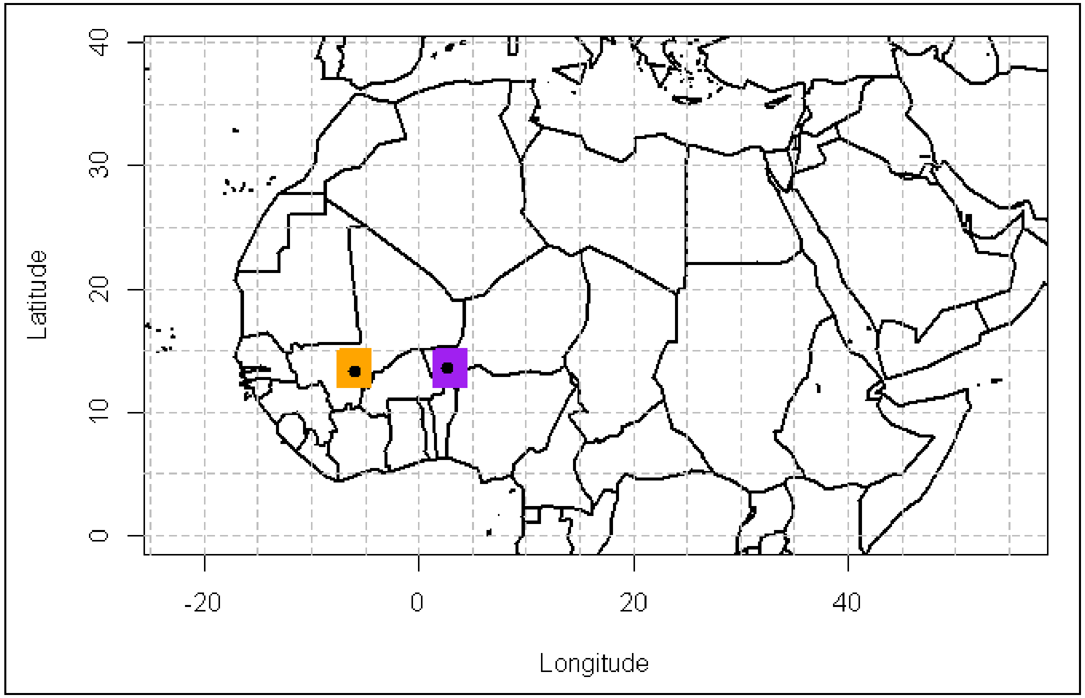
From the 1st of January 2005 to the 31st of December 2008

Spatial resolution : 1.5°lon*1.5°lat

The u10m and v10m components are averaged over and around both stations:

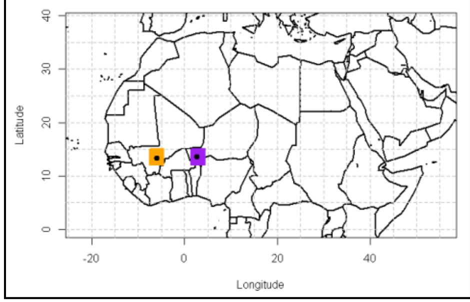
9 points = area 4.5°*4.5°

Capture of the synoptic (versus local) wind feature

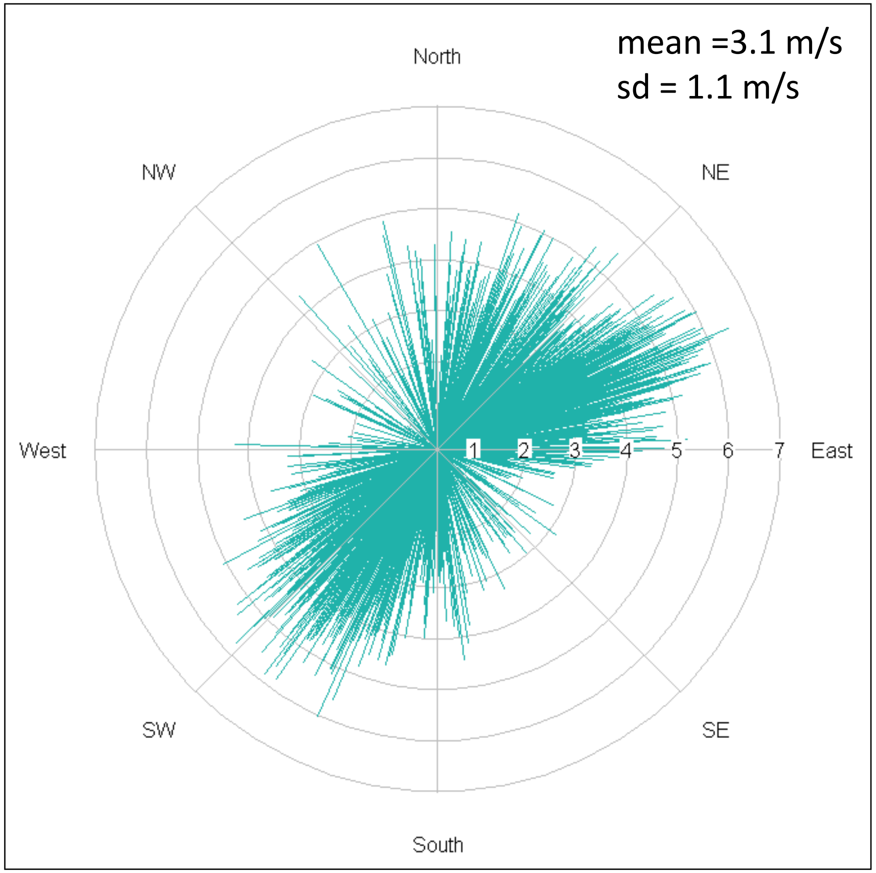


Daily mean wind speed and direction at 10 meters

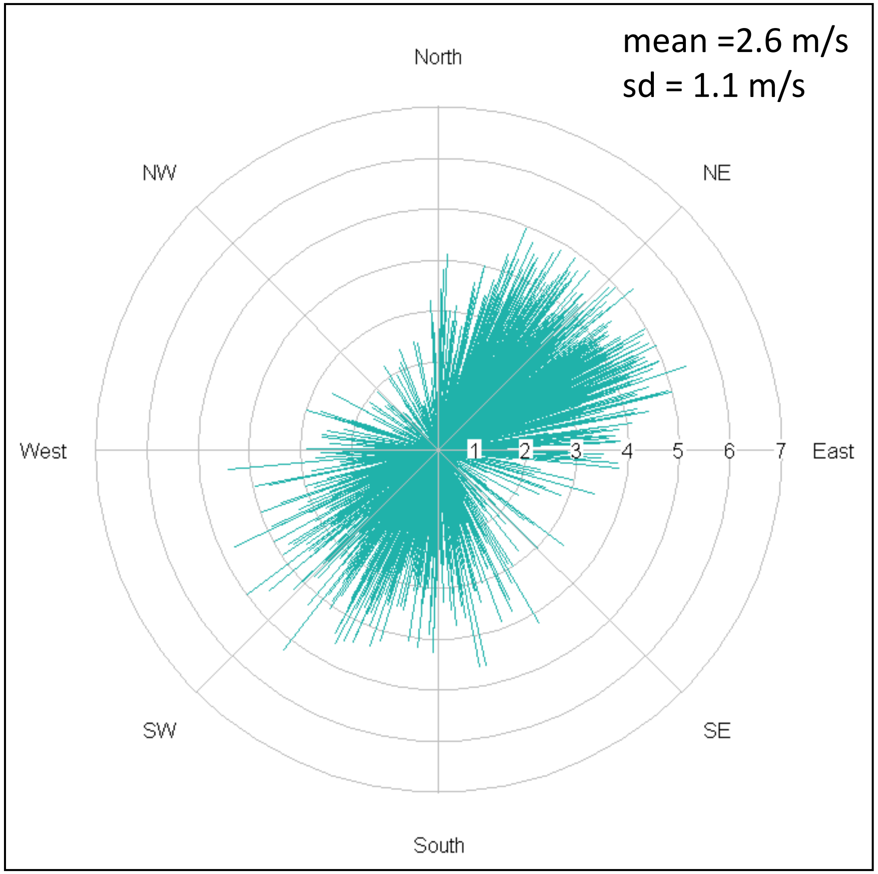
From the 1st of January 2005 to the 31st of December 2008
n= 1461
radial unit = m/s



Banizoumbou



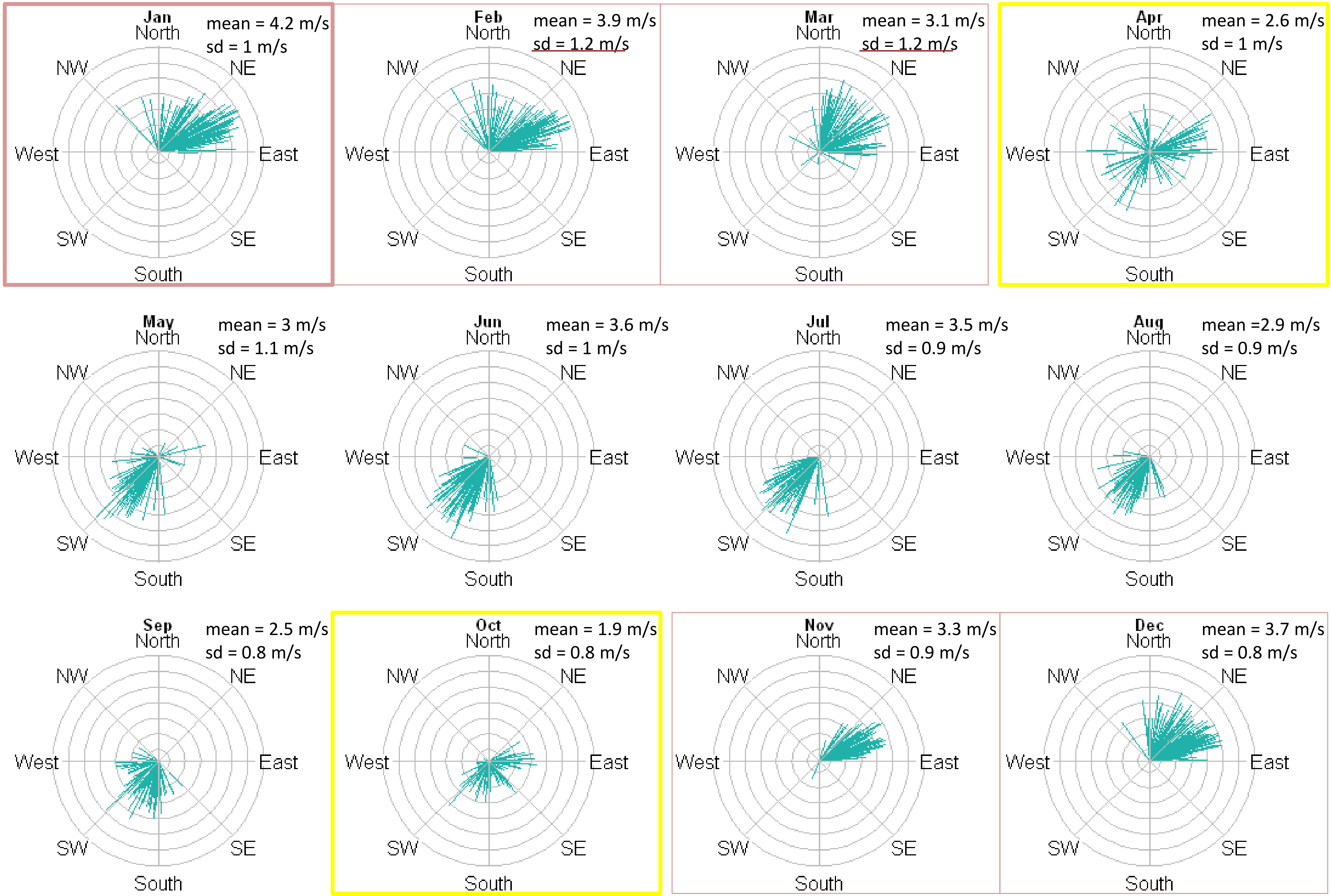
Cinzana



For both stations, the wind direction shows 2 preferential sectors: North-East and South-West

Banizoumbou

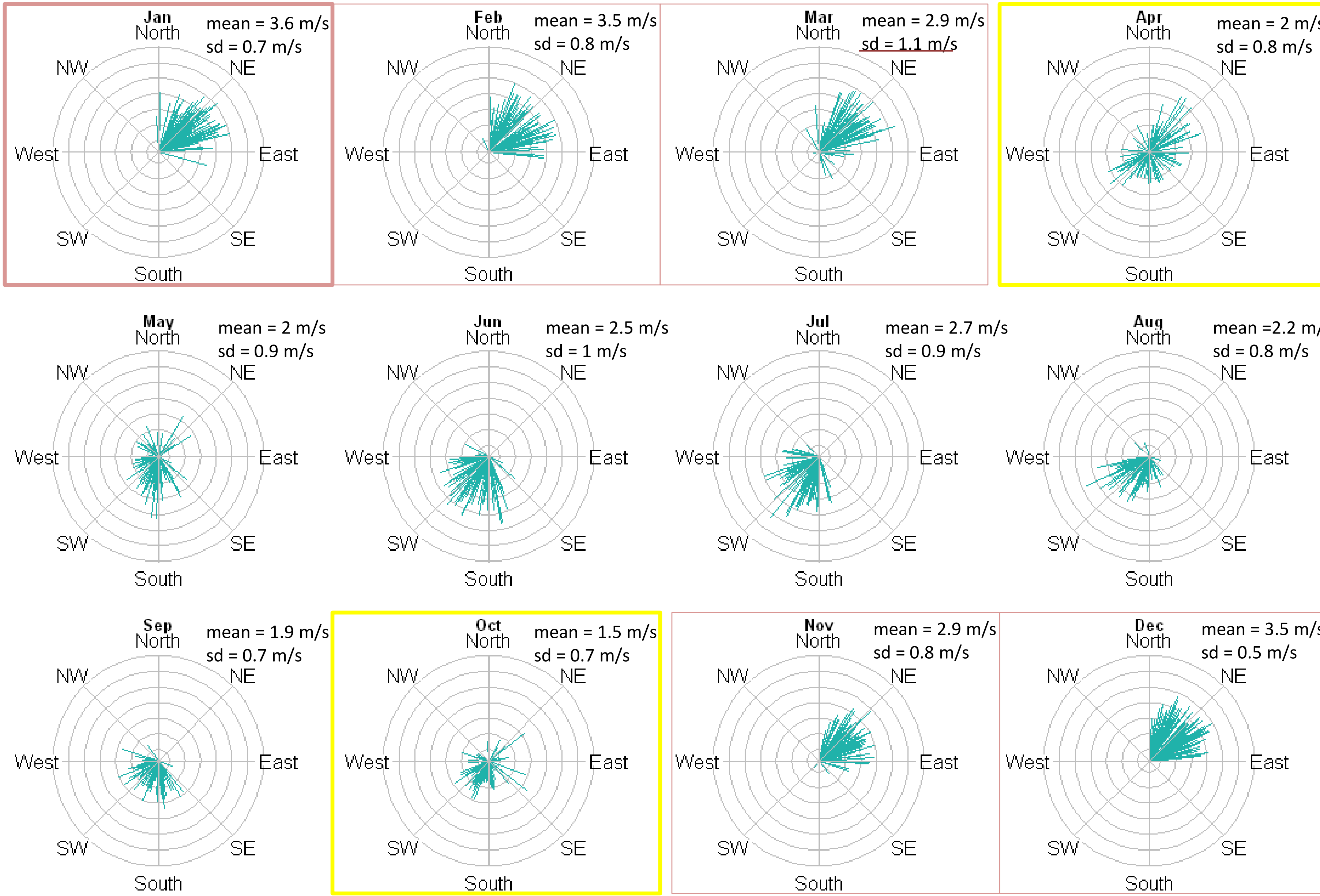
Daily mean wind speed and direction at 10 meters (per month) radial unit = m/s



Transition between winter (harmattan) and summer (monsoon) is accomplished in April and inversely in October

Maximum harmattan strength in January and maximum of variance in February and March

Cinzana **Daily mean wind speed and direction at 10 meters (per month)** **radial unit = m/s**

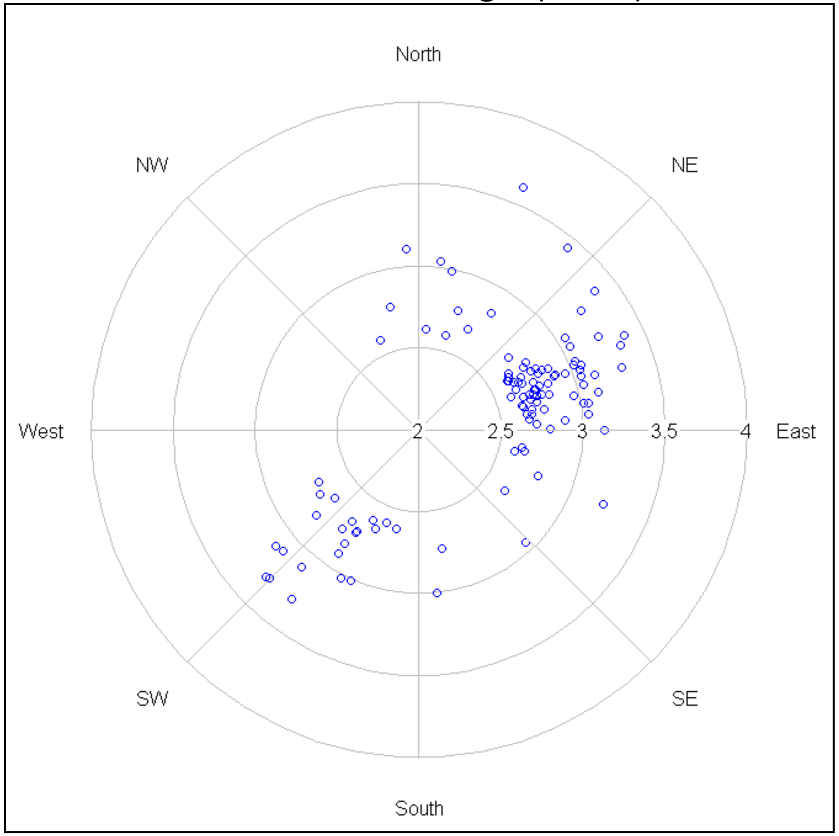


Transition between winter (harmattan) and summer (monsoon) is accomplished in April and inversely in October

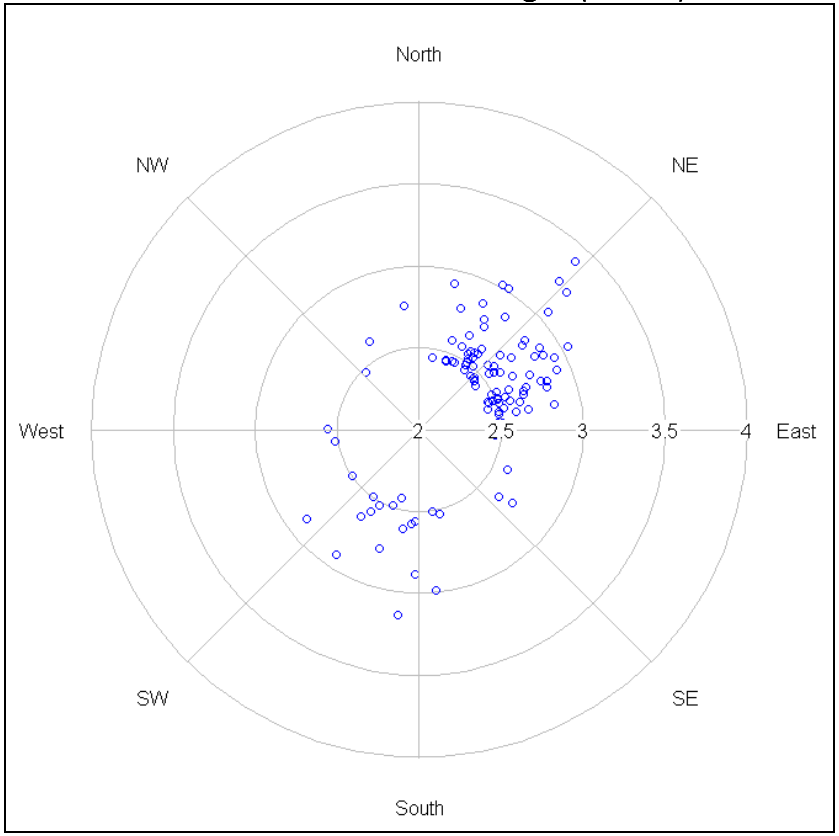
Maximum harmattan strength in January and maximum of variance in March

Extremes of PM10 (>= 90th perc.) and wind direction at 10 m

Banizoumbou
PM10 90th perc = 392
n= 108 radial unit = log10(PM10)

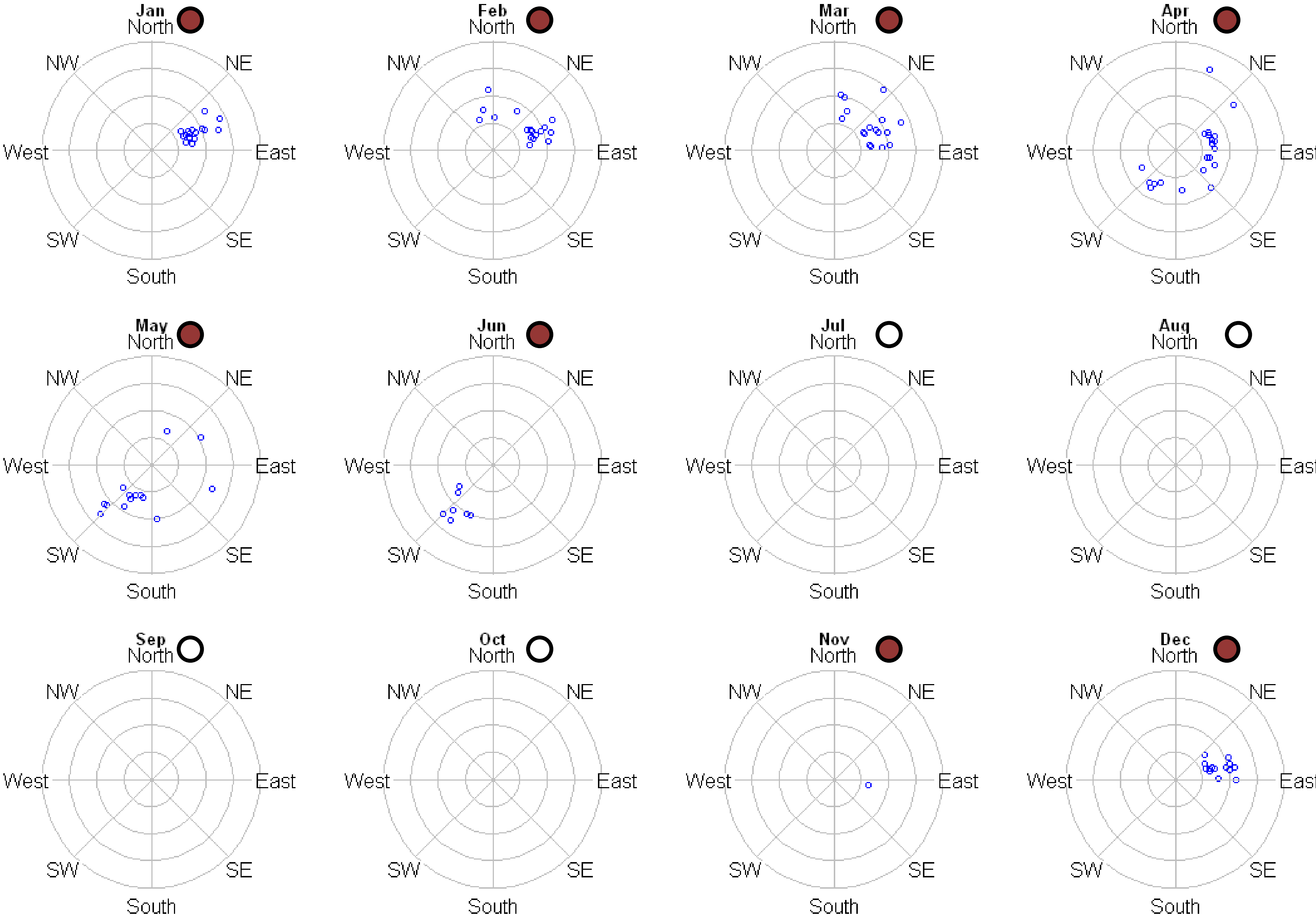


Cinzana
PM10 90th perc = 269
n= 109 radial unit = log10(PM10)



Ext(PM10) occurred more frequently in the north to east sector of wind

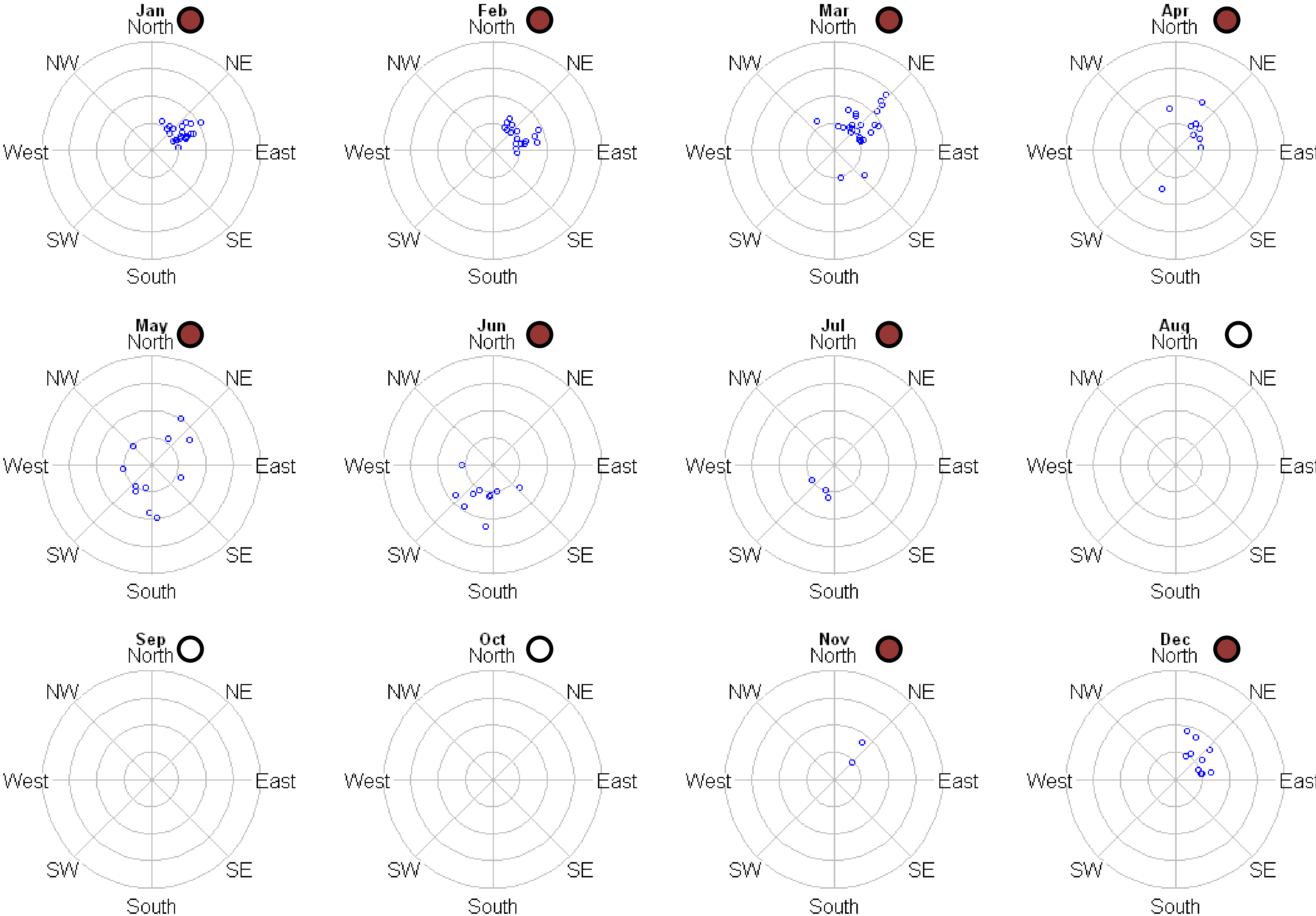
Banizoumbou Ext(PM10) and wind direction at 10 meters (per month) radial unit = log10(PM10)



Ext(PM10) occurred between November and June.

Most of them happened in the harmattan wind sector (North-East).

Cinzana Ext(PM10) and wind direction at 10 meters (per month) radial unit = log10(PM10)



Ext(PM10) occurred between November and July.

Most of them happened in the harmattan wind sector (North-East)

Harmattan wind sector = North to East

At Banizoumbou **68%** of Ext(PM10) occurred in the harmattan wind sector (total number of days =73)

At Cinzana **75%** of Ext(PM10) occurred in the harmattan wind sector (total number of days =82)

Number of daily Ext(PM10) in the north to east sector per month

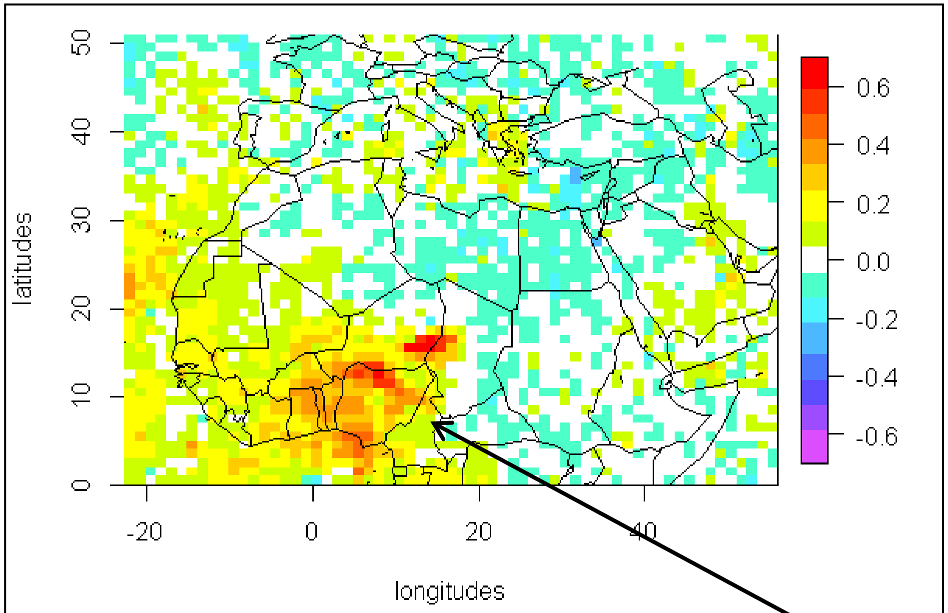
	Banizoumbou	**Cinzana**	**Co-occurrence**
Jan	17	21	12
Feb	14	16	8
Mar	17	23	13
Apr	10	7	3
May	2	3	2
Jun	0	0	0
Jul	0	0	0
Aug	0	0	0
Sep	0	0	0
Oct	0	0	0
Nov	0	2	0
Dec	13	10	4
Total	**73**	**82**	**42**

Ext(PM10) in the harmattan are more frequent from January to March

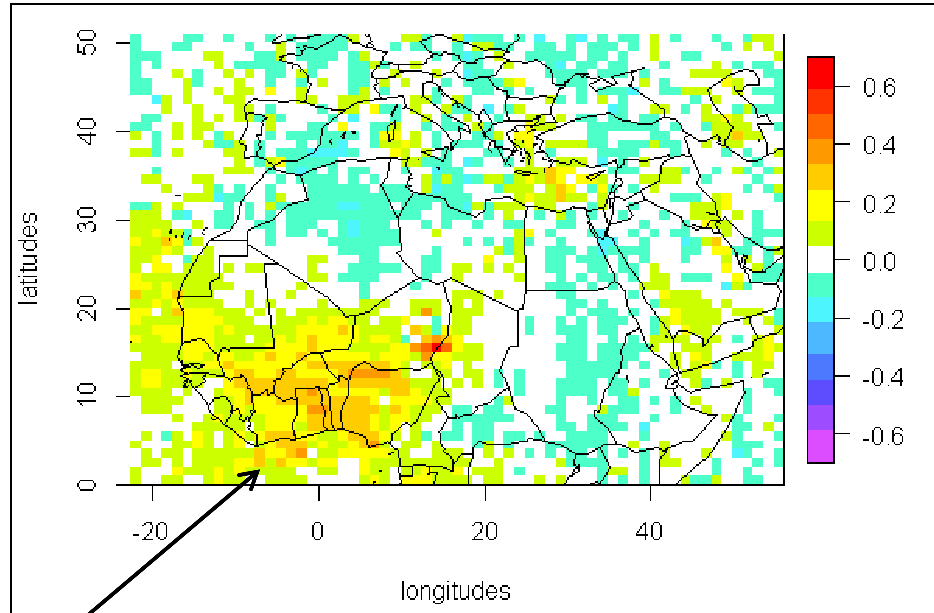
Composites Ext(PM10) in the harmattan

Mean daily anomalies (annual cycle is removed from daily data)

Banizoumbou (n= 73)
AI-OMI



Cinzana (n= 82)
AI-OMI



Aerosol Index (AI-OMI) = positive anomalies over the western Sahel toward the Guinean coast

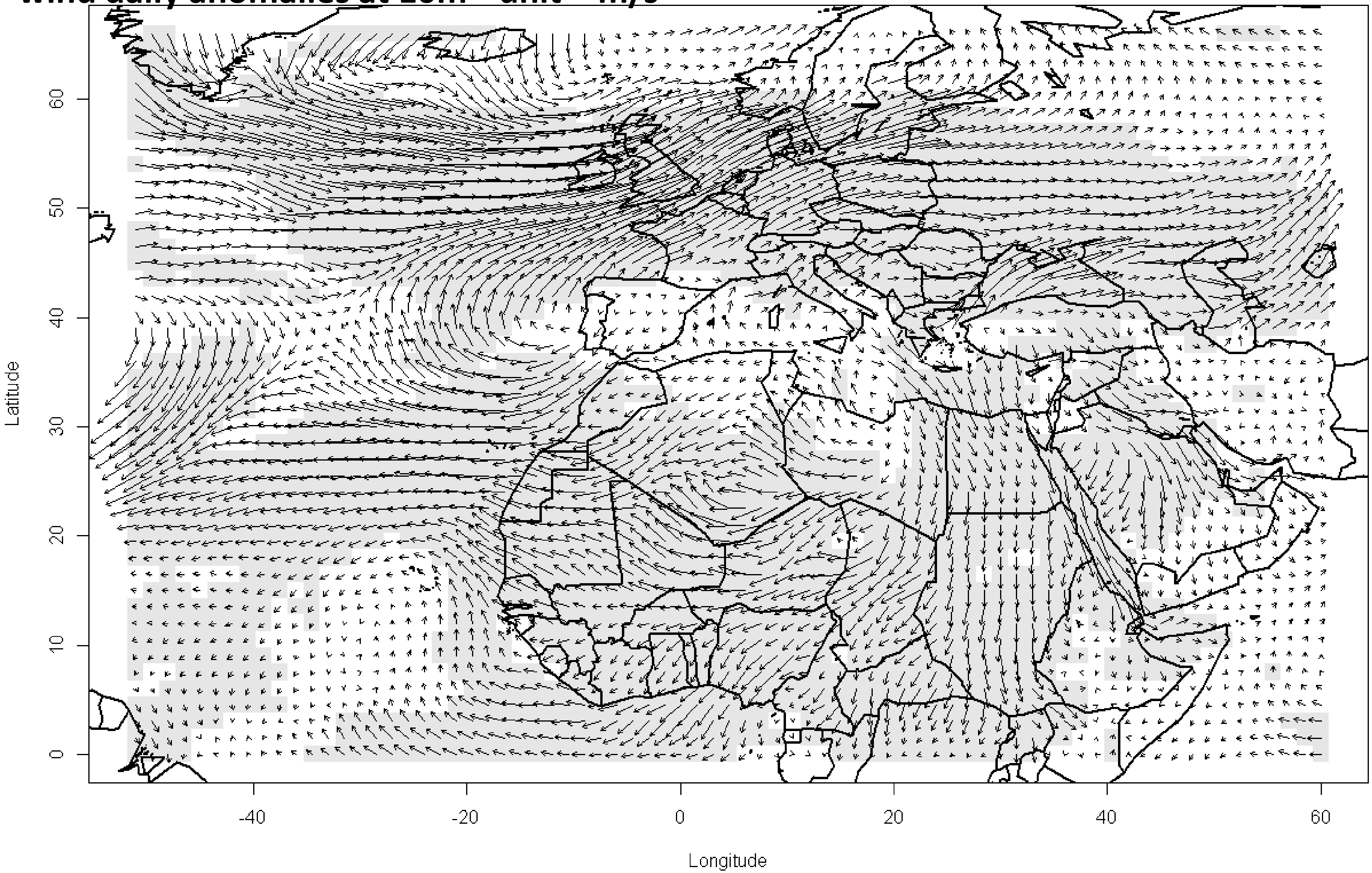
→ Correct capture of Ext(PM10) in the harmattan wind
(in accordance with e.g. Huang et al. 2010)

→ Structure more marked for Banizoumbou with stronger positive anomalies than for Cinzana
(consistent with previous results: PM10 and AOT, aerosol concentration is stronger at Banizoumbou than at Cinzana)

Banizoumbou Composites Ext(PM10) in the harmattan

n= 73 shading= sig> 99% bootstrap test: nb samples = 100 length samples = n= 73

wind daily anomalies at 10m unit = m/s



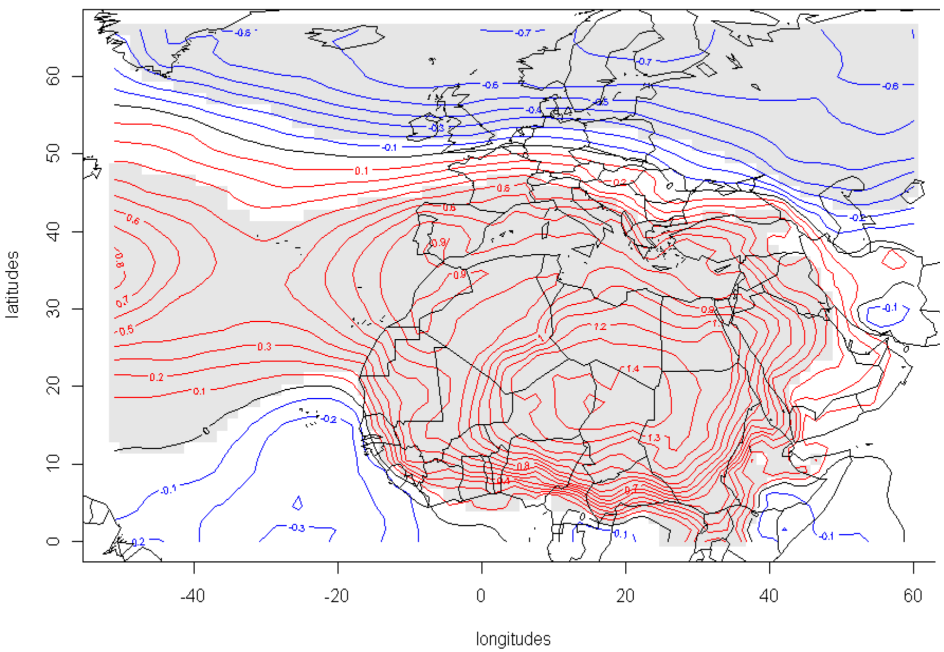
Reinforcement of the north and east components from eastern Libya to the Guinean coast (consistent with the AI OMI pattern)

Banizoumbou

Composites Ext(PM10) in the harmattan

n= 73 shading= sig> 99% bootstrap test: nb samples = 100 length samples = n= 73

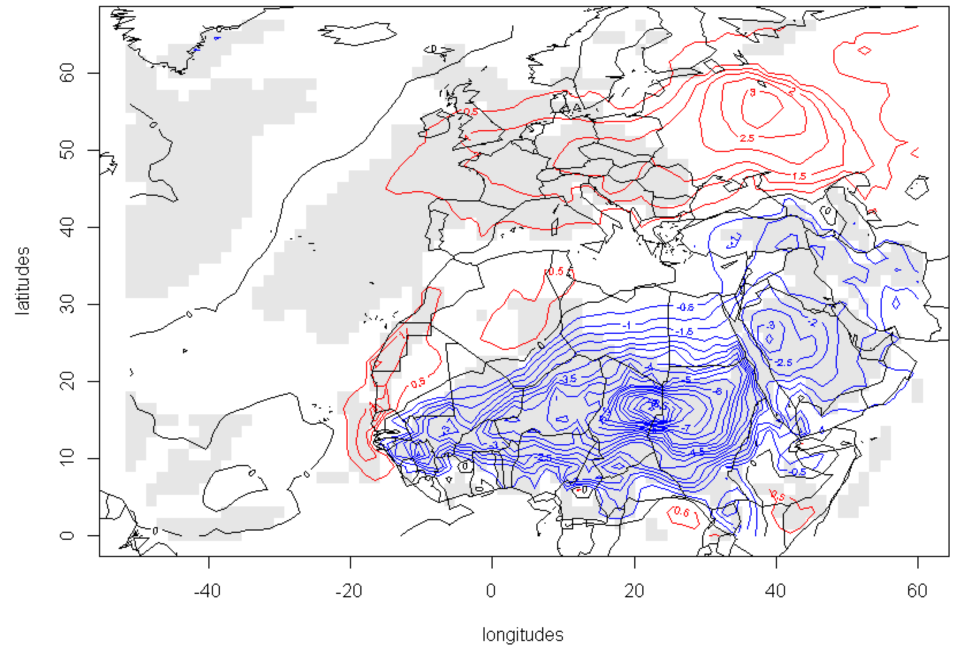
Mslp unit = nb sd (daily) interval contour = 0.1



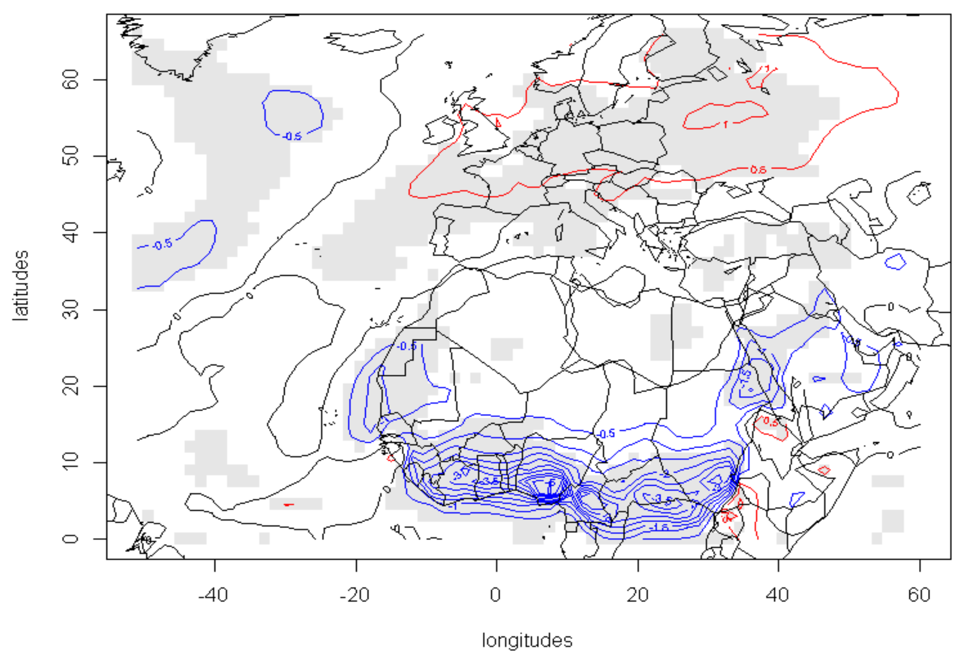
At Banizoumbou, Ext(PM10) are associated with:

- → a reinforcement of mslp over Northern Africa and the Mediterranean sea more marked over Chad;
- → colder temperature from the red sea to the western Sahel;
- → drier conditions over the western Sahel toward the Guinean coast.

Ta2m unit = nb sd (daily) interval contour = 0.5



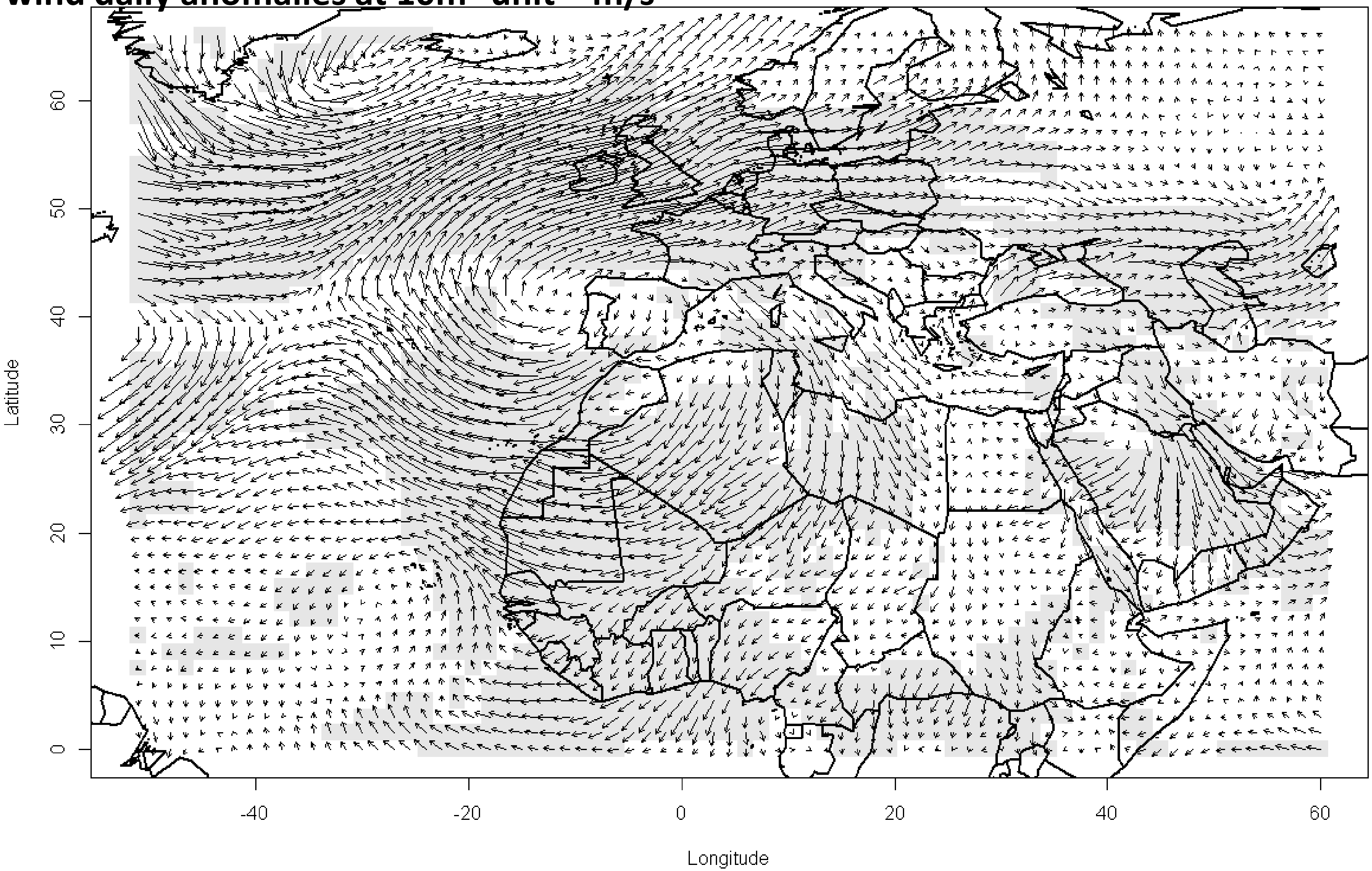
Sp1000 unit = nb sd (daily) interval contour = 0.5



Cinzana Composites Ext(PM10) in the harmattan

n= 82 shading= sig> 99% bootstrap test: nb samples = 100 length samples = n= 82

wind daily anomalies at 10m unit = m/s



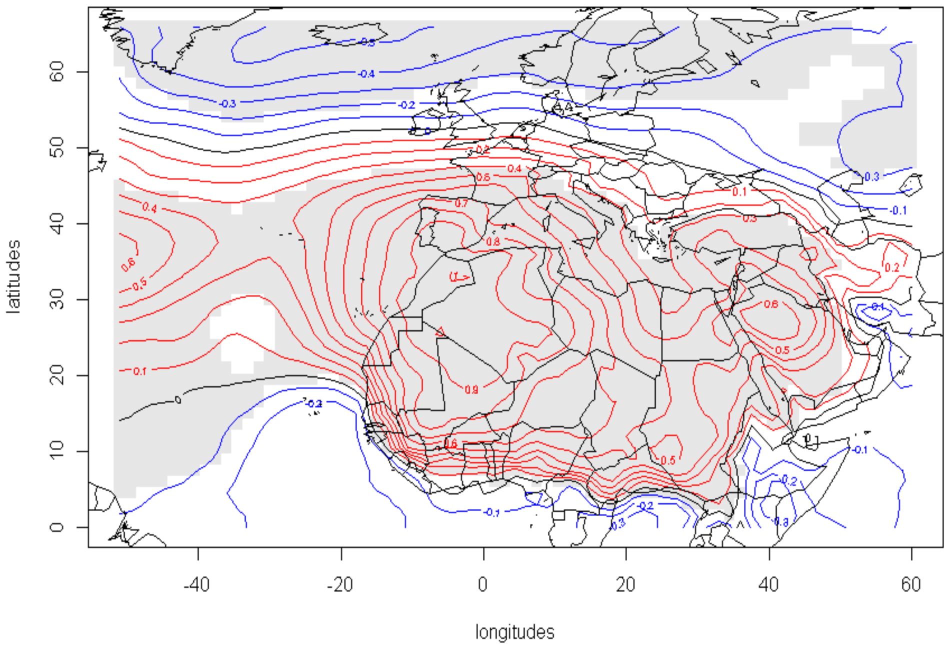
→ Reinforcement of the north and east components from Western Libya/Eastern Algeria to the Guinean coast (consistent with the AI OMI pattern)

Cinzana

Composites Ext(PM10) in the harmattan

n= 82 shading= sig> 99% bootstrap test: nb samples = 100 length samples = n= 82

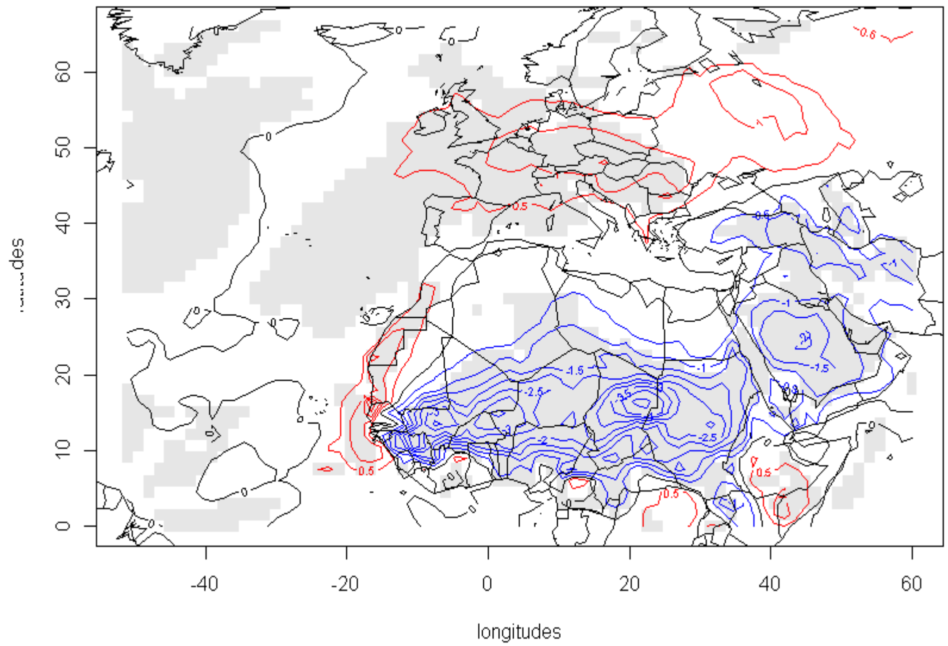
Mslp unit = nb sd (daily) interval contour = 0.1



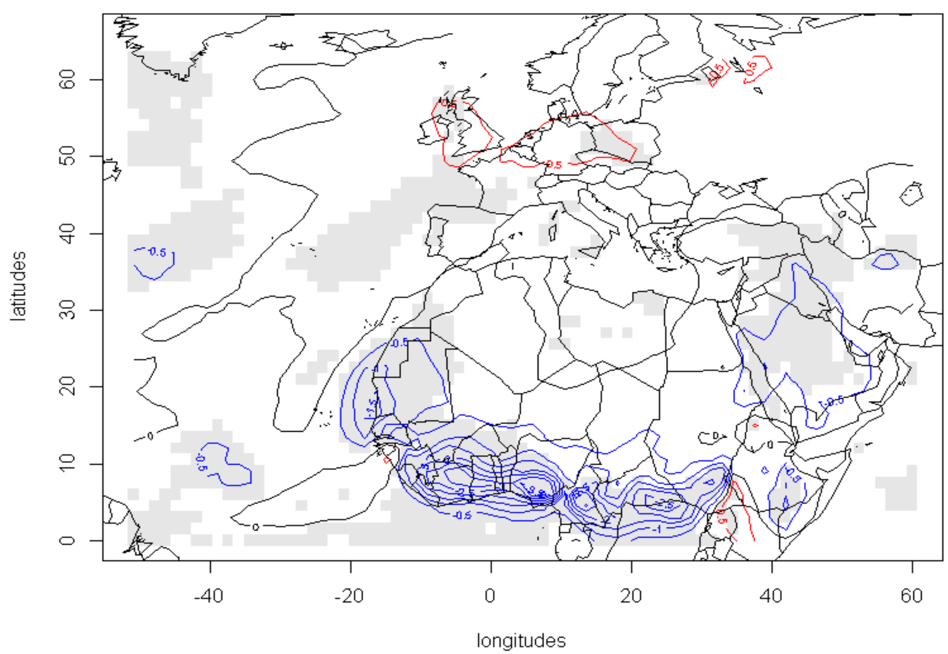
At Cinzana, Ext(PM10) are associated with:

- a reinforcement of mslp over Northern Africa and the Mediterranean sea, more marked over Algeria;
- colder temperature from the red sea to the western Sahel;
- drier conditions over the Guinean domain.

Ta2m unit = nb sd (daily) interval contour = 0.5



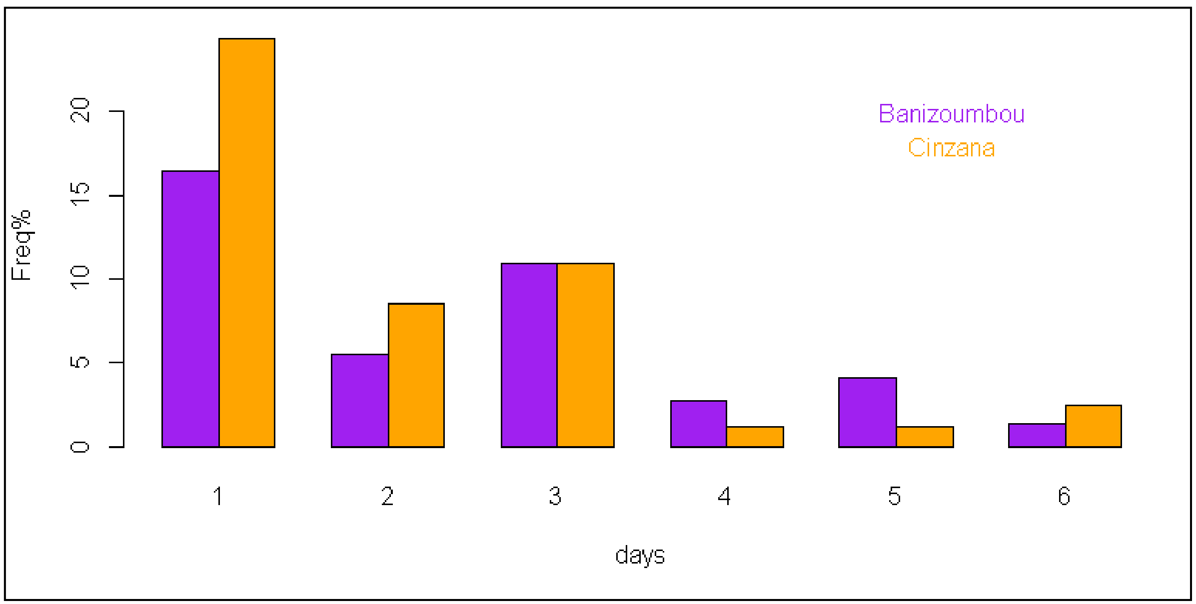
Sp1000 unit = nb sd (daily) interval contour = 0.5



Definition of event = sequence of Ext(PM10) in the harmattan

	total number of events (per year)	mean duration (in days)	mean (PM10)
Banizoumbou	30 (10)	2.43	870
Cinzana	40 (13)	2.05	515

Duration of harmattan dust events (in days)



→ At Banizoumbou, dust events are less numerous but are stronger and have a longer duration than at Cinzana

Conclusion

Summary

Using PM10 data at Banizoumbou and Cinzana and wind at 10m from Era-Interim, we have shown that

1- most of dust extremes occurred in the hamattan wind and more frequently from January to March;

2- Specific synoptic conditions are associated with Ext(PM10) in the harmattan wind;

- a reinforcement of mslp over Northern Africa and the Mediterranean sea;
- a reinforcement of the north and east wind components upstream of stations;
- colder and drier conditions over the Sahelian and Guinean domains respectively;

3- dust events are more frequent at Cinzana but shorter and less intense than at Banizoumbou.

Future work

A future work will be dedicated to the classification of synoptic configurations associated with harmattan dust event features.

→ Analysis of synoptic configurations at interannual time-scale

→ Potential links with meningitis epidemic dynamics

Thanks !

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NASA GES Disc Goddard Earth Sciences Data and Information Services Center (AI-OMI data)