Advances in research on the relationships between climate, dust and meningitis in West Africa in the AMMA frame

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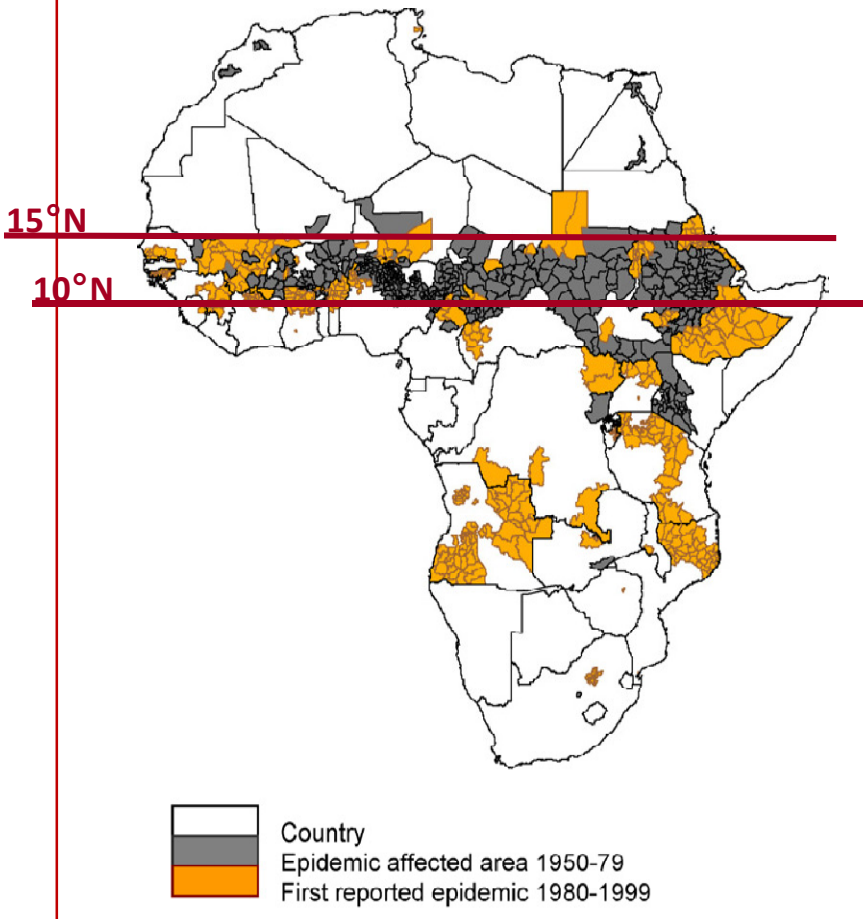
« Climate-Health» AMMA Work Package

Introduction



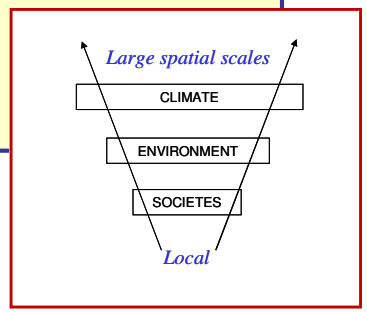
Spatial distribution of meningitis epidemics

(Cuevas *et al.*, 2007)

- Meningitis « belt » (Lapeyssonnie, 1963)
- Heart of the dry season : February-April
- Meningoccocal Meningitis, Bacteria Neisseria Meningitidis, serogroup **A**, C, Y et **W135** (Alonso et al., 2005)
- 25-250.000 cases a year (WHO, 2002)
- Children < 15 (Teyssou & Muros-Le-Rouzic, 2007)
- 10% of mortality (Kaplan & Feigin, 1985)
- 10-20% of survivors with neurological repercussion (Smith et al., 1998)

A HUGE PUBLIC HEALTH PROBLEM IN AFRICA

A COMPLEX MULTI-SCALE CLIMATE-ENV-SOCIETY PROBLEMATIC

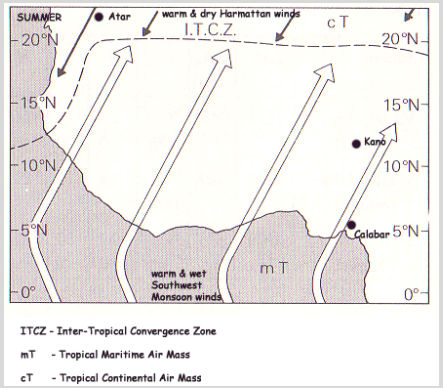


CLIMATE

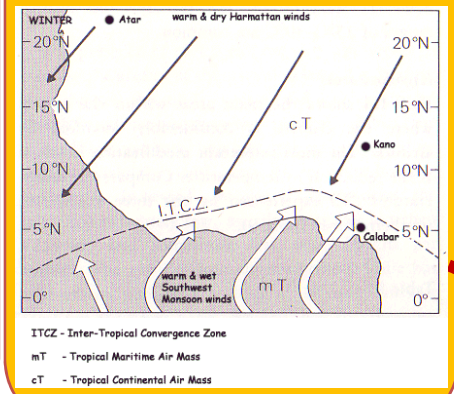
feedbacks

ENV : DUST

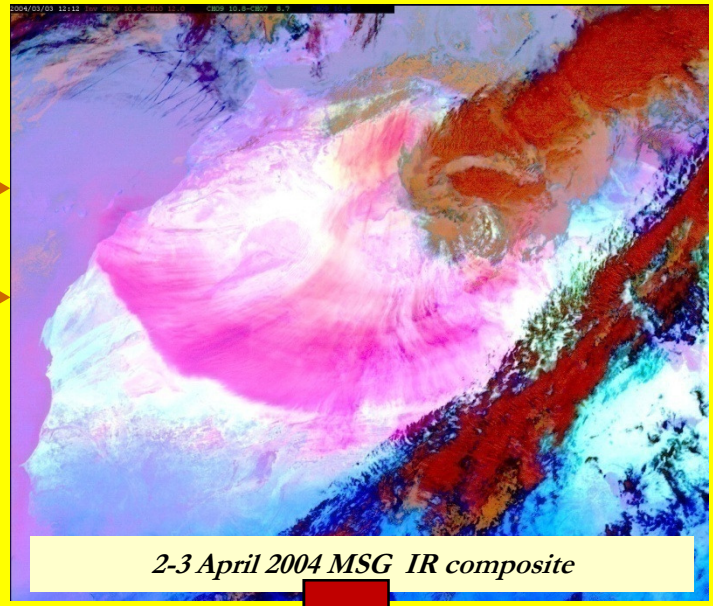
MONSOON (SUMMER)



HARMATTAN (WINTER)



Large scale



2-3 April 2004 MSG IR composite

Local scale

Wind, Temperature, Humidity

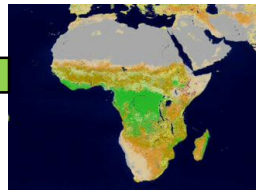
feedbacks

MENINGOCCOCAL MENINGITIS

ENV : VGT

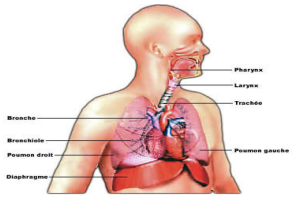
MODIS, March 2003

SOCIETY

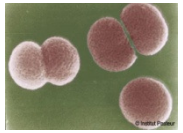


Land Cover

Socio-economic factors



Bacteria : Neisseria Meningitidis



Hypotheses for the role of dust

Dust event in Morila (Mali) in March 2008

About meningitis :

"Extremely high air dryness combined to high dust load that persists over many weeks may increasingly damage the pharyngeal mucosa, to the point where the colonizing meningococci are more likely to invade the epithelium"
(Mueller & Gessner, 2010)

About other respiratory disease :

"The link between asthma and dust in the Caribbean is based largely on anecdotal evidence that associates sharp increases in the occurrence of asthma symptoms with hazy conditions often caused by dust" (Prospero *et al.*, 2008)

THERE IS A HIGH PROBABILITY FOR DUST TO BE A CAUSATIVE FACTOR IN THE MENINGITIS EPIDEMICS IN WEST AFRICA

Scientific questions

♦ What are the key climate and environment factors susceptible to play a role in the intensity, the beginning, and more generally the calendar of the epidemics?

- Presentation today

♦ At which spatial scale(s) can we detect a climate/dust-meningitis signal ?

- Spatial units considered by now : region - country – district

♦ What are the processes involved?

- Recent opening of the AMMA group to epidemiology and medecine

A quick state of the art …

♦ Low absolute humidity, and dusty atmospheric conditions, associated with the Harmattan trade winds, which occur during the meningitis season are suspected to be risk factors for meningitis epidemics (Horn, 1908; Sicé et al., 1940; Waddy, 1952; Lapeysonnie, 1963; Molineaux, 1969; Greenwood et al., 1984; Cheesbrough et al., 1995; Besancenot et al., 1997; Molesworth et al., 2002)

→ QUALITATIVE

♦ Rainfall and dust are major statistical predictors for intensity (annual incidence) of the epidemics (Molesworth et al., 2003, Thomson et al., 2006)

→ FIRST STEP BUT NO ASSUMPTIONS ON THE PROCESSES INVOLVED

& IMPORTANT KEY FACTORS LIKE WIND ARE NOT PUT IN EVIDENCE

& THE INTENSITY OF THE MENINGITIS ALONE

At the beginning of AMMA :

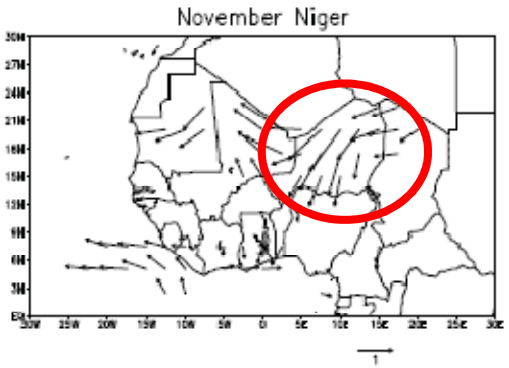
♦ Importance of the wind conditions on the intensity of the epidemics (Yaka et al., 2008)

♦ Importance of the wind conditions on the beginning of the epidemics (Sultan et al., 2005)

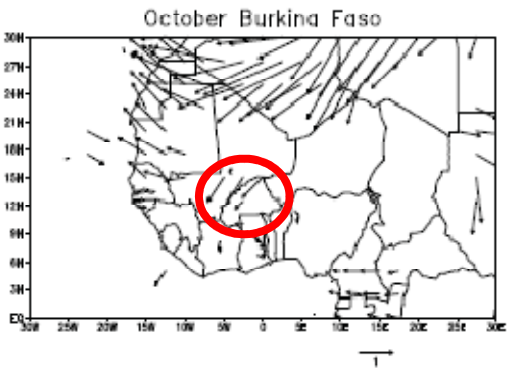
The intensity

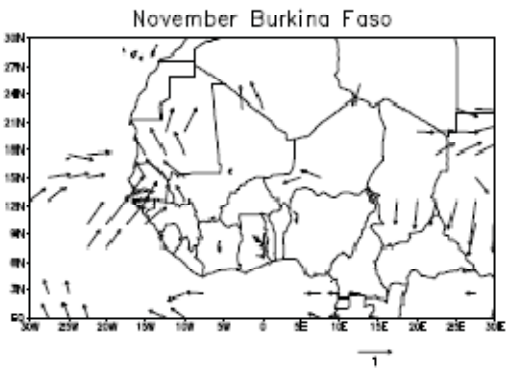
Data sets : WHO for EPI & NCEP/NCAR for CLIMATE (1969-2005)

Epidemic years in Niger



Epidemic years in Burkina Faso





Linked to early specific wind conditions

Yaka *et al.*, 2008

To go a little bit further …

- Is this confirmed for the recent time period?
- How to explain these specific climate configurations?
- How to relate these conditions to meningitis, and especially, 5 months before the meningitis season?

Thanks to a partnership with epidemiologists

Data sets : WHO for EPI & ERA-i for CLIMATE (1989-2010)

Méthodology : monthly climate composites for epidemic and non-epidemic years

E. Fluck (Master student, 2012)

A significant signal in the surface wind in Oct

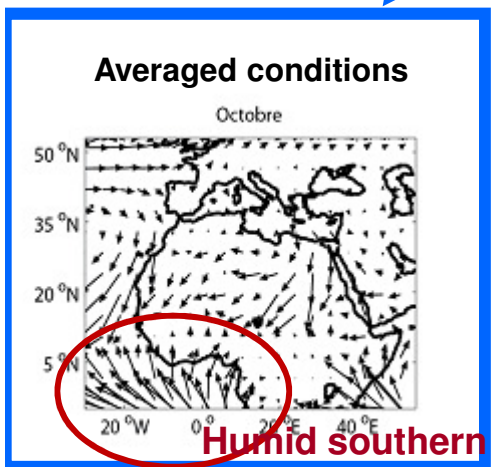
Reinforcement of the NE wind in Algeria and Southern Maroc

Reinforcement of the continental trade wind in October in the Sahel for epidemic years

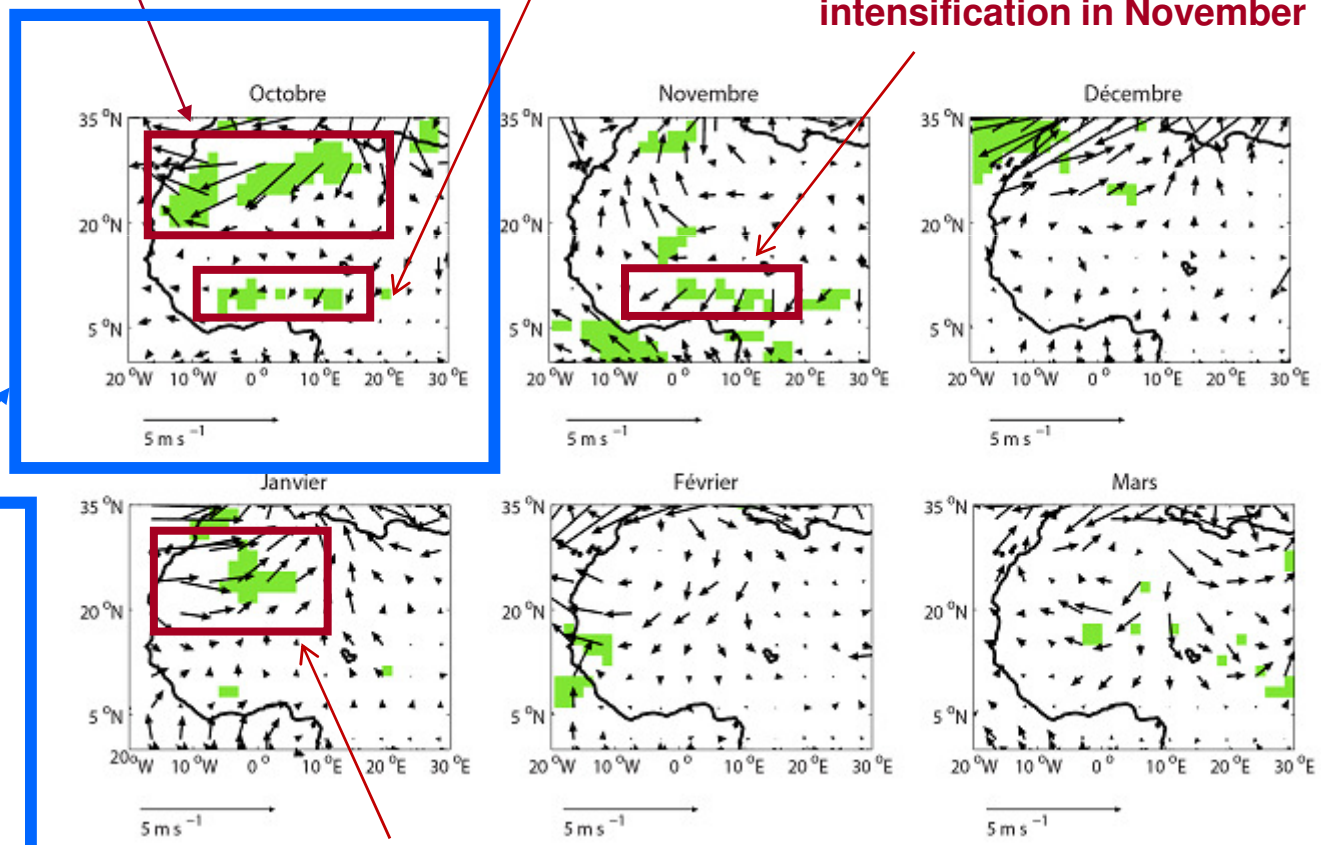
Persistence and intensification in November

Epidemic – Non Epidemic years in Burkina Faso

Variable : Wind at 10m



Humid southern flows



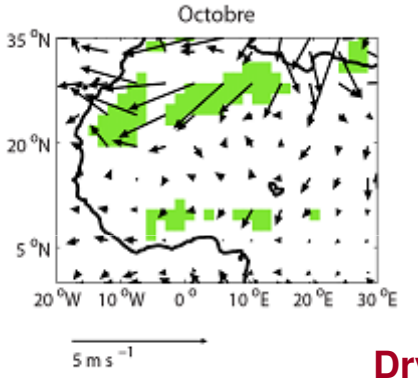
West Atlantic flows in January → weakening of the wind in the Sahel

E. Fluck (Master student, 2012)

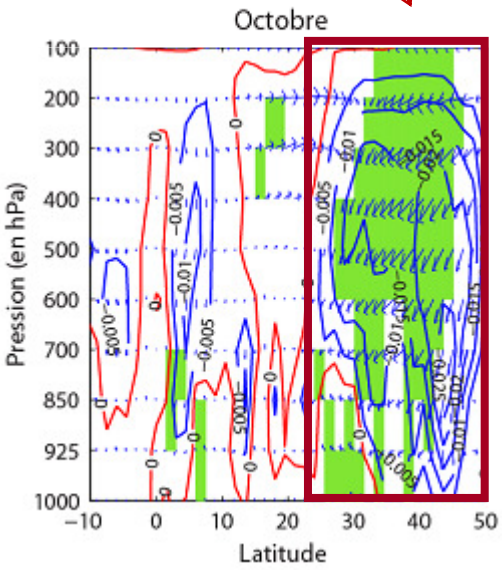
A significant signal in the surface wind in Oct

Variable :
Wind at 10m

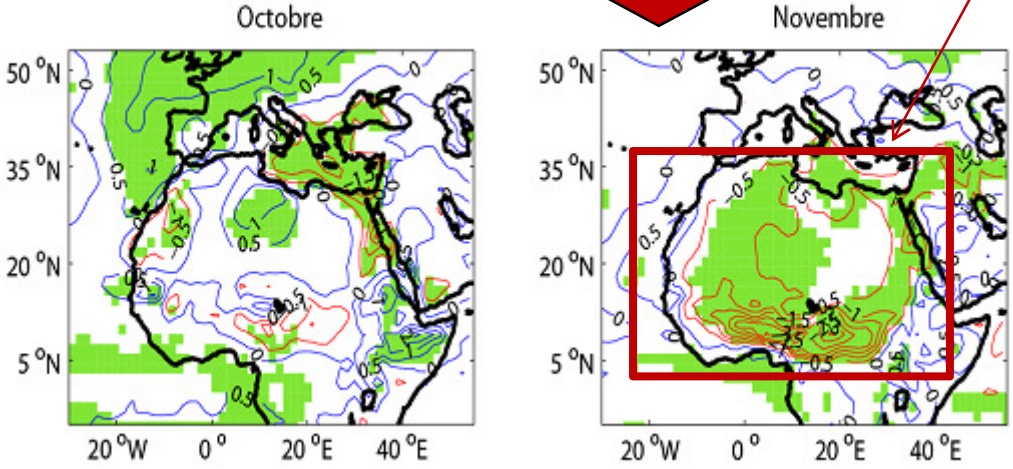
Epidemic – Non Epidemic years in Burkina Faso



Due to an anomaly of subsidence in the Mediterranean Sea



Dry conditions in November



E. Fluck (Master student, 2012)

The onset

Data sets : WHO for EPI & NCEP/NCAR for CLIMATE (1994-2002)

Epidemic years in Mali

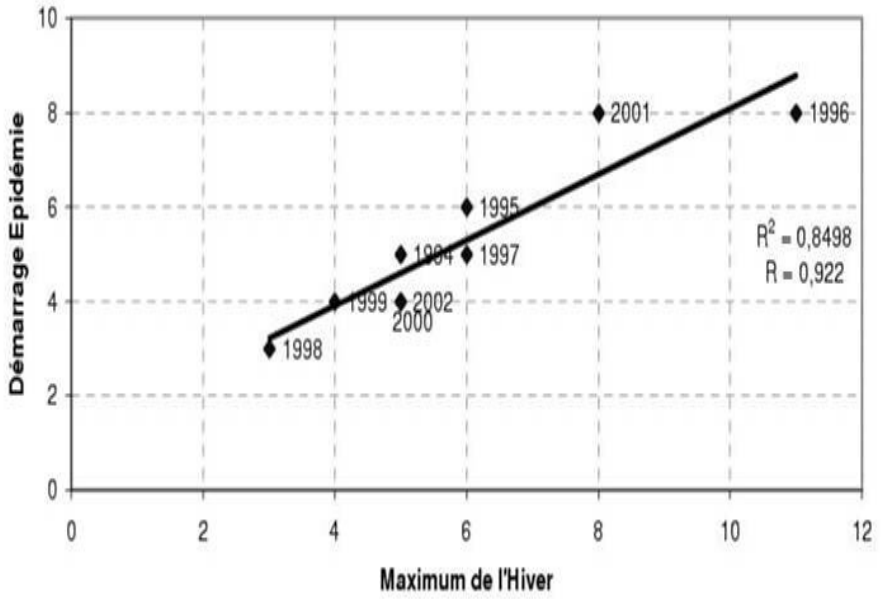


Figure adapted from Figure 5 by Sultan et al. (2005) :

Relationship between the week of the **meningitis onset** (Y axis) and the week of the **Winter Maximum** (X axis)

Linked to the maximum of Harmattan circulation

To go a little bit further …

- Is this confirmed elsewhere?
- How to relate these specific conditions to meningitis?

Thanks to a partnership with epidemiologists

Data sets : WHO for EPI & ERA-i for CLIMATE (1989-2010)

Méthodology : weekly climate composites for epidemic and non-epidemic years

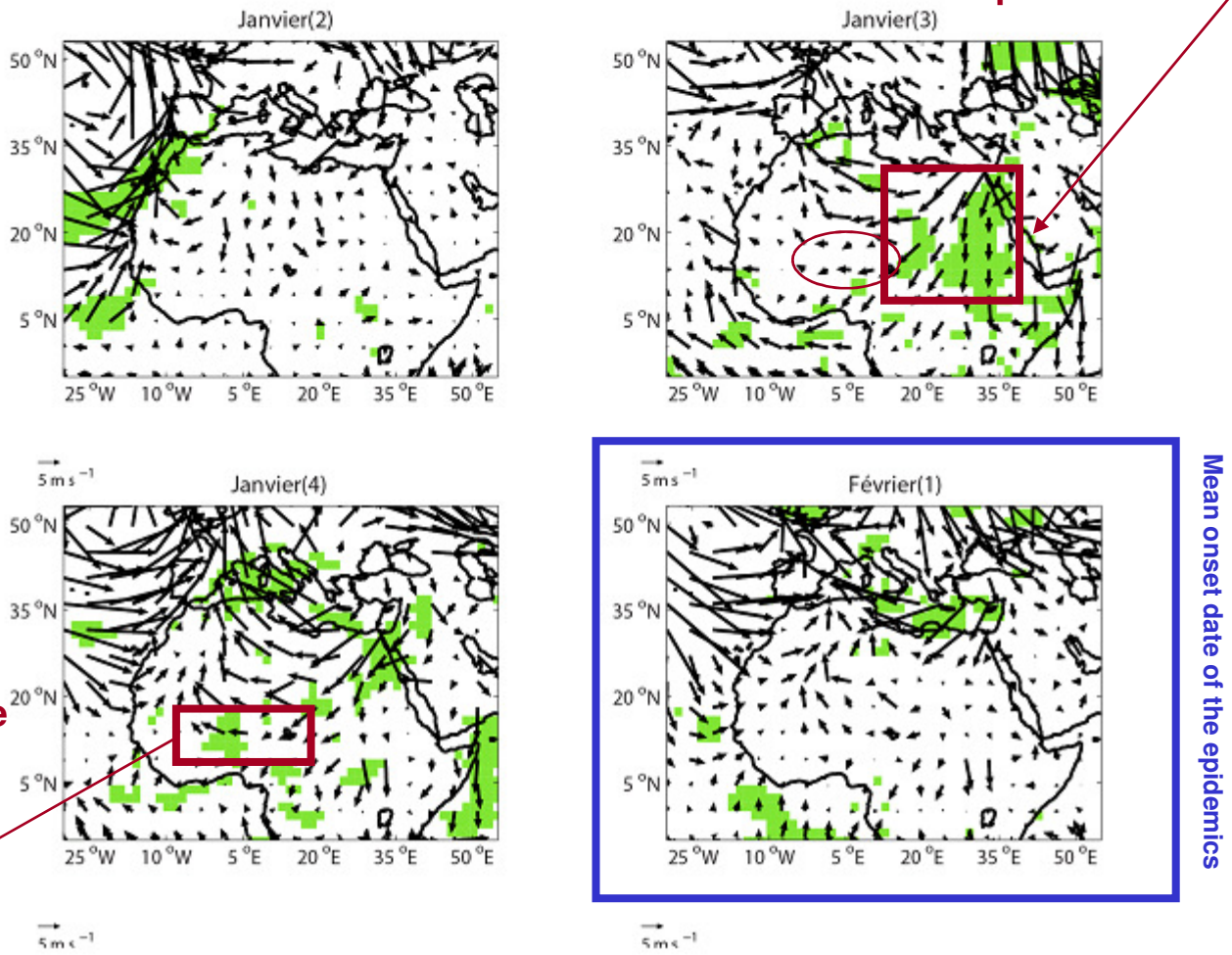
E. Fluck (Master student, 2012)

A significant signal 2 weeks before the onset

Reinforcement of the Harmattan wind in Egypt, Sudan and Chad 2 weeks before the mean onset date of the epidemics

Epidemic – Non Epidemic years in Burkina Faso

Variable : Wind at 10m



Zonal wind reinforcement in Burkina Faso 1 week before the mean onset date : this is due to the occurrence of an anticyclone which reinforce the eastern flows

Mean onset date of the epidemics

In Burkina Faso, the onset does not seem to be synchronous with the maximum of Harmattan circulation

E. Fluck (Master student, 2012)

Dust, the key to understand the climate-meningitis complex ?

♦ Intensity of the epidemics / specific wind conditions in October :

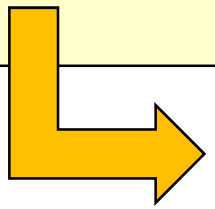
October is not in a dusty month in West Africa ...

Assumption : Based on the carriage/humidity relationship (Muëller et al., 2008), windy and dry conditions in October may favour the meningoccocal bacteria to pass into the blood, implying early cases in meningitis (Yaka et al., 2008) that may, in turn, impact on the intensity of the epidemics few months later

♦ Onset of the epidemics / specific wind conditions 2 weeks before :

The end of January is a dusty period in West Africa !

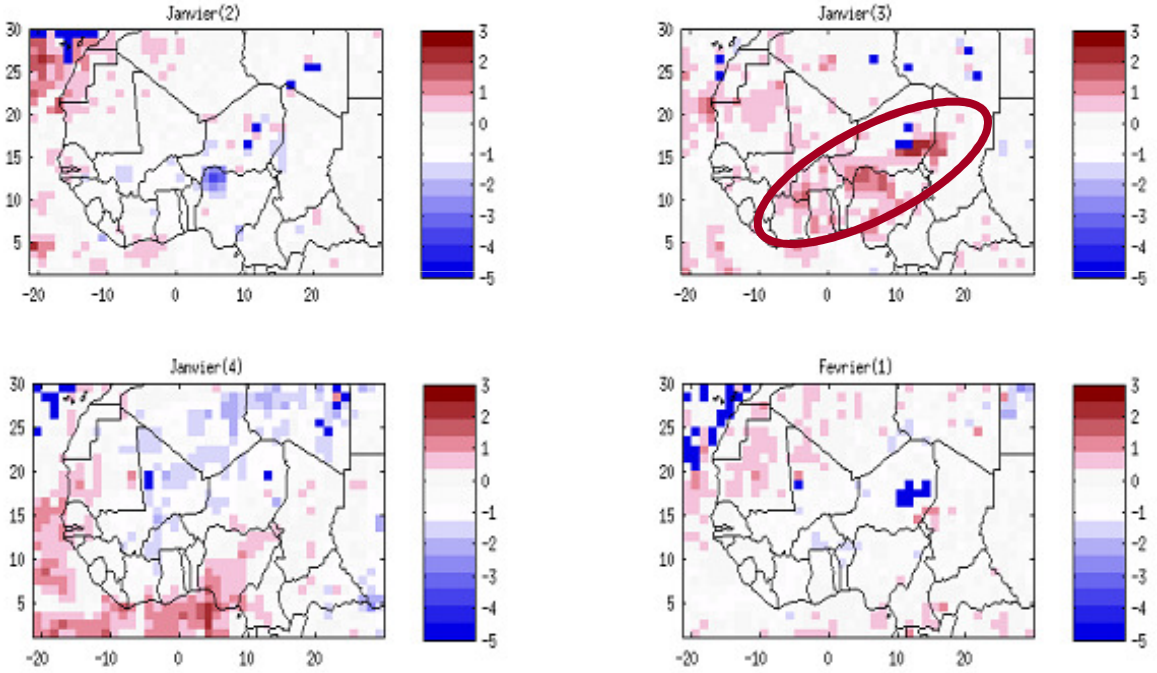
Assumption : the specific wind conditions are related to the occurrence of huge dust events in Burkina Faso. The dry conditions associated to high dust load may damage the pharingeal mucosa (Mueller & Gessner, 2010).

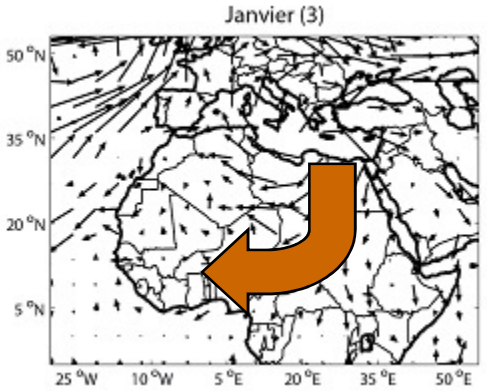


Study of two specific years

2007 (epidemic) minus 2005 (non epidemic)

Data set : Aerosol Index from OMI

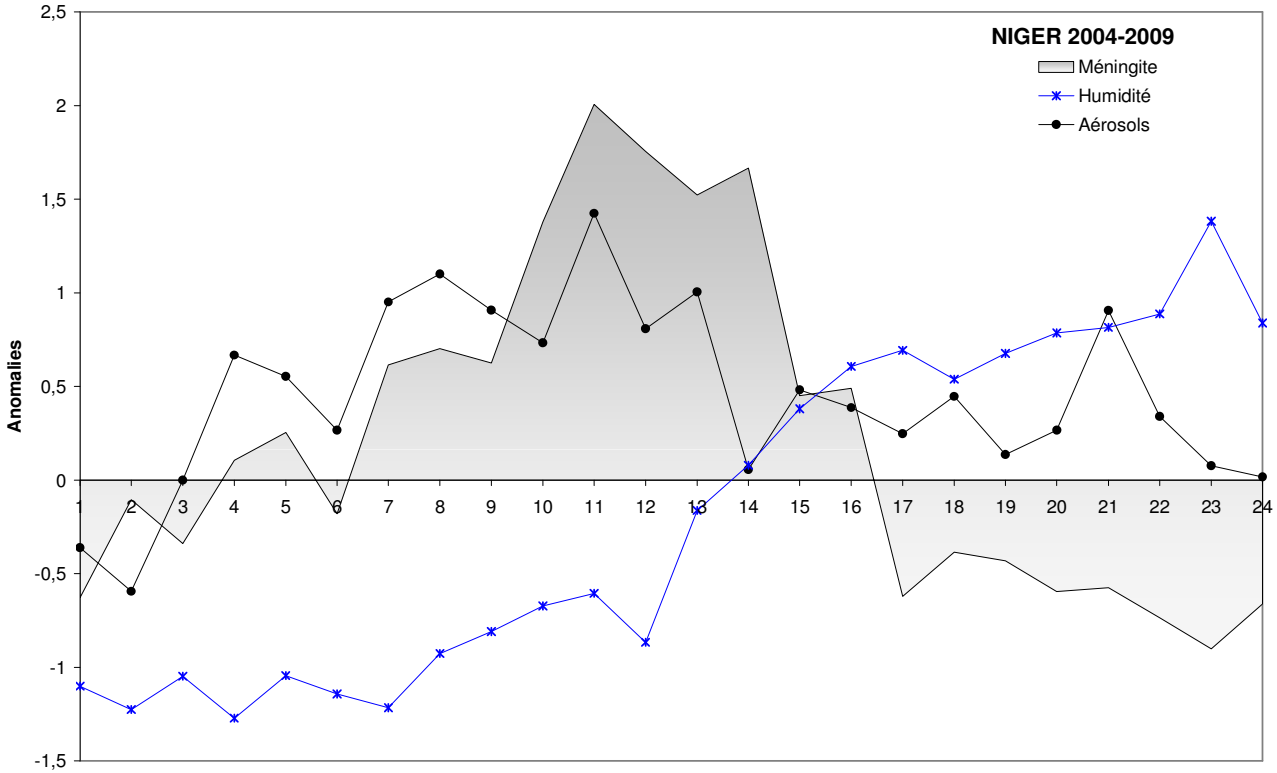




Dust arrival may be linked to the onset of meningitis epidemics, with a 2-week time-lag
This is consistent with the results by Jeanne et al., 2005 , and more recently ...

E. Fluck (Master student, 2012)

Dust / meningitis mean annual regimes



Data sets :

WHO for EPI & AERONET for AEROSOLS (2004-2009)

- **The onset of the dust season** occurs just before the onset of the meningitis season
- **The variability in dust seems to trigger that in meningitis and each meningitis peak** is preceded by a dust peak with a 1 or 2 week time-lag
- **The meningitis season ends** before the end of the dust season, with the **increase in humidity**

Martiny et al., 2012

Summary

♦ Meningitis epidemics seems to be the result of :
COND1 (Specific climate conditions in Autumn) + COND2 (Specific climate conditions at the beginning of the year) with proposal of assumptions on the mechanisms involved

Under development : research of the weigth of each condition

♦ Dust seems to play an important role on the onset and the developement of the epidemics (Martiny et al., 2012). A mean 2-week time-lag between dust and meningitis seems to be consistent with the incubation period required for the bacteria (Agier et al., 2012)

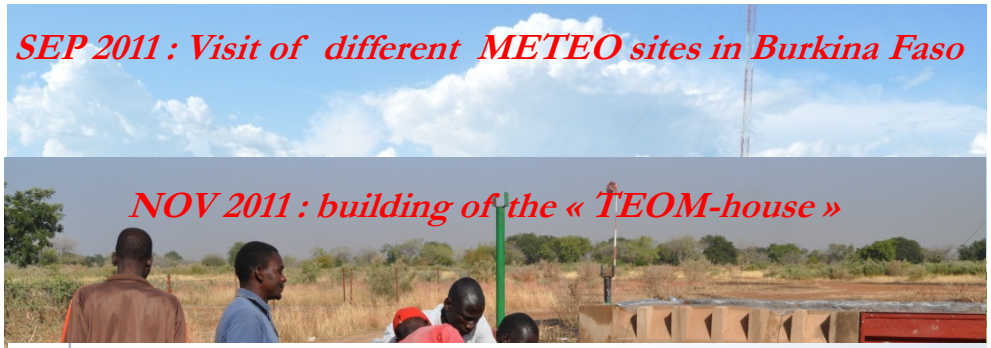
Under development : test of the robustness of the results based on long & spatialized dust data sets (modelling approach)

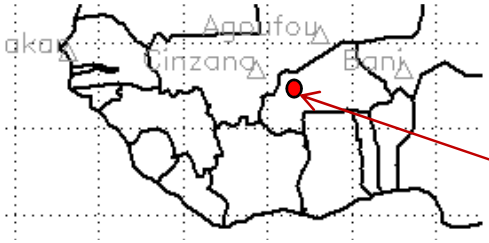
♦ The epidemics are stopped before the end of the dust season, by the increase in humidity (arrival of the Monsoon). This is in agreement with other climate/meningitis studies in the world – in India (eg. Sinclair et al., 2010)

Under development : Progress on the understanding of the mechanisms involved, given possible with the recent connexions with the MERIT (WHO) community

Perspective : fine spatial scales

♦ The settlement of a new TEOM instrument in Burkina Faso in collaboration with Meteorological services in Burkina Faso (PI : N. Martiny, CRC)





OCT 2011 : choice of the site

***DEDOUGOU,** Meteorological station located 250km North-West of Ouagadougou*

MARCH 2012 : settlement of the TEOM and first data sets

MANY THANKS !!!

Recent references in the AMMA frame

Agier, L., A. Deroubaix, N. Martiny, P. Yaka, A. Djibo, H. Broutin (2012), Meningococcal meningitis seasonality in Africa and climate forcing: aerosols stand out, Journal of the royal society interface., **submitted**

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Yaka, P., B. Sultan, H. Broutin, S. Janicot, S. Philippon, and N. Fourquet (2008), Relationships between climate and year-to-year variability in meningitis outbreaks: A case study in Burkina Faso and Niger. *Int. J. of Health Geographics*, 7:34, doi:10.1186/1476-072X-7-34.