

Predicting the Meningitis epidemics in West Africa by using climate dynamics

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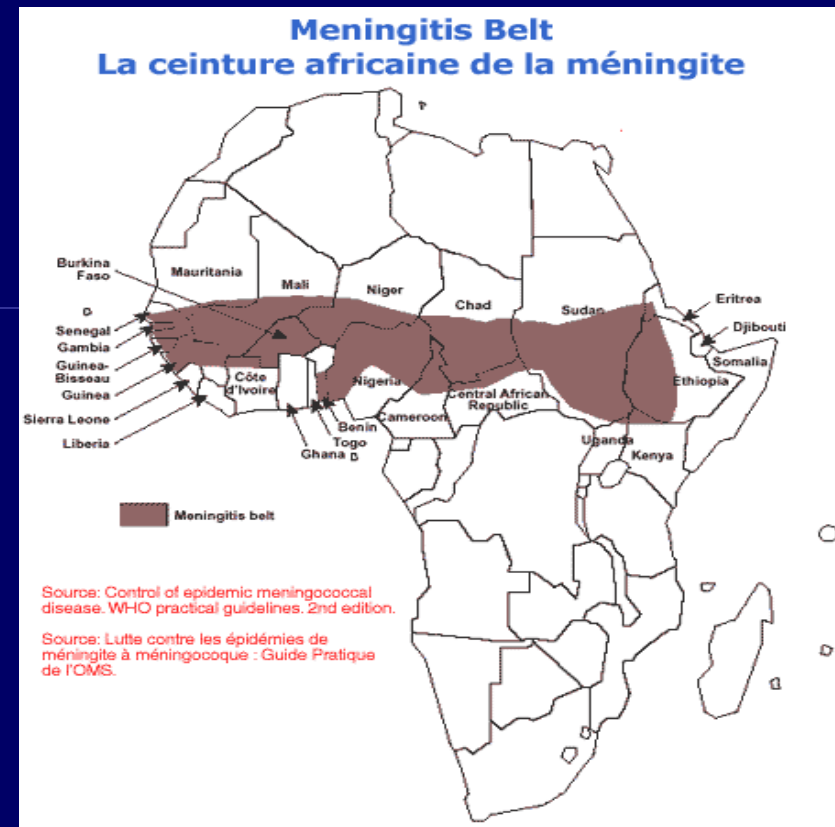
The Meningitis in West Africa

- **Meningococcal Meningitis (MCM) is endemic in West Africa since the 1980**
- **25 000 to 200 000 cases per year with 10% of deadly cases**
- **A human bacteria with aërial transmission**
- **Several favourable factors to epidemics :**
 - **immune receptivity,**
 - **low socio-economical level,**
 - **virulent serogroups (W135 for instance)**
 - **specific climate conditions**
- **Disease with seasonal pattern (high cases from February to April during dry season, low cases during rainy season)**

RELATIONSHIPS BETWEEN M.C.M. AND CLIMATE.

1. Geographical and climatic localization

- Global disease burden is in western Africa (MCM belt)
 - Sahelian or dry tropical climate
 - Between rainfall isohyets 300mm to 1000mm



2. Climatic factors unfavorable to the meningitis bacteria

- Meningococcal meningitis is sensitive to external conditions
- Affected by temperatures higher than 37 °C
- Sensitive to ultra-violets radiations and strong dryness

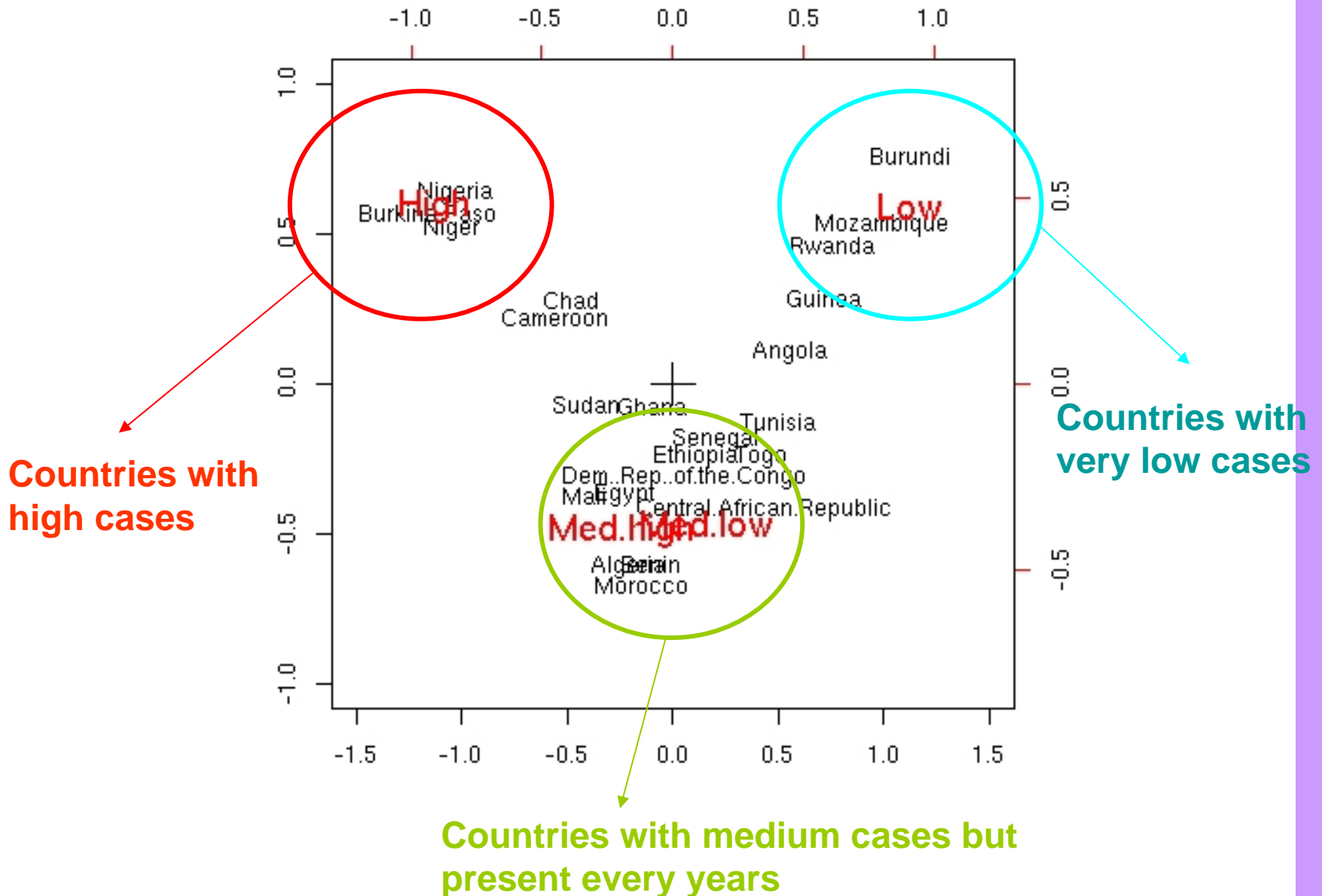
3. Climatic factors favorable to meningitis transmission

- low humidity index
- external coldness combined sometimes with wind
- strong wind
- earth aerosol (haze)
- lithometeores (various atmospheric particle)

Climate impacts are amplified by :

- The virulence of meningococcal meningitis bacteria
- Poor Immune status
- Irritated rhino pharyngeal mucous membrane

Meningitis in west Africa



MODELISATION MCM - REANALYSES NCEP/NCAR IN AFRICAN SAHELIAN COUNTRIES

Definition Results of assimilation (from multiple sources) of observed data which are unequally distributed in space and short-term forecasts models (6hr) for a wide and three-dimensional cover of Ground - Ocean - Atmosphere assimilation.

DATA SELECTED

Data in mesh of 2,5 degrees including:

- Pressure (slp)
- Specific moisture (shum)
- Relative humidity (rum)
- The temperature of the air (air)
- The temperature on ground and sea (skt)
- The module of wind (MOD)
- The zonal component of the wind (uwnd)
- The meridian component of the wind (vwnd)

OBJECTIVES

1. Determine if NCEP/NCAR Re-analyses parameters are associated with interannual variation of MCM cases.
2. Develop spatio-temporal models of MCM prediction using NCEP re-analyses
3. Test and validate these models for CSM survey and its early warning in African Sahelian Countries

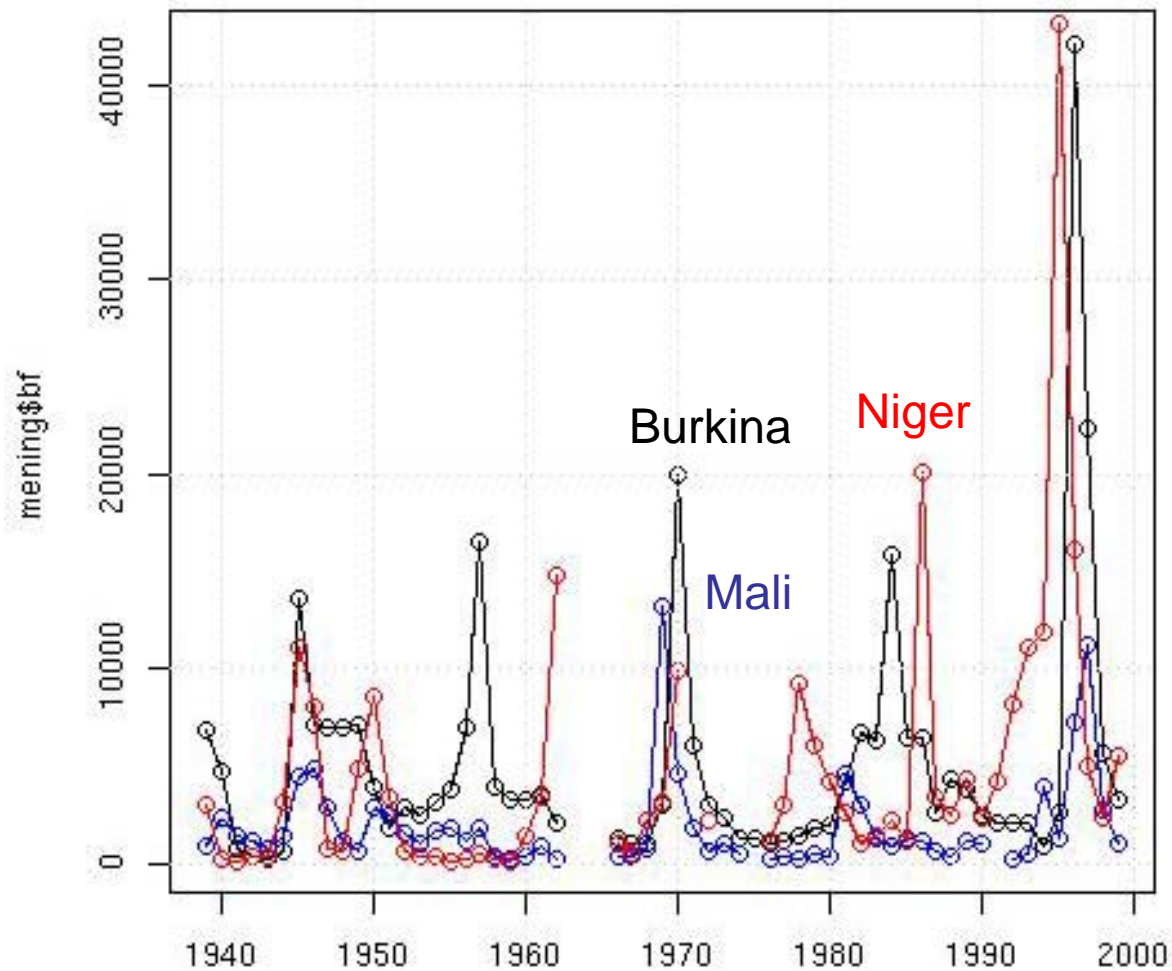
APPROACH METHODOLOGY

- ✓ Elaboration of correlations maps between MCM indexes in Sahel and NCEP re-analyse
- ✓ Analysis of correlations maps and extraction of climate indexes in target zones
- ✓ Computation of statistical Multi-varied Analysis (*Generalized Linear Model*)
- ✓ Elaboration of the final model to forecast the MCM annual cases

Selected countries : BURKINA FASO , NIGER



MCM inter-annual dynamics

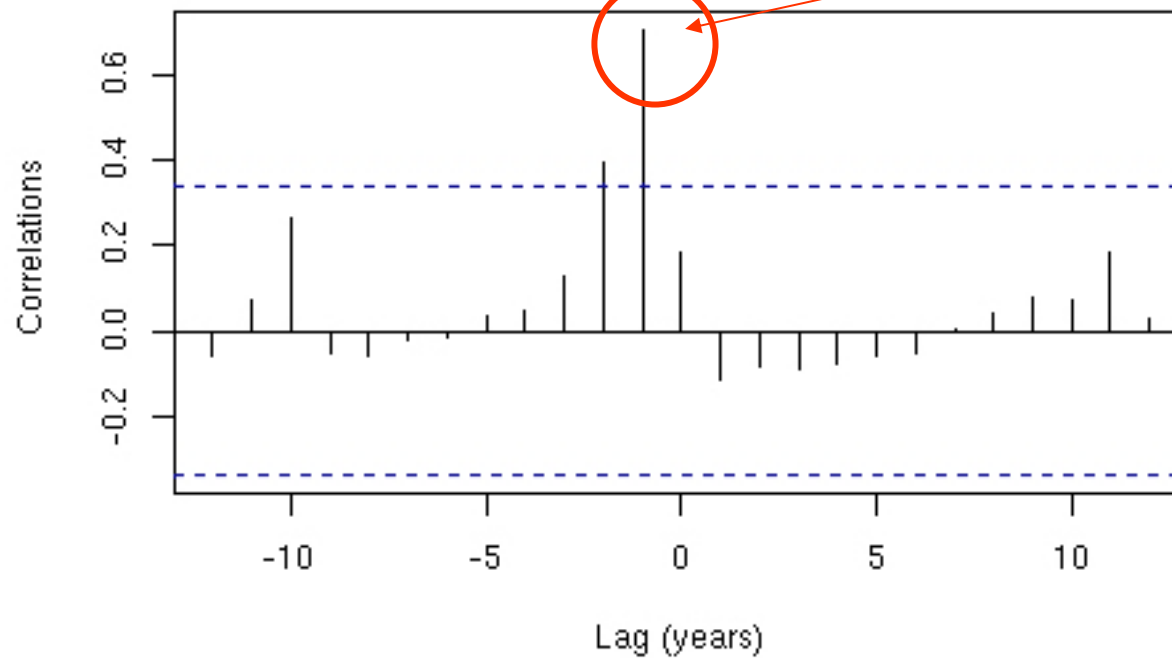


Disease dynamic :
several years without
high cases followed
by years with very
high cases

→ a cyclicity ?

MCM inter- annual dynamics

Cross-correlations between Niger and Burkina



Niger MCM cases are 1 year in advance than Burkina

MCM Inter-annuals dynamics

What we observe : A particular dynamic of epidemics (existence of cycles, the propagation from a country to another...)

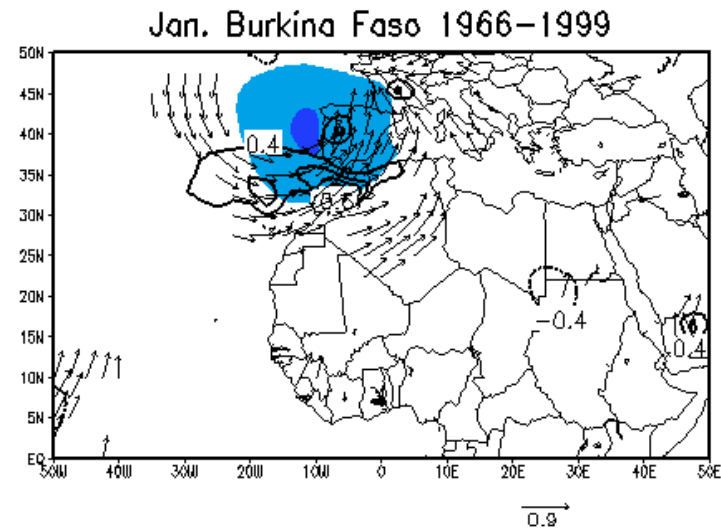
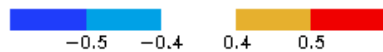
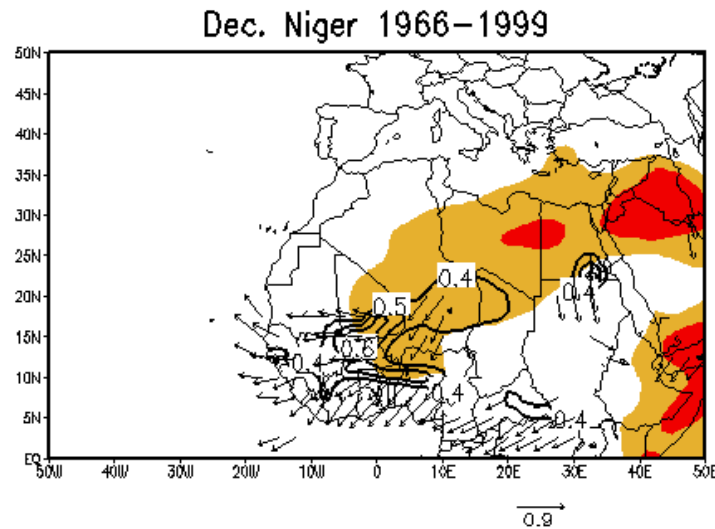
Problematic : does it exist a climate forcing on the disease dynamics (e.g. cyclicity, spatial distribution in different countries...) ?

If yes, could we use it to predict the occurrences of disease ?

Difficulties : others factors need to be taken into account (immune receptivity, pilgrinages...), data quality...

Relationships between climate / MCM 1966-1999

Correlation maps between atmospheric circulation and meningitis yearly cases during winter from 1966 to 1999



An enhanced Libyan High and Harmattan wind related to epidemics in Niger

→ A confirmation of the common knowledge of the climate / MCM relationships

An cyclonic anomaly in North-west of Africa correlated to MCM epidemics occurrences :

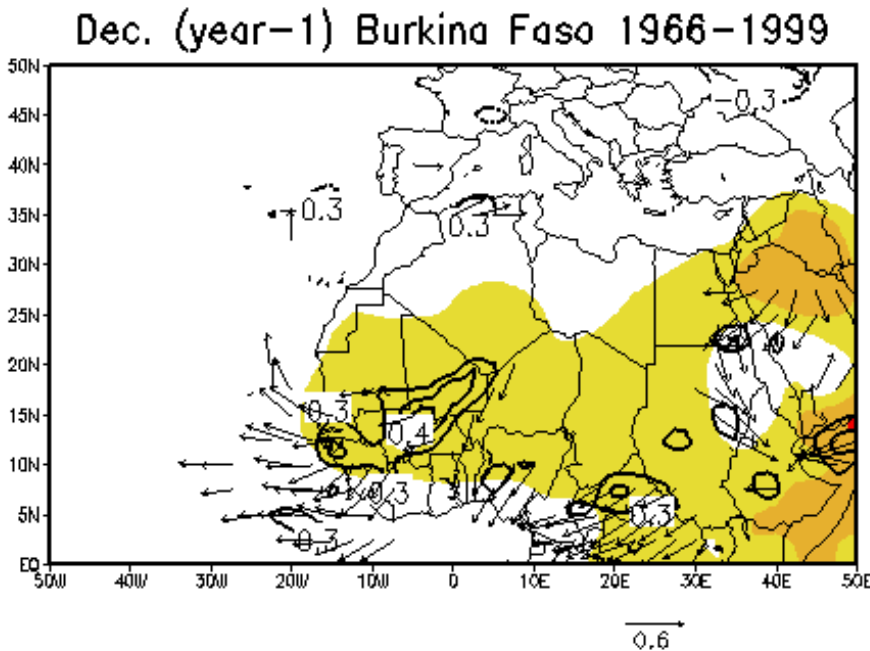
→ physical link or statistical artifact ?

Relationships between climate / MCM 1966-1999

An hypothesis :

An enhanced Harmattan in Niger → Epidemic in Niger → propagation of epidemic (population migrations, immunization) one year later in Burkina

According to this hypothesis the climate and meningitis relationships observed in Burkina between 1966 to 1999 could be a random effect !!!

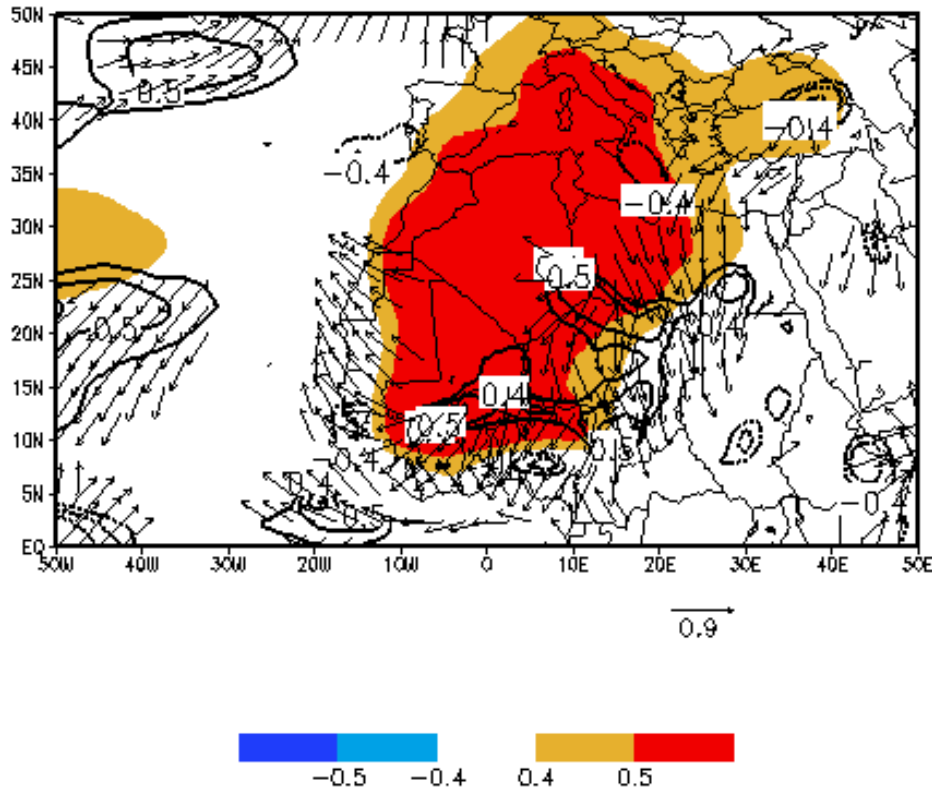


Hypothesis consolidated by the one-year lagged correlations between climate and MCM cases

→ An enhanced hamattan-type circulation correlated with epidemic cases of one year later.

Relationships between climate / MCM 1948-1967

Dec. Burkina Faso 1948-1967



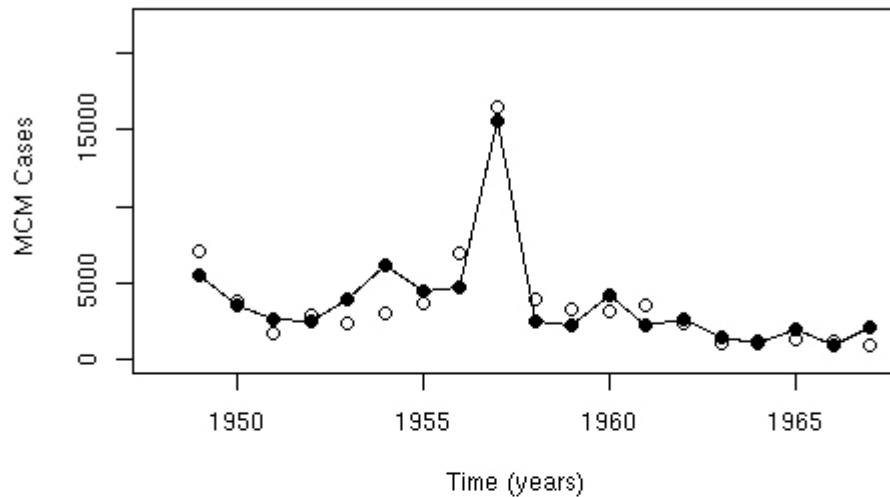
Correlation maps between climate and meningitis in Burkina from 1948 to 1967

An enhanced pressure and Harmattan wind correlated with the meningitis epidemics:

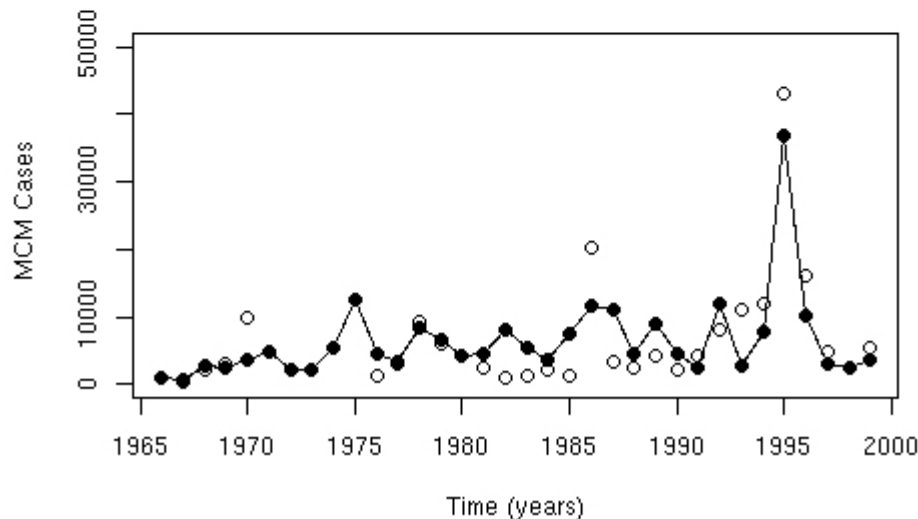
→ the relationship with climate is evident before 1967, but not in the 1966-1999 period.

Prediction of MCM cases

obs. and pred. MCM cases in Burkina



obs. and pred. MCM cases in Niger



Selection of 4 predictors based on the atmospheric circulation in Burkina and 1 predictor in Niger

Generalized linear Model :
Poisson

$$Y = e^{a_1X_1+a_2X_2+\dots+a_6X_6+b}$$

A good prediction in Burkina
($R=0.93$ $R^2=0.87$)

→ It explains 87 % of variance

A good prediction in Niger
($R=0.87$ $R^2=0.76$)

→ It explains 76 % of variance

CONCLUSIONS and PRESPECTIVES

MENINGITIS in Burkina, in Niger...in Sahel generally :

- is endemic, severity differs from year to year, countries to countries...
- Relationships between atmospheric dynamics and annual cases of MCS are instable and variable from one country to another.
- A multiplicity of epidemics causes : sometimes the climate forcing is dominant but sometimes not...
- Elaboration of significant models of MCM inter-annual cases prediction in Burkina and Niger by using climate dynamics
- Elaboration of research axes (brainstorming) on :
 - ✓ no stable correlations between atmospheric dynamics and MCM seasonal re-emergence . (variability or climatic change, quality of data (re-analysis , epidemiological data) pilgrinages, vaccinations...)
 - ✓ MCM dynamics transmission between sahelian countries.
 - ✓ Towards an Early Warning Index

Merci de votre attention...