Environmental factors and population dynamics as determinants of meningococcal meningitis epidemics in the Sahel: an investigation of NASA and NOAA products

NASA-Roses: 1 Yr Feasibility Study
Sept 1, 2009 - Aug 31, 2010, no cost extension

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CIESIN: S. Adamo (Co-PI), M. Levy, G. Yetman, SA

GISS: J. Perlwitz, R. Miller

JPL: O. Kalashnikova

Collaborators: C. Perez (EI, IRI, GISS), J. del Corral (IRI), M. Bell

Meningococcal Meningitis – a few facts

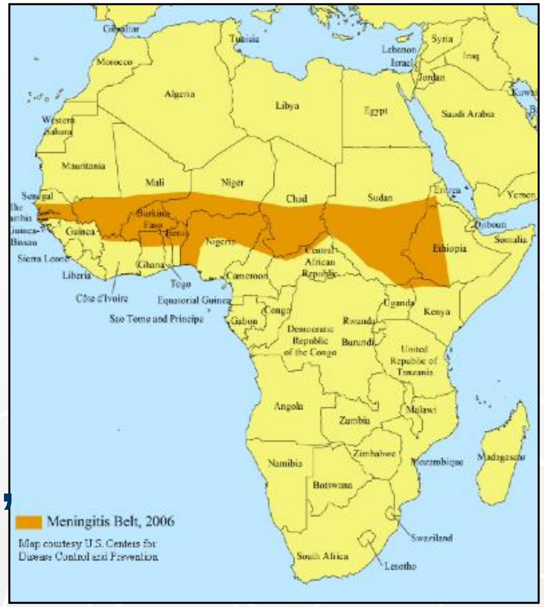
- Bacterial meningitis
- Human to human transmitted
- High rate of asymptomatic carriers (10-20% of general population)

Pathogenesis

- Respiratory acquisition
- Colonization of the nasopharynx
- Penetration the respiratory mucosa and entrance into the bloodstream

- If untreated fatality rates > 50%, and 10% despite treatment
- 10-20% of survivors develop severe neurological sequelae

Meningococcal Meningitis – a few facts



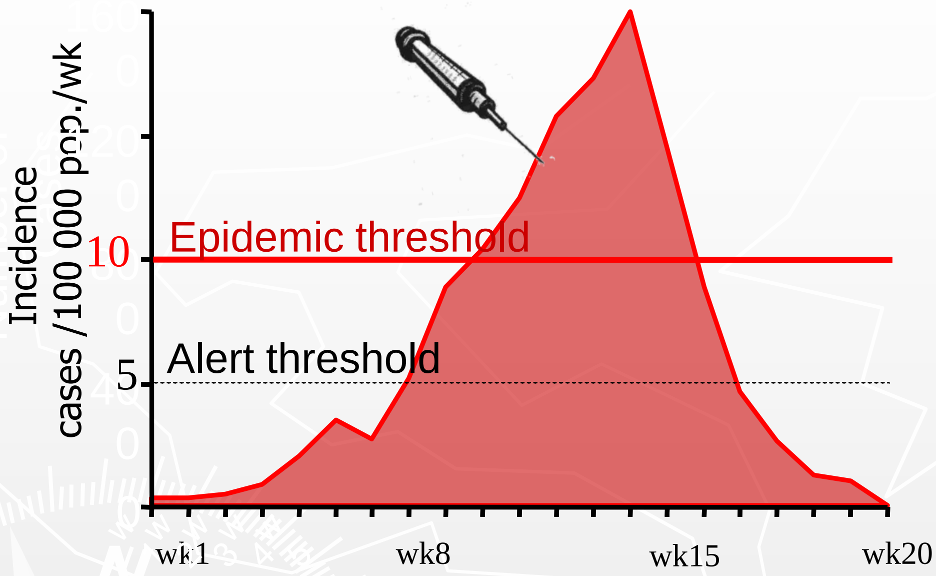
Courtesy CDC

- **Highest prevalence in Subsaharan Africa**
  => Meningitis belt
- **Highly seasonal**
- **Identified since 1963 (Lapeyssonie, 1963)**
- **Population at risk each year**
>350 million, 25 countries
- **Largest recorded outbreak, in 1996: 250,000 cases, approx. 25,000 deaths and at least 50,000 persons suffered permanent disability**
- **The burden is estimated to be more than $11 million/year in diagnostic, tests and case treatment costs.**
- **Additional burden at the household level in Burkina Faso: $90/case – 34% annual GDP/capita – and up to $154 more when permanent disability occurred.**

Yet, no efficient preventive treatment exist

Control Strategies

- **Current control: reactive vaccination, polysaccharide vaccine**



CHALLENGES:

☛timely vaccination to optimize the control of the epidemics

☛Vaccination campaign 2-3 weeks after alert threshold

- **Future control**

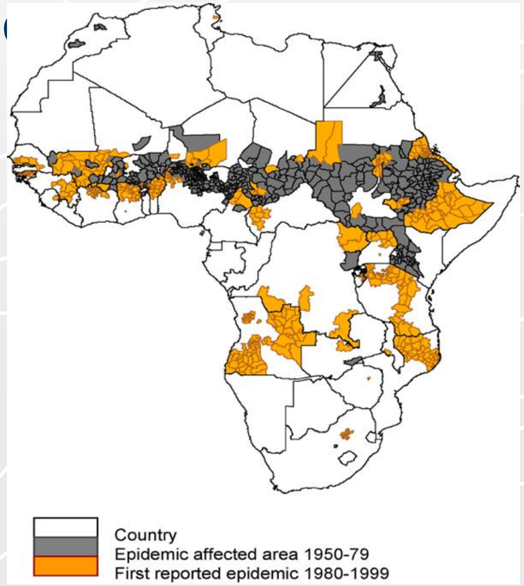
– **Preventive vaccination Men A conjugate vaccine**
– **Reactive vaccination for other strains and/or in places where MenA not implemented**

☛ **Need for any timely information on risk**

Stake-holders and decisions

- **WHO – Global Alert and Response**
  National Public Health Ministries and Services
  MERIT

- **Decisions:**
  - **Short term, within season (2-3 weeks): which district to vaccinate**
    - ☛ **to reduce operational delays, to decide whether vaccinate (U**
  - **Seasonal, before the season: how bad is the season going to be**
    - ☛ **enhance surveillance, capacity buildin**
  - **Annual**
    - ☛ **vaccine production, stockpile (ICG)**
  - **Decadal**
    - ☛ **changes in Meningitis Belt**



Changes in the areas of MM epidemics risk in Africa between 1950-79 and 1980-1999 periods, Cuevas et al. 2007

Causes of meningitis epidemics still poorly understood

❑ Known Risk Factors

- Individual and population risk factors
  - –Age-related acquisition of bactericidal antibodies
  - –Underlyinng immune defects (i.e., asplenia, genetics)
  - –Crowding
  - –Smoke exposure
  - –Upper respiratory tract infections

- Climatic conditions (dry season)
  - –Excessively dry& hot season
  - –Dust storms

- Immunological susceptibility
  - –Introduction of a novel, virulent strain
  - –Waning herd immunity
  - –Large population movements

Courtesy CDC

IRI

IMPACT OF THE ENVIRONMENT

On the pathway of infection

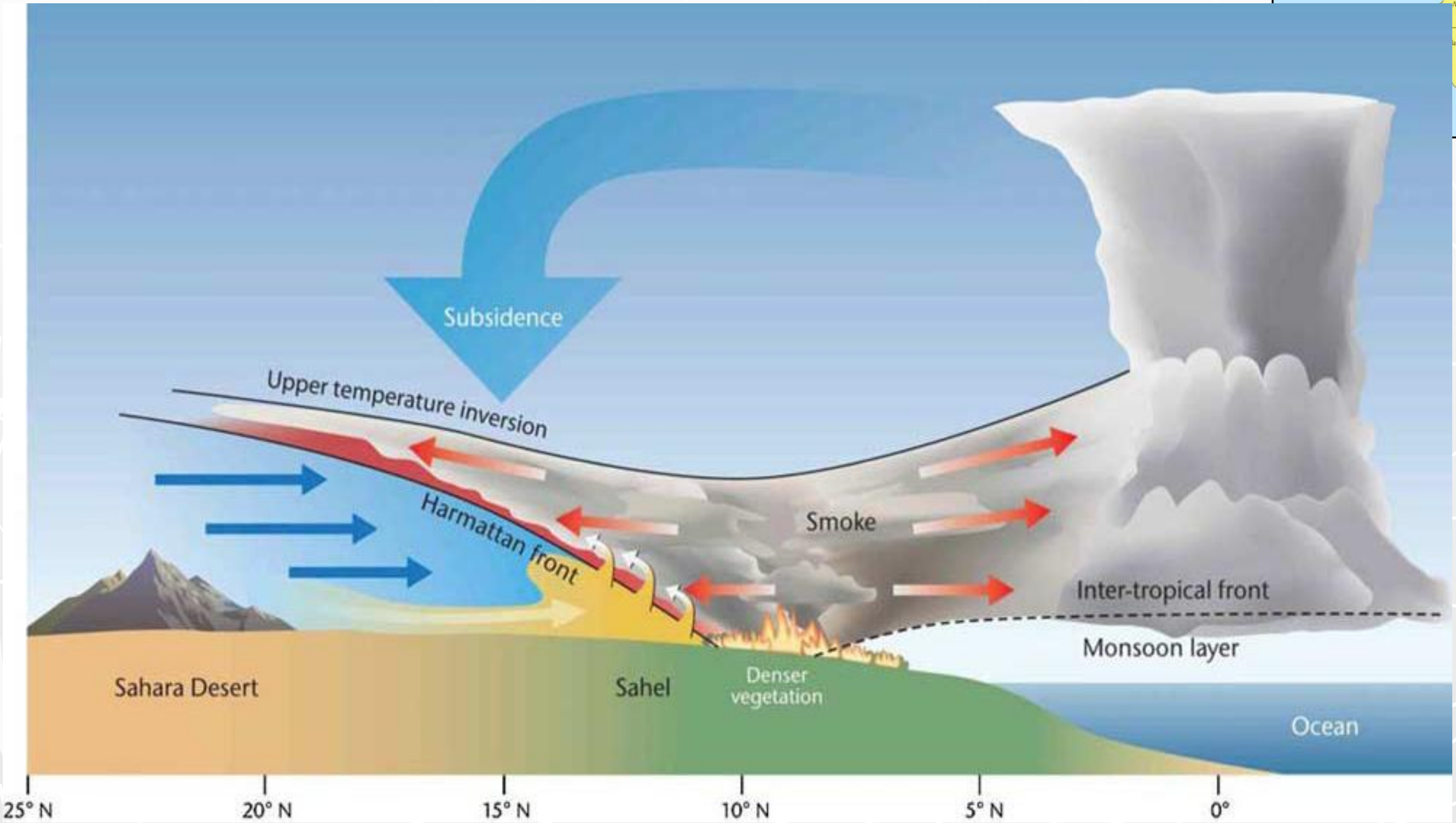
- Pharyngeal carrier
- Respiratory droplets (meningococci) ← Survival of meningococci in droplets
- Susceptible host
- ← Damage to mucosa facilitating colonisation
- Pharyngeal carrier
- ← Damage to mucosa facilitating invasion
- ← Influence on the immune response
- Case

Courtesy Brian Greenwood

Indirect

1. Enhancing bacterial survival via iron content of dust
2. High dust levels affecting human behaviour, including crowding and reduced ventilation
   (e.g. blocking windows)
3. (More controversially) serving as carriers for bacteria

Climate features in the Meningitis Belt/Sahel



Schematic meridional cross section of atmospheric circulations over West Africa. *(Haywood et al., 2008).*

Project Objectives

Statistical model, forecasting the likelihood of epidemic threshold to be crossed (or not) at a given district at different time leads (before, at the beginning and during the season)

Using environmental <u>and</u> demographic predictors

- **Detect the optimal combination of predictors at different time lags**
- **Evaluate model's skill (capacity to predict past epidemics and their timing)**
- **Demonstrate that different decision can be made based on the available forecasts**

- **Meningitis data for Niger: weekly district level, 1086-May 2008, QC**

Using multiple source information information for predicting meningitis risk

Population factors:
•Population density
•Population stratification: gender, Age, Rural-urban
•Mobility

Environmental factors
▪Dust (concentration, particle size….) from in-situ observation, Satellite (MISR), Models (global and regional) and dust forecasts
▪Weather and Climate Conditions - wind, humidity, temperature, rainfall - in situ (Met Station), Satellite (TRMM), NCEP Reanalysis
▪Seasonal forecasts (ECHAM4.5)

Epidemiological state of the population at the district level based on:
• Past history of epidemics
• Past history of immunization
• Migration paths
• Seasonality

Generalized Linear Model to predict crossing alert/epidemic threshold
• For each district and at country level
• At different lead-times: seasonal, monthly, 2 weeks and simultaneous
•Probability based on historical model performance
Skill assessment

GIS based maps to display the probability of alert/epidemic threshold
•For each district and at country level
• At different lead-times

Outputs

•Build GIS based predictive tool using models and predictors selected in the project to provide risk maps at district and country level at different lead-times

☛ **Extract relevant climate information**

Related research

•Quantify the relationship dust-meningitis

•Quantify the relationships between atmospheric conditions (wind, temperature, humidity…) and meningitis

•Validate dust models

•Validate seasonal forecast models

•Assess the usefulness of satellite and model data for predictive purposes

•Investigate a range of statistical models, predictors and lead-times and select most appropriate

Project participants and their responsibilities

IRI:

- analysis of relationships between atmospheric conditions & dust and meningitis, analysis of their predictability; construction and evaluation of the model - S. Trzaska, L. Cibrelus;
- advisory role on the use of satellite data - P. Ceccato, T. Dinku;
- advisory role on links between environmental conditions and meningitis and on general statistical model - M. Thomson;
- advisory role on the evaluation of decision improvement processes - M. Madajewicz

CIESIN:

- population mapping by age structure, urban/rural distribution, population mobility, georefernced datasets, construction of predictive model - S. Adamo, G. Yetman);
- advisory role on data integration and model construction – M. Levy;

GISS:

- Aerosols simulation – J. Perwitz
- Advisory role on validation and interpretation of model results – R. Miller

JPL:

- MISR data and related technical expertise - O. Kalashnikova

Where we are now…

Data Collected

Epi

- **Meningitis data in Niger, weekly, district, 1986-May 2008**

Pop

- **CIESIN Gridded Population data**
    - **pop density**
    - **urban /rural**
    - **age structure**

Dust

- **Aeronet data from Banizoumbou**
- **Visibility data from field measurements**
- **MISR Aerosol data**
- **Outputs from model simulation of mineral dust (regional and global)**

Climate

- **Temperature, wind data from NCEP reanalysis**
- **TRMM rainfall estimates**
- **IRI Seasonal Forecast Outputs**

Data (cont.)

Data Library

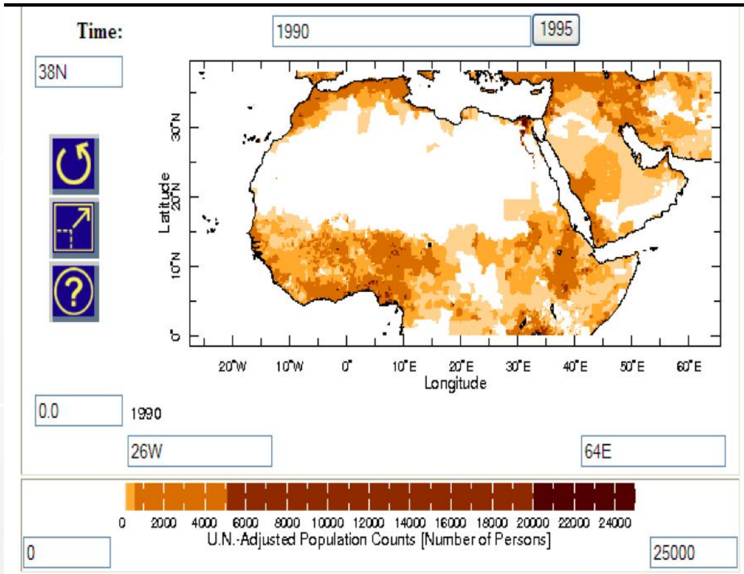
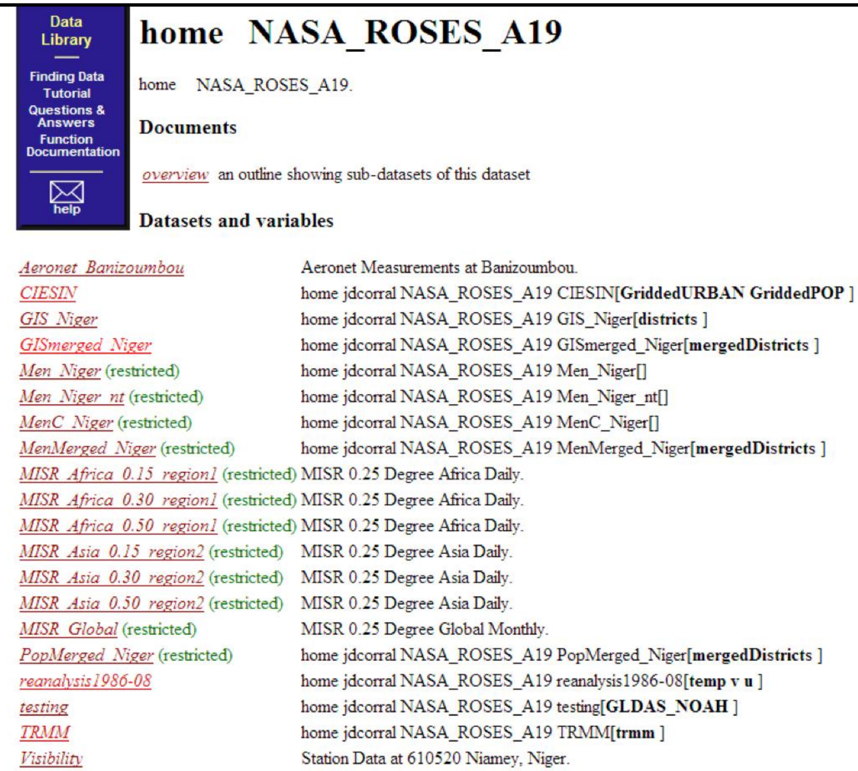


Figure 1: Gridded Population produced by CIESIN, the Earth Institute at Columbia University available via the IRI Data Library



Data Library

Finding Data
Tutorial
Questions & Answers
Function Documentation
help

home NASA_ROSES_A19

home NASA_ROSES_A19.

Documents

overview an outline showing sub-datasets of this dataset

Datasets and variables

Aeronet Banizoumbou	Aeronet Measurements at Banizoumbou.
CIESIN	home jdcorral NASA_ROSES_A19 CIESIN[**GriddedURBAN GriddedPOP**]
GIS Niger	home jdcorral NASA_ROSES_A19 GIS_Niger[**districts**]
GISmerged Niger	home jdcorral NASA_ROSES_A19 GISmerged_Niger[**mergedDistricts**]
Men Niger (restricted)	home jdcorral NASA_ROSES_A19 Men_Niger[]
Men Niger nt (restricted)	home jdcorral NASA_ROSES_A19 Men_Niger_nt[]
MenC Niger (restricted)	home jdcorral NASA_ROSES_A19 MenC_Niger[]
MenMerged Niger (restricted)	home jdcorral NASA_ROSES_A19 MenMerged_Niger[**mergedDistricts**]
MISR Africa 0.15 region1 (restricted)	MISR 0.25 Degree Africa Daily.
MISR Africa 0.30 region1 (restricted)	MISR 0.25 Degree Africa Daily.
MISR Africa 0.50 region1 (restricted)	MISR 0.25 Degree Africa Daily.
MISR Asia 0.15 region2 (restricted)	MISR 0.25 Degree Asia Daily.
MISR Asia 0.30 region2 (restricted)	MISR 0.25 Degree Asia Daily.
MISR Asia 0.50 region2 (restricted)	MISR 0.25 Degree Asia Daily.
MISR Global (restricted)	MISR 0.25 Degree Global Monthly.
PopMerged Niger (restricted)	home jdcorral NASA_ROSES_A19 PopMerged_Niger[**mergedDistricts**]
reanalysis1986-08	home jdcorral NASA_ROSES_A19 reanalysis1986-08[**temp v u**]
testing	home jdcorral NASA_ROSES_A19 testing[**GLDAS_NOAH**]
TRMM	home jdcorral NASA_ROSES_A19 TRMM[**trmm**]
Visibility	Station Data at 610520 Niamey, Niger.

Figure 2: List of data collected for the NASA Meningitis project (including Meningitis data from UN WHO, MISR data Reanalysis data on wind, temperature, TRMM data, and Visibility data) available via the IRI Data Library

Descriptions and relevant bibliography on project accessible portal

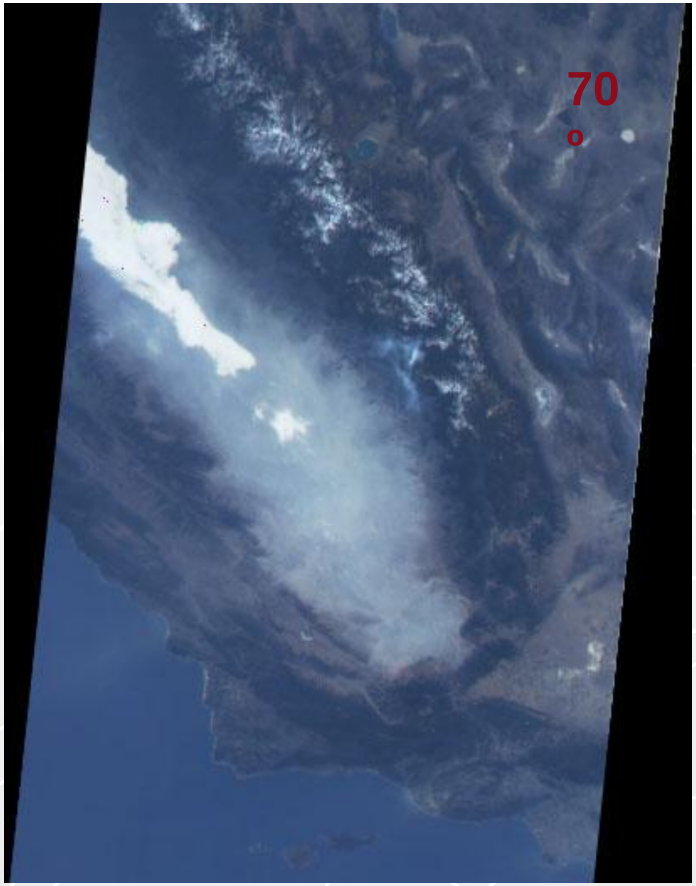
Metadata of the Nasa/Roses project

	Variable category	Variable name	Source of the data	Origin of the data	Type of variable	Computation of the variable	Time resolution	Spatial resolution	Time coverage	Spatial coverage	Missing data
EPIDEMIO-	Epidemiological	**Incidence of meningitis**	Ground	WHO routine surveillance	Count	Derived from the number of meningitis cases	**Week**	**District**	Dec 1985 - May 2008	All districts, Niger	
	Immunological state of the population	**Recent history of outbreaks**	Ground	WHO routine surveillance	Count	Derived from the number of meningitis cases	**Week**	**District**	Dec 1985 - May 2008	All districts, Niger	
CLIMATE	Aerosol/Dust	**Absorption Angstrom Exponent (α)**	Satellite	AERONET[i], NASA	Continuous		Daily	Single point	Oct 1995- June 2009	Banizoumbou, Niger	
			Satellite	MISR[ii], NASA	Continuous		Daily	0.25x0.25	Apr 2000-Apr 2009	Africa north of the Equator Longitude: [74.875W,64.875E]; Latitude: [0.125N,34.875N]	
		AOD[iii]/ AOT[iv]	Satellite	AERONET, NASA	Continuous		Daily	Single point	Oct 1995- June 2009	Banizoumbou, Niger	
			Satellite	MISR, NASA	Continuous		Daily	0.25x0.25	Apr 2000-Apr 2009	Longitude: [74.875W,64.875E]; Latitude: [0.125N,34.875N]	
			Model	Mineral Dust aerosol model GISS, NASA: Global Climate Model E	Continuous		Hourly and Monthly	Horizontal: 144x90 grid cells (2.5°x2°) Vertical : Total over troposphere	1984-2009	Global	
		Dust fraction: Total, large, medium, small	Satellite	MISR, NASA	Continuous		Daily	0.25x0.25	Apr 2000-Apr 2009	Longitude: [74.875W,64.875E]; Latitude: [0.125N,34.875N]	
		Dust surface concentration	Model	Mineral Dust aerosol model GISS[v], NASA: Global Climate Model E	Continuous		Hourly and Monthly	Horizontal: 144x90 grid cells (2.5° x 2°) Vertical : surface layer	1984-2009	Global	
		Visibility	Ground	Met Station	Continuous		Daily	Single point	1995-2009	Niamey, Niger	
	Wind	**Wind speed**	Ground	Met Station	Continuous		Daily	Single point	1995-2009	Niamey, Niger	
			Model	Seasonal forecast	Continuous		Daily and monthly	Vertical: near surface (2m, 10m) and Plevels (925, 950, 850 etc) Horizontal: ECHAM 4.5 T42: 2.5°x2.5°			
			Model	NCEP/NCAR Reanalysis	Continuous		Daily and monthly	Vertical: 1.'diagnostic' or 'near-surface' (also 'top') variables: one level, specified (surface, 2m, 10m etc) 2.'intrinsic' variables: across the atmospheric depth, on specified Pressure levels (950hPa, 500hPa, sea level pressure) or total atmospheric column Horizontal: 1. diagnostic ' variables : 1.875° (long)x2.5° (lat). 2.'intrinsic' variables 2.5°x2.5°	1948 -present (last week for daily, last month for monthly)		
		Wind direction	Model	Seasonal forecast	Categorical		Daily and monthly	Vertical: near surface (2m, 10m) and Plevels (925, 950, 850 etc) Horizontal: ECHAM 4.5 T42: 2.5°x2.5°			
			Model	NCEP/NCAR Reanalysis	Categorical		Daily and monthly	Vertical: 1.'diagnostic' or 'near-surface' (also 'top') variables: one level, specified (surface, 2m, 10m etc) . 2.'intrinsic' variables: across the atmospheric depth, on specified Pressure levels (950hPa, 500hPa, sea level pressure) or total atmospheric column Horizontal: 1. diagnostic ' variables : 1.875° (long)x2.5° (lat). 2.'intrinsic' variables 2.5°x2.5°	1948 -present (last week for daily, last month for monthly)		
	Humidity	**Dew point**	Ground	Met Station	Continuous		(unitless) ordered (1.) to (137231.)	Single point	(unitless) ordered (1.) to (137231.)	Niamey, Niger	

L. Cibrelus

MISR multi-angle imagery

- 9 view angles at Earth surface:
  70.5º forward to 70.5º aft-ward
- Spectral bands: 446, 558, 672, 866 nm
- 275 m spatial resolution
- 7 min. to observe a scene at 9 angles



MISR provides reliable AOT values (~0.05 precision), over bright desert *[Diner et al., 2001, Martonchik et al., 2004*; *Christopher and Wang, 2004]*

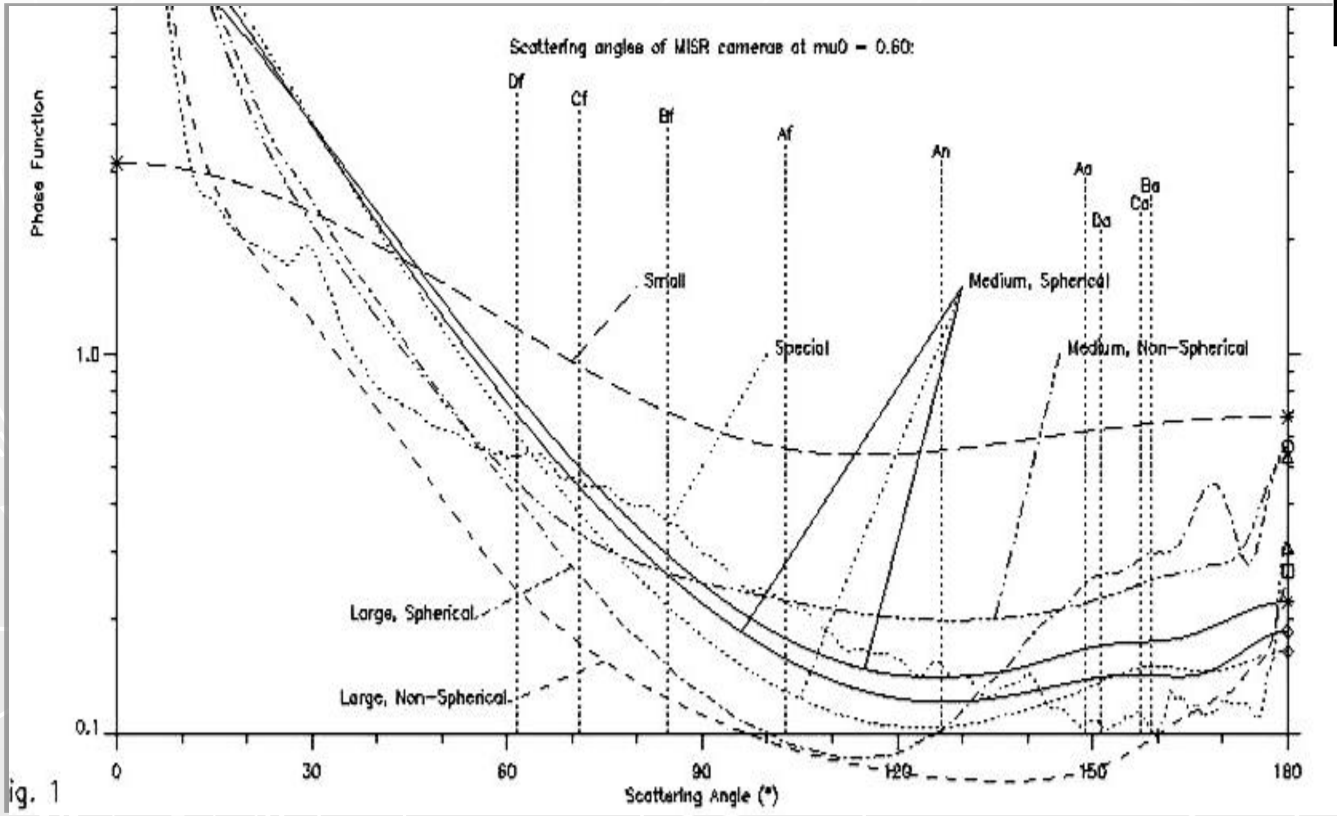
63% of the MISR-retrieved AOT values in the green band fall within 0.05 or 20% of AERONET AOT, and about 40% are within 0.03 or 10% *[Kahn et al., 2005].*

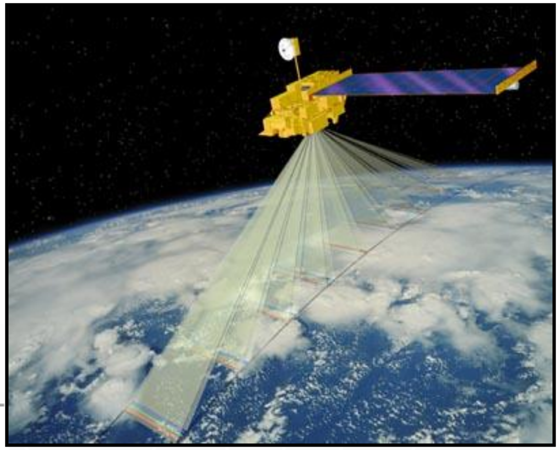
Absolute radiometric uncertainty 4%
Relative radiometric uncertainty 2%
Temporal stability 1%
Geo-location uncertainty 50 m
Camera-to-camera registration < 275 m

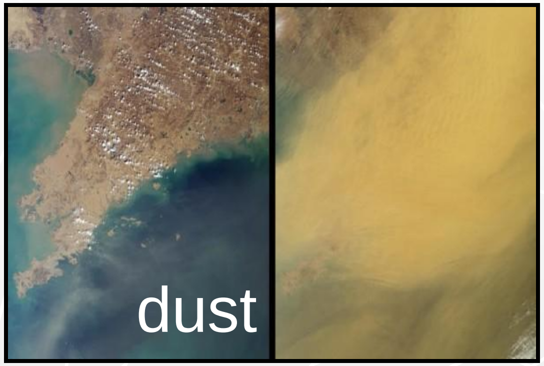
Diner et al., 1998
Kahn et al., 2004

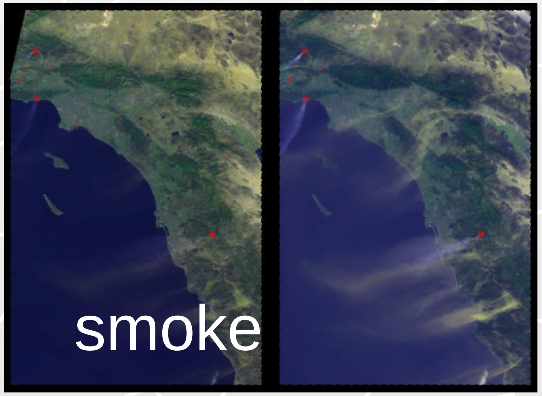
Courtesy O.Kalashnikova

MISR aerosol type discrimination









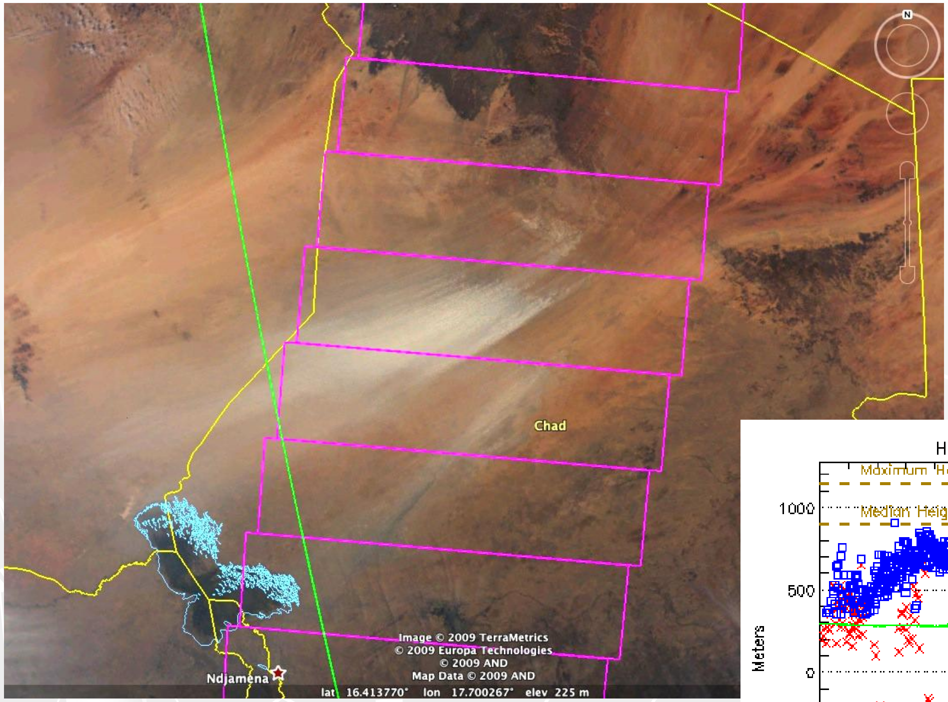
The MISR viewing geometry allows discrimination of aerosol types. Multi-angle remote sensing can distinguish spherical from dust particles

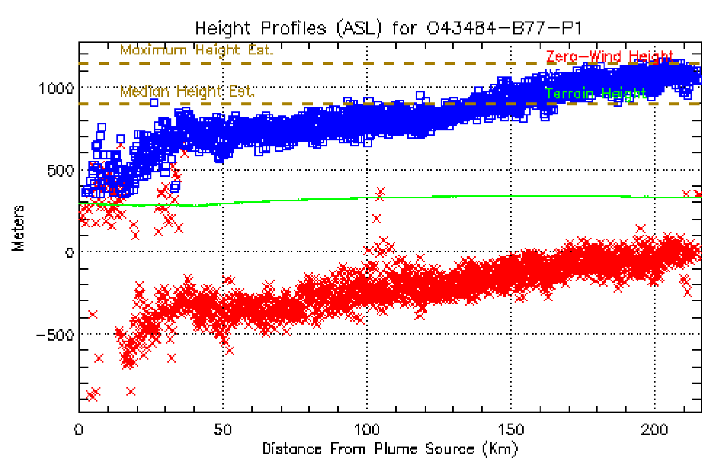
Courtesy O.Kalashnikova

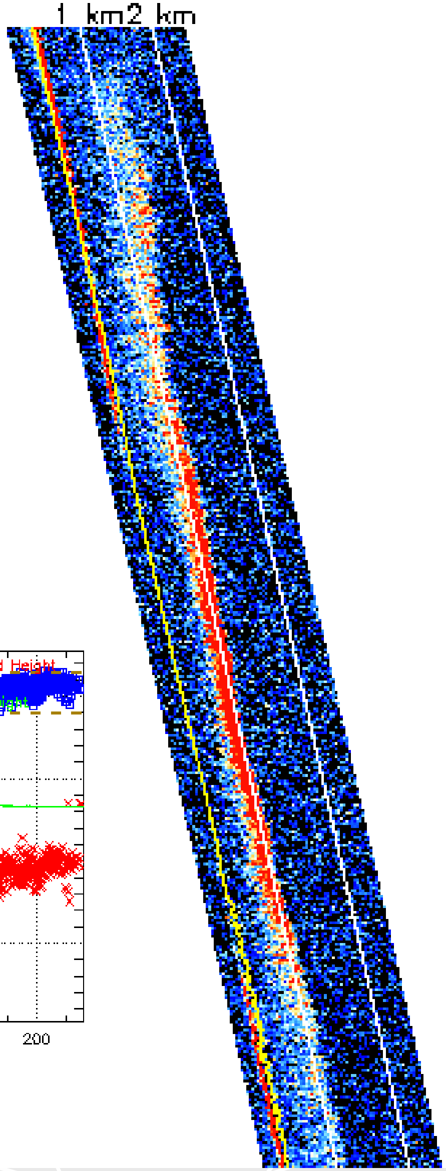
MISR stereo heights (MINX)

Saharan Dust Source Plume

Bodele Depression **Chad** 20 February 2008 around 0930 UT







Plume rises from the surface (at about 300 m) to 1000 - 1100 m at a distance of 200 km.

Dust is injected near-surface and rises to 1km

Courtesy O.Kalashnikova

Credit M. Garay, JPL

MISR aerosol data for the project

Daily hi-resolution 0.25 by 0.25 degree MISR aerosol product, 2000-present

Standard product:

- **AOT at 552um (green band) - provided**
- **Angstrom exponent**
- **Nonspherical fraction**

Derived products:

- **AOT at 552um (green band) where Angstrom exponent is less than 0.7 – indication of dust**
- **AOT at 552um (green band) where nonspherical fractions are larger than 0.3 – indication of dust**
- **Angstrom exponent sub-setted for AOT>0.15 - provided**
- **Nonspherical fraction sub-setted for AOT>0.15- provided**

Courtesy O.Kalashnikova

Population and migration data available for the NASA/Roses project

Demographic risk factors

- Population size
- Population distribution and density
- Gender
- Age
- Migration dynamics and migrant stocks

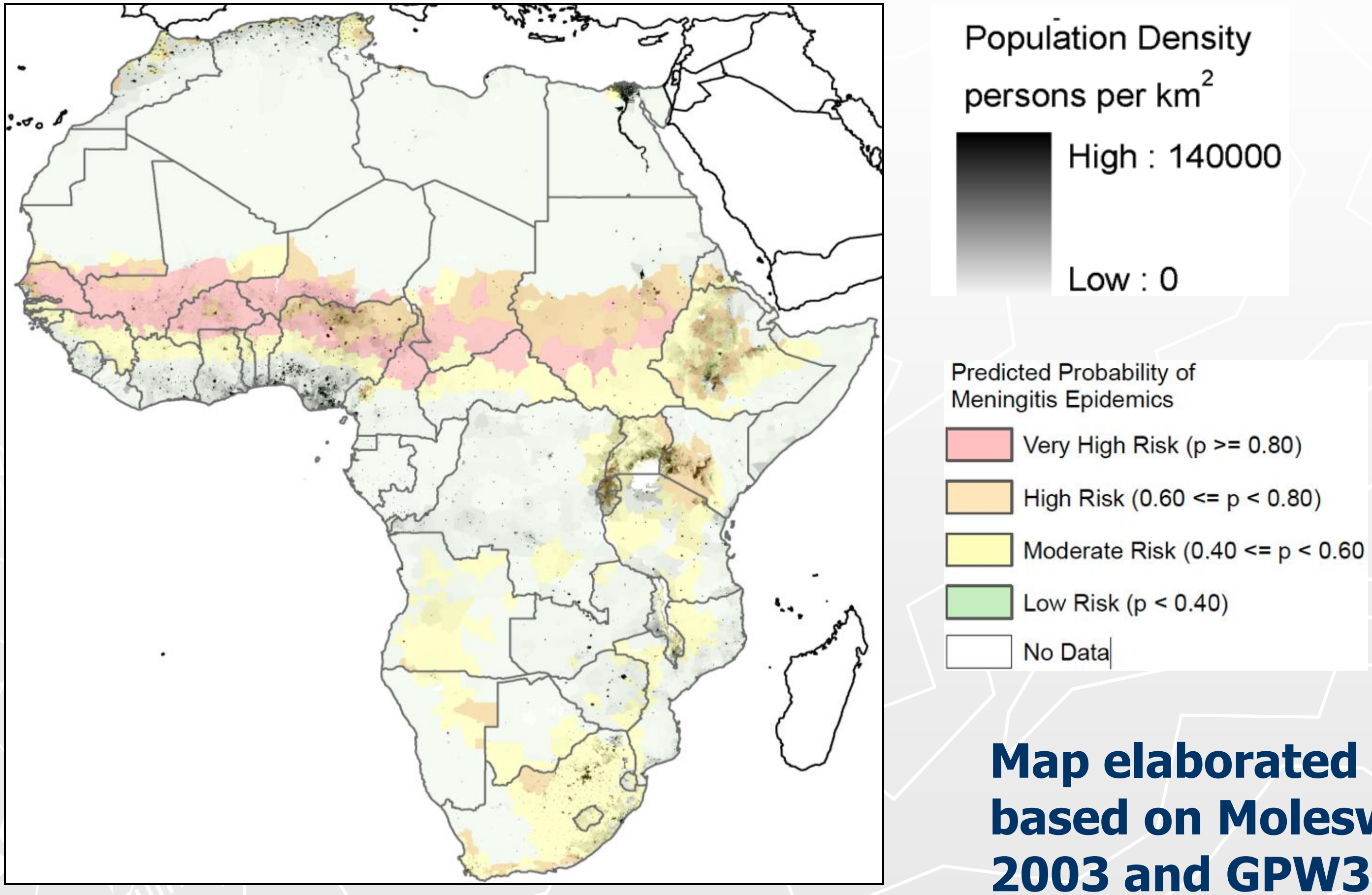
Population data

- **GPW3 - Gridded Population of the World v3 provides a spatially disaggregated population layer, compatible with datasets from social, economic, and earth science fields.**
  - the distribution of human population is converted from national or subnational spatial units (usually administrative units) of varying resolutions, to a series of geo-referenced quadrilateral grids at a resolution of 2.5 arc minutes.
  - Most countries (80%) have data for two census dates
  - Population data estimates are also now provided for the period 1990–2015, by quinquennial years.

- **GRUMP - Global Rural-Urban Mapping Project provides a new suite of data products that add rural-urban specification to GPWv3.**
  - This project was developed out of a need for researchers to be able to distinguish population spatially by urban and rural areas.
  - The central data product is a Gridded Population of the World with Urban Reallocation in which spatial and population data of both administrative units and urban extents are gridded at a resolution of 30 arc-seconds.
  - Additional data sets resulting from **GRUMP** include a 30 arc-second grid showing urban area extents worldwide, and a database of human settlements, their spatial coordinates, and populations.
  - GRUMP beta is about to be released

SEDAC

Population density in meningitis risk areas of Africa



Map elaborated by CIESIN, based on Molesworth et al. 2003 and GPW3

Source CIESIN

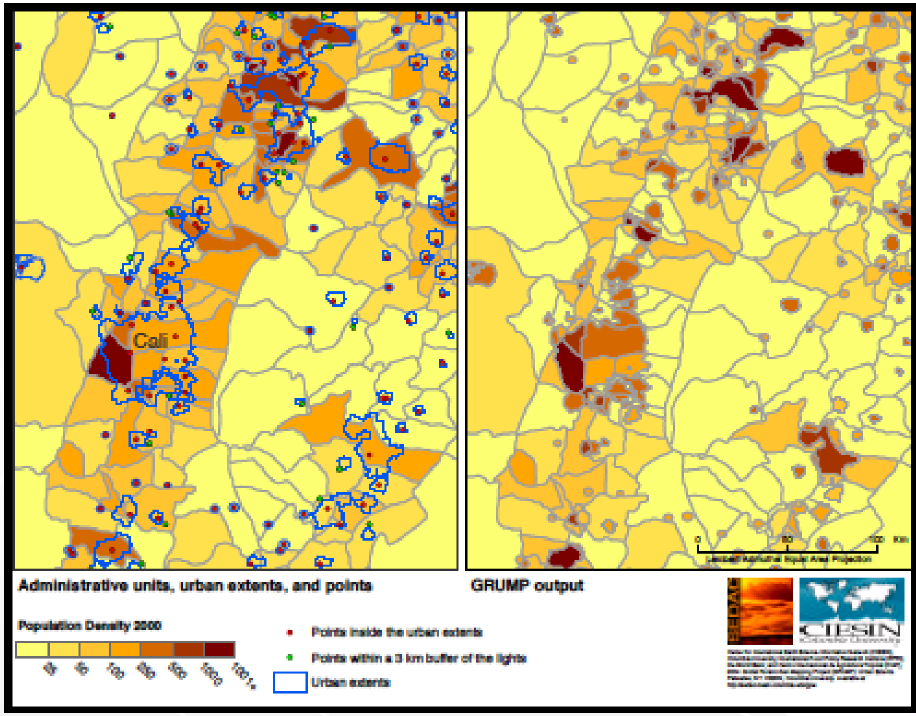
GRUMP

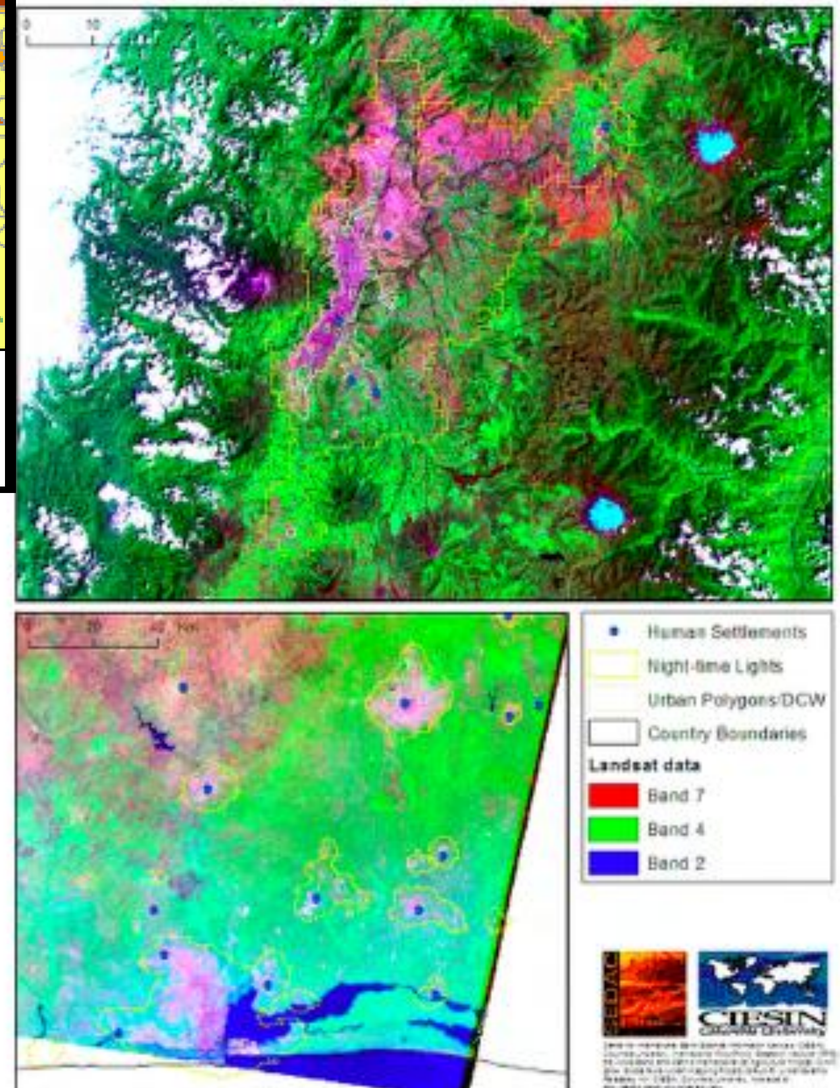
- **Based on a previous pilot study to map urban land cover by fusing the night-time lights dataset with GPW and a MODIS-derived land cover classification (Schneider *et al. 2003)*, and Pozzi et al. (2003), which mapped global urban population by integrating GPW and the night-time lights.**

- **using GPW as a base, in 2000, CIESIN, IFPRI, the World Bank and CIAT began the multi-year effort to construct an improved population grid, but also to construct a globally consistent database of urban area**
  - ☛ **the Global Rural Urban Mapping Project (GRUMP).**

  - ☛ **Will allow to determine the urban fraction of the area**

GRUMP





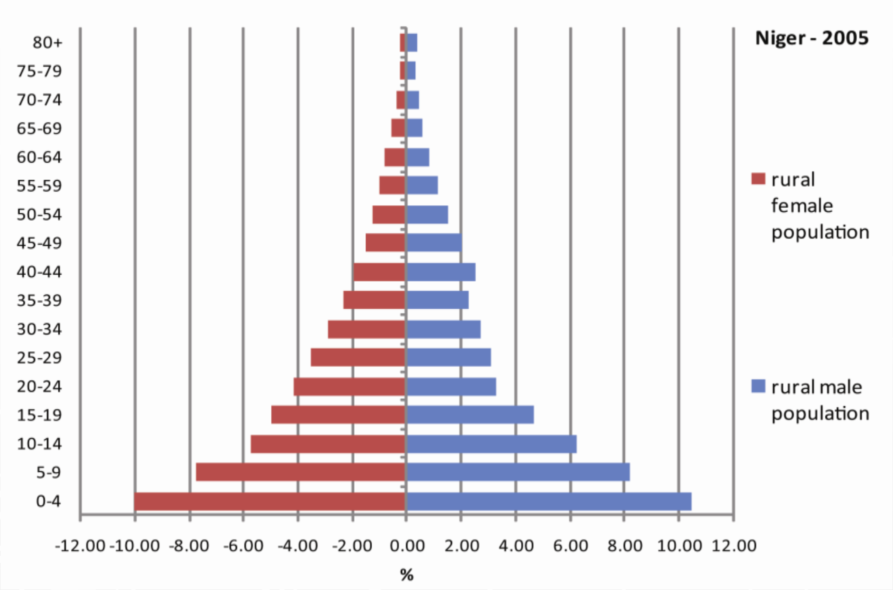
Source: Balk et al. in prep.

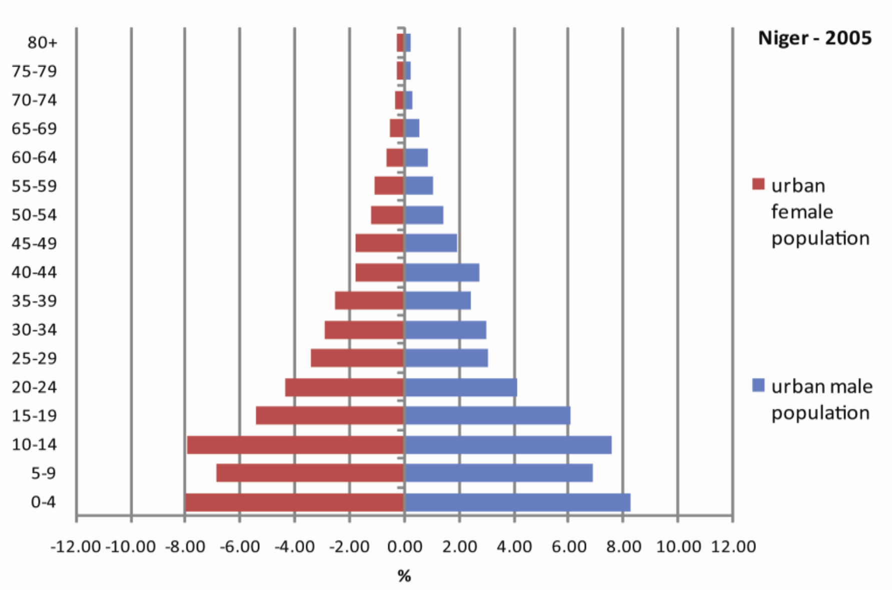
Figure 6. Night-time lights and urban polygons overlayed to Landsat scenes for Quito, Ecuador (top) and southern Nigeria (bottom). Urban areas are easily identifiable in purple. In the Quito

Niger Urban Extents and Populated Places

Source CIESIN

Gender, Age structures





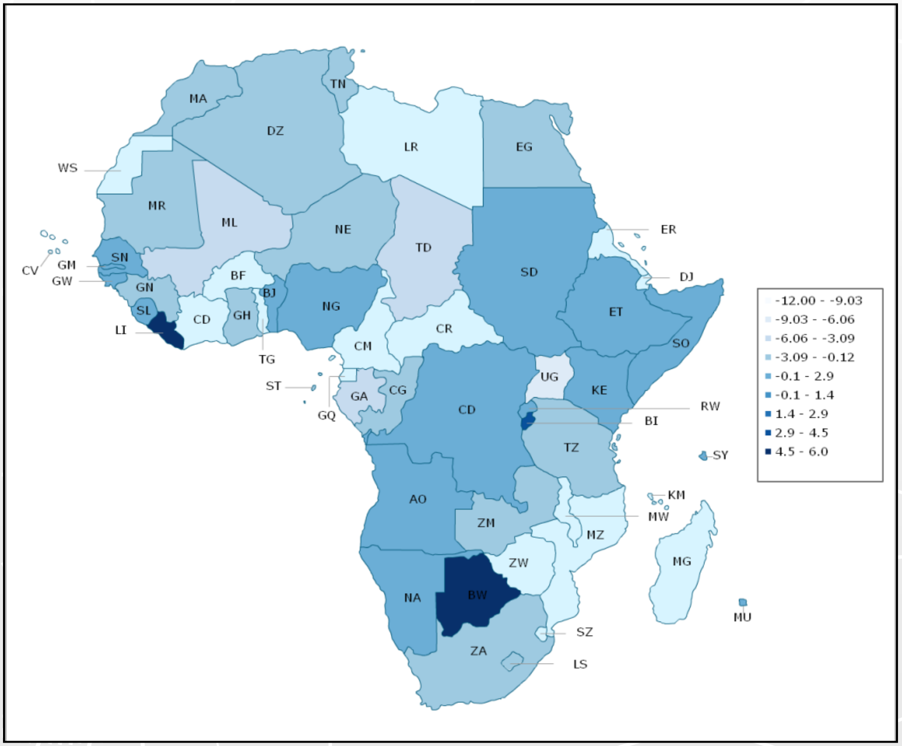
Available at district level

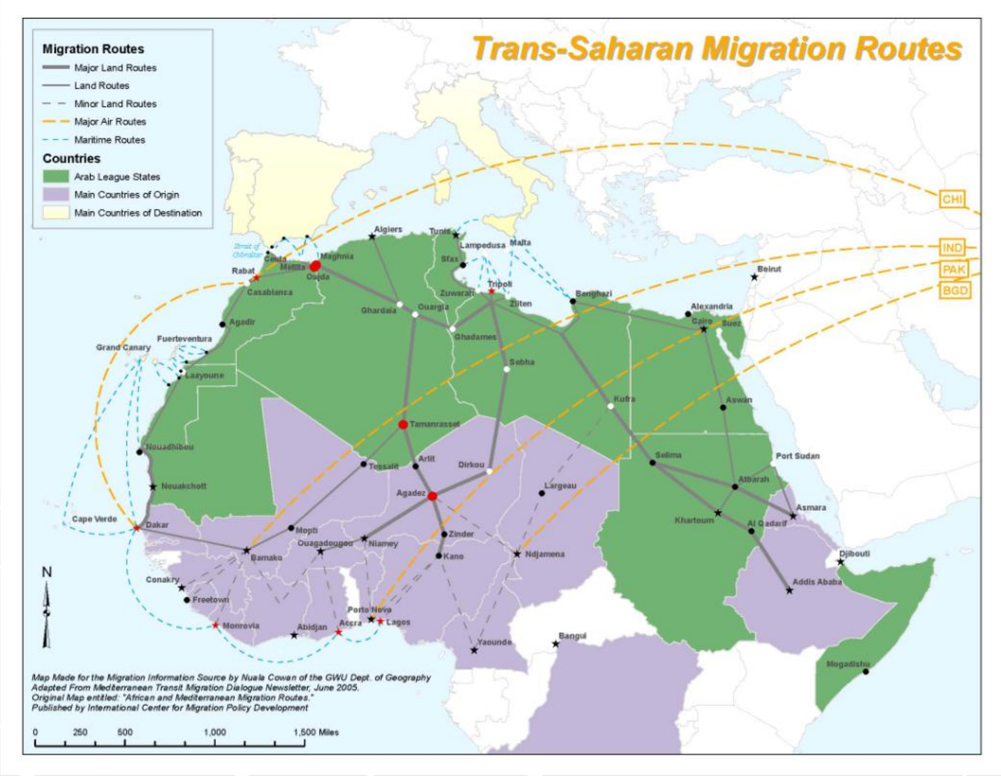
Source CIESIN

About migration

Two different views/approaches:

- **Migrant stocks: gross and net migration rates**
- **Networks: migration flows; points of entry, transit and exit**





Courtesy CIESIN

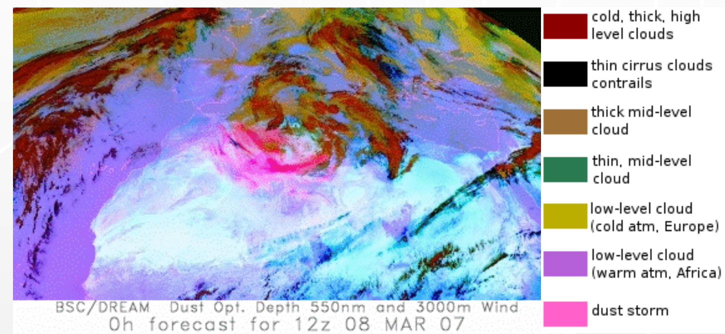
Dust modeling

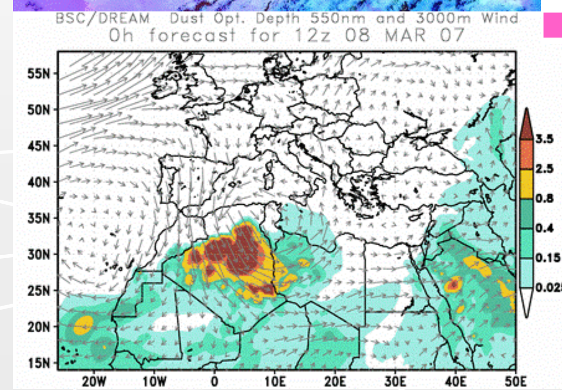
Very few in-situ observations exist

Satellite data do not provide information with satisfactory spatial/temporal coverage and at the surface

Dust models simulate the atmospheric dust cycle:

- **Dust emission**
- **Advective and convective transport**
- **Turbulent diffusion**
- **Sedimentation, wet and dry deposition**





ADEQUATELY CONSTRAINED BY THE AVAILABLE OBSERVATIONS MODELS CAN PROVIDE HISTORICAL AND CONTINUOUS DATA FILLING THE TEMPORAL AND SPATIAL GAPS OF THE OBSERVATIONS

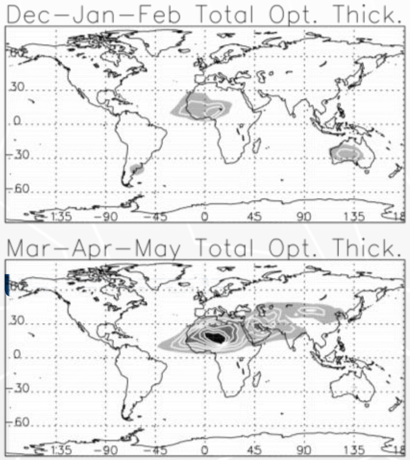
THEY ARE USED AS SHORT-TERM FORECASTING TOOLS (3-5 days ahead)

C. Perez, J. Perlwitz

Dust models

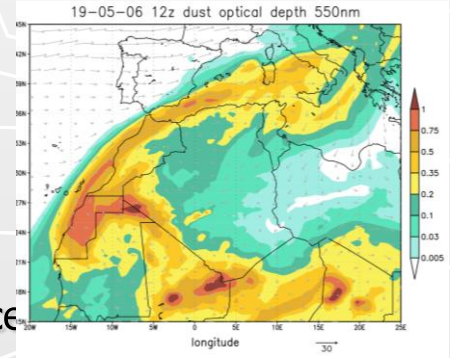
GISS ModelE

- Dust module developed at NASA GISS (Miller et al., 2006)
- Embedded into the GISS ModelE AOGCM
- 2ºx2.5º resolution
- Topographical depressions + ERS roughness maps to identify d
- Probability distribution to represent subgrid wind variability



NMMb/BSC-Dust

- Dust module developed by Pérez et al., 2009
- Embedded into the NCEP NMMb weather forecast model
- Global and regional domains (selectable resolution)
- Topographical depression + USGS landuse cover to identify dust source



C. Perez, J. Perlwitz

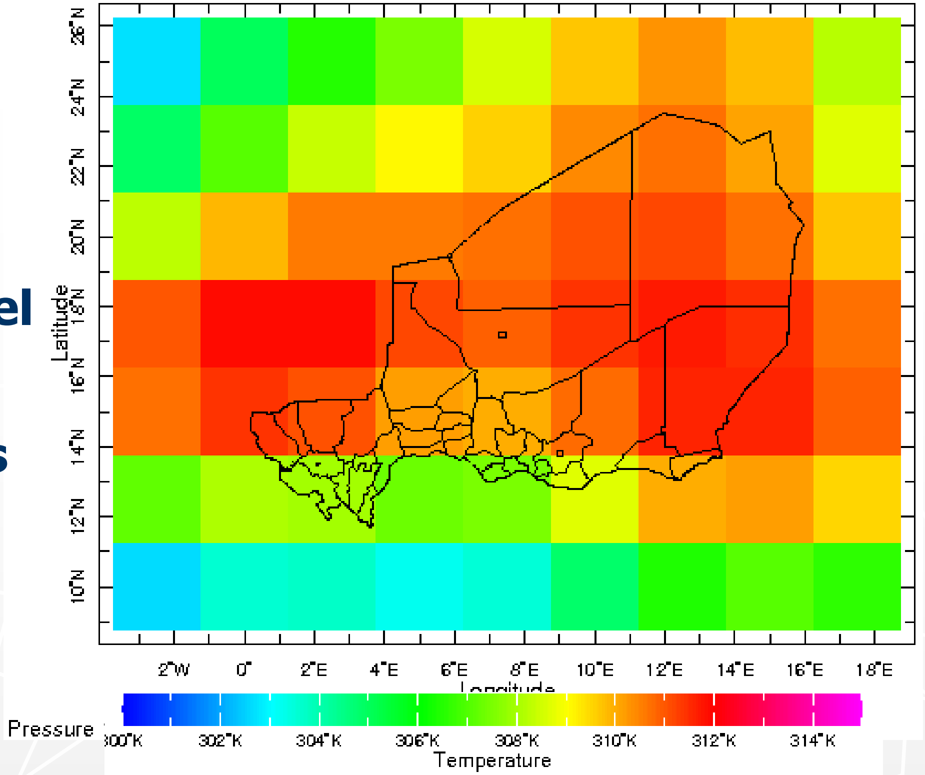
Dust modeling: ongoing work

- 1979-2010 simulations with the dust models to provide modeled daily dust concentration levels
- Intensive validation against observations (sun photometers, satellites)
- Understanding the role of dust in relation to other environmental and climatic variables. Studying the relationship of dust events with humidity, winds, temperature., etc.
- Careful analysis of the different sources and pathways of dust

Some issues/solutions

Spatial scale

- Extract information at district level
- Specific tool in IRI Data Library
- BUT pbs with obtaining shapefiles



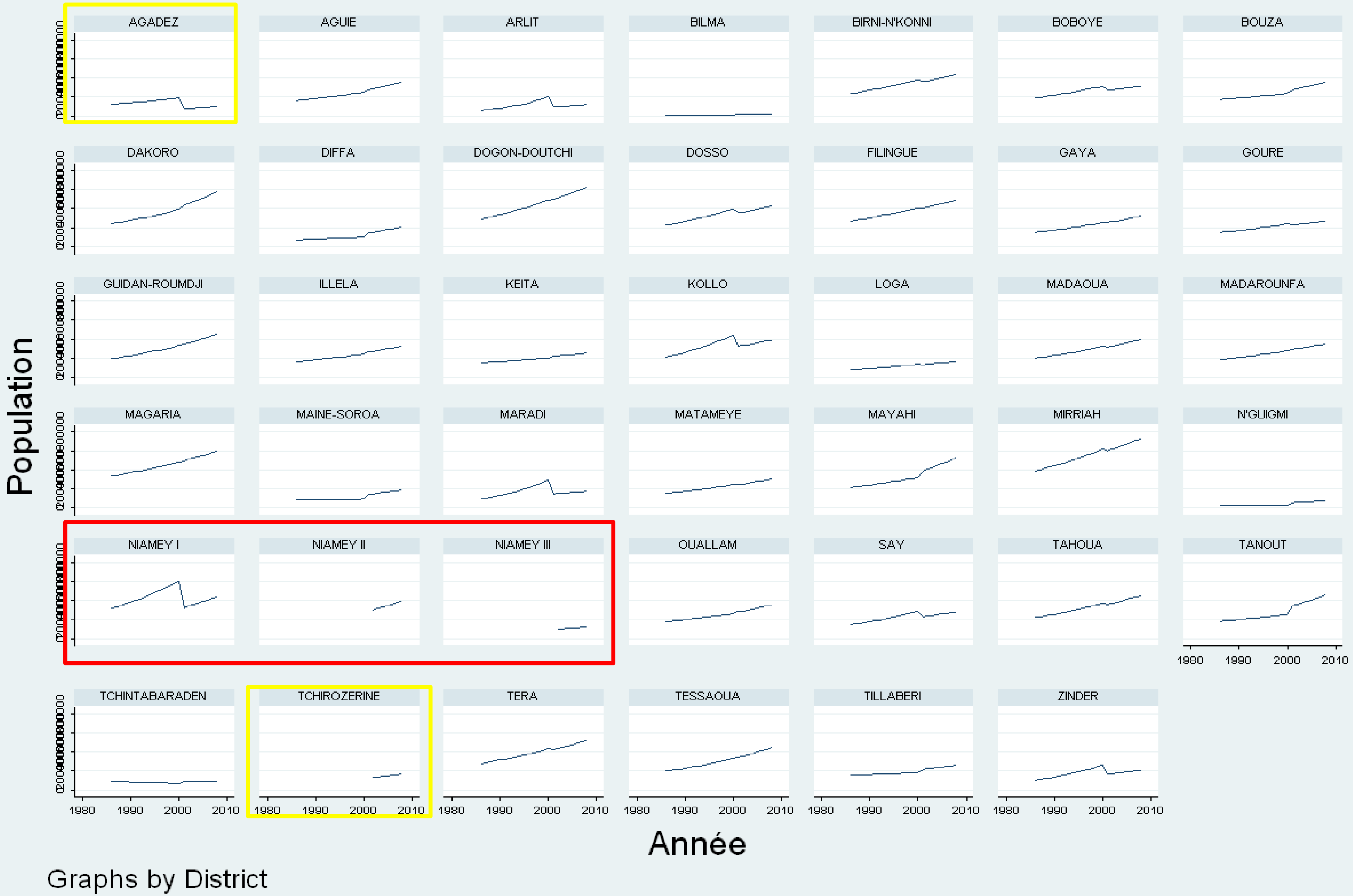
Time resolution

- Weeks: Monday to Sunday
- Calendar done for 1986-2008
- DL extracts weekly averages according to this calendar
- Still only 1 yr with 53 weeks on records

Year	Starting Week	Ending Week	Number of Weeks
1986	12/29/1985	01/03/1987	53
1987	01/04/87	01/02/88	52
1988	01/03/88	12/31/88	52
1989	01/01/89	12/30/89	52
1990	12/31/89	12/29/90	52
1991	12/30/90	12/28/91	52
1992	12/29/92	01/02/93	53
1993	01/03/93	01/01/94	52
1994	01/02/94	12/31/94	52
1995	01/01/95	12/30/95	52
1996	12/31/95	12/28/96	52
1997	12/29/96	01/03/98	53
1998	01/04/98	01/02/99	52
1999	01/03/99	01/01/00	52
2000	01/02/00	12/30/00	52
2001	12/31/00	12/29/01	52
2005	12/30/01	12/28/02	52

Some issues (cont)

Pop Data



S. Adamo

Re-estimation of population series

Aggregation of districts

- Agadez and Tchirozerine: in the original dataset, TCHIROZERINE included data (population, cases and deaths) from 2002 to 2008. It was aggregated with AGADEZ, under the assumption that the districts were one until 2000.
- Niamey(s): Niamey I, II and III were aggregated in NIAMEY3.
- Abalak district: information on population, cases and deaths is available for 2002-2005 only.

Population series

- The population for each year from 1986 to 2008 was re-calculated as follow:
  - First, the average annual growth rate 1986-2001 was estimated as

$$r = Ln(P_2/P_1)/15$$

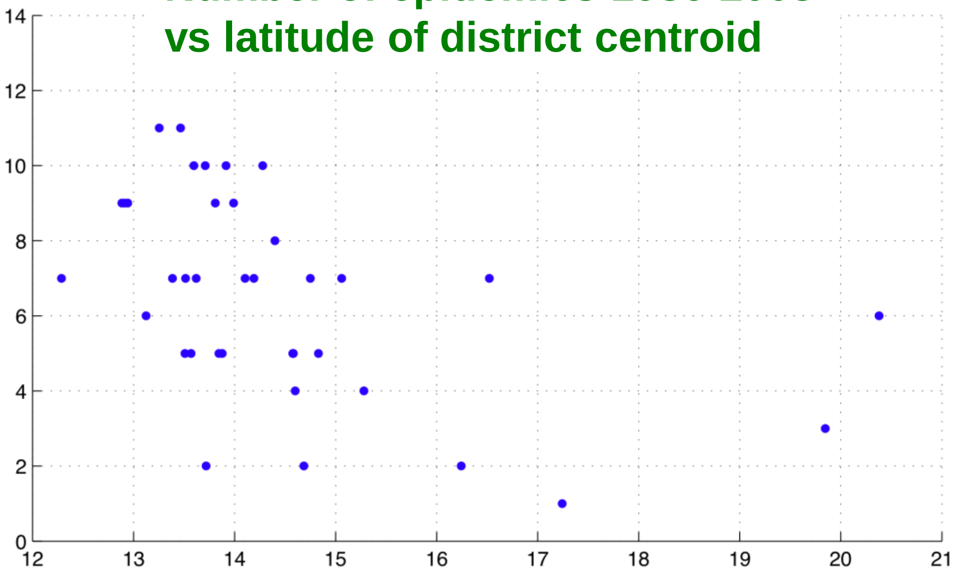
  - where P_1=population in 1986 , P_2=population in 2001 (from census records), and "15" the years between 1986 and 2001.
  - Second, this growth rate was then used to generate the annual time series from 1986 to 2008, using → $P_{y+1} = P_y * e^{rt}$

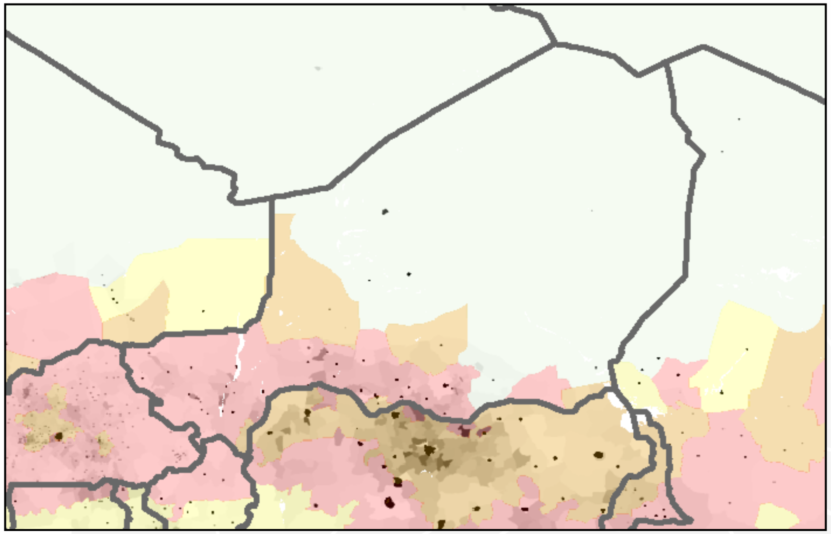
New Pop Data

S. Adamo

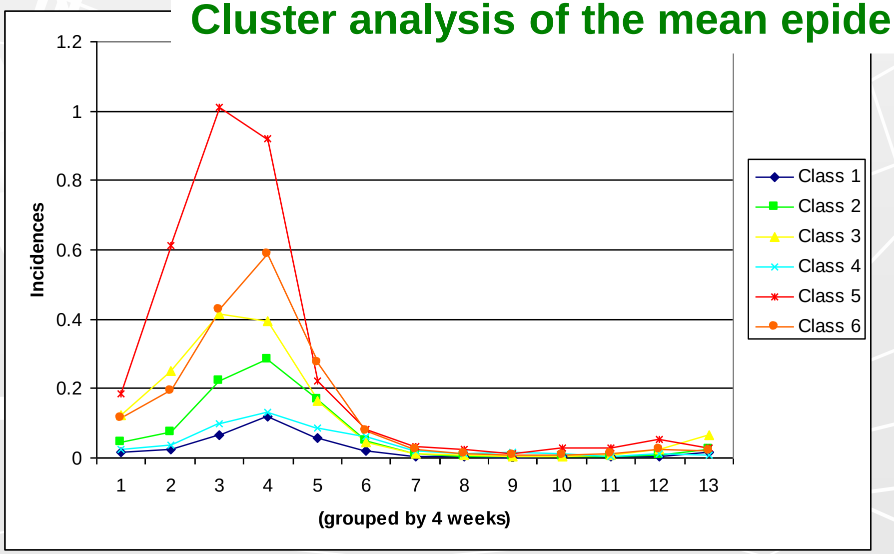
Some preliminary analyses

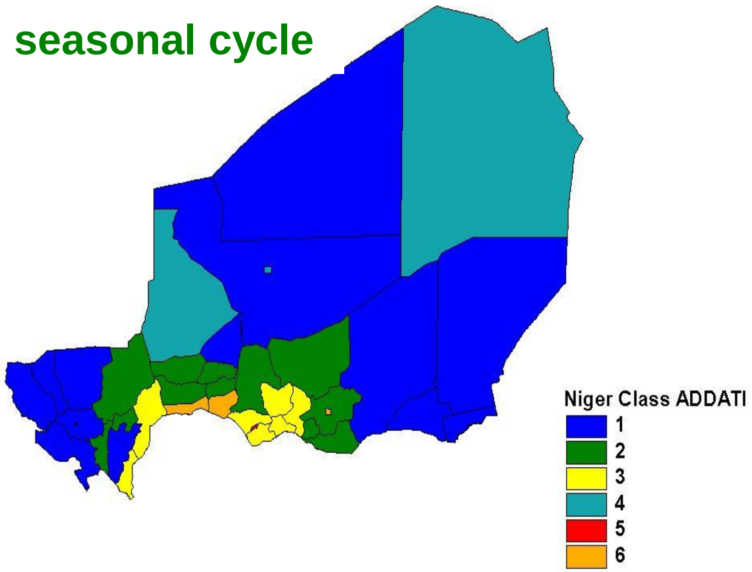
Number of epidemics 1986-2008
vs latitude of district centroid





Cluster analysis of the mean epidemic seasonal cycle



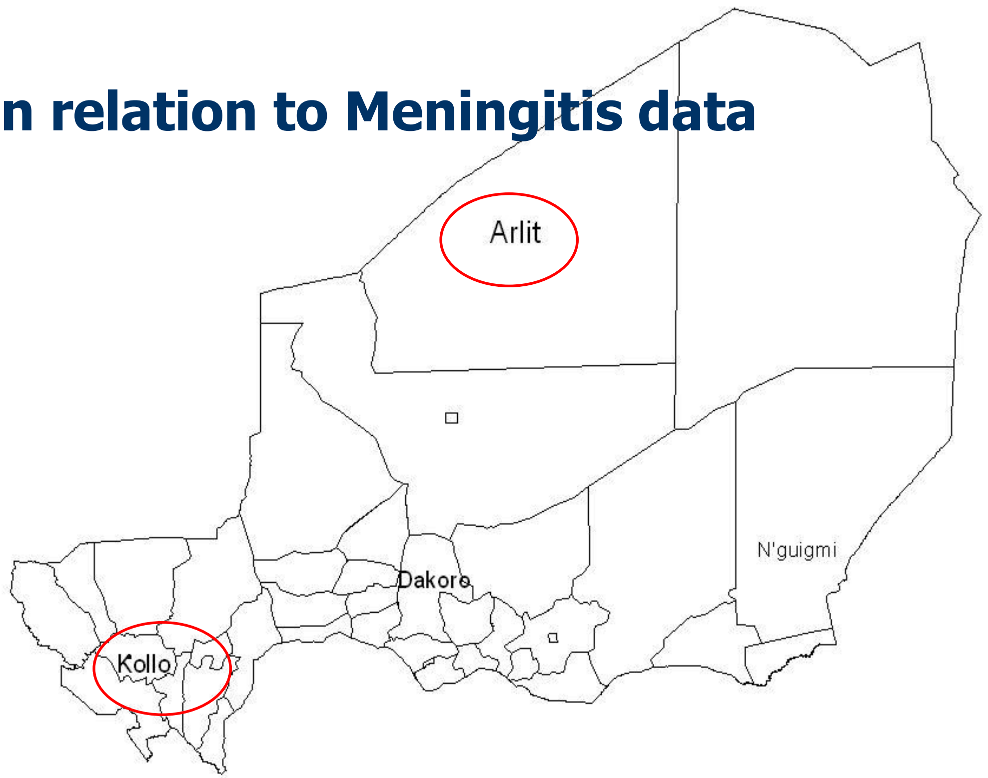


Monitoring Dust with MISR

Analyze daily data from 1 Apr 2000 to 30 Apr 2009:

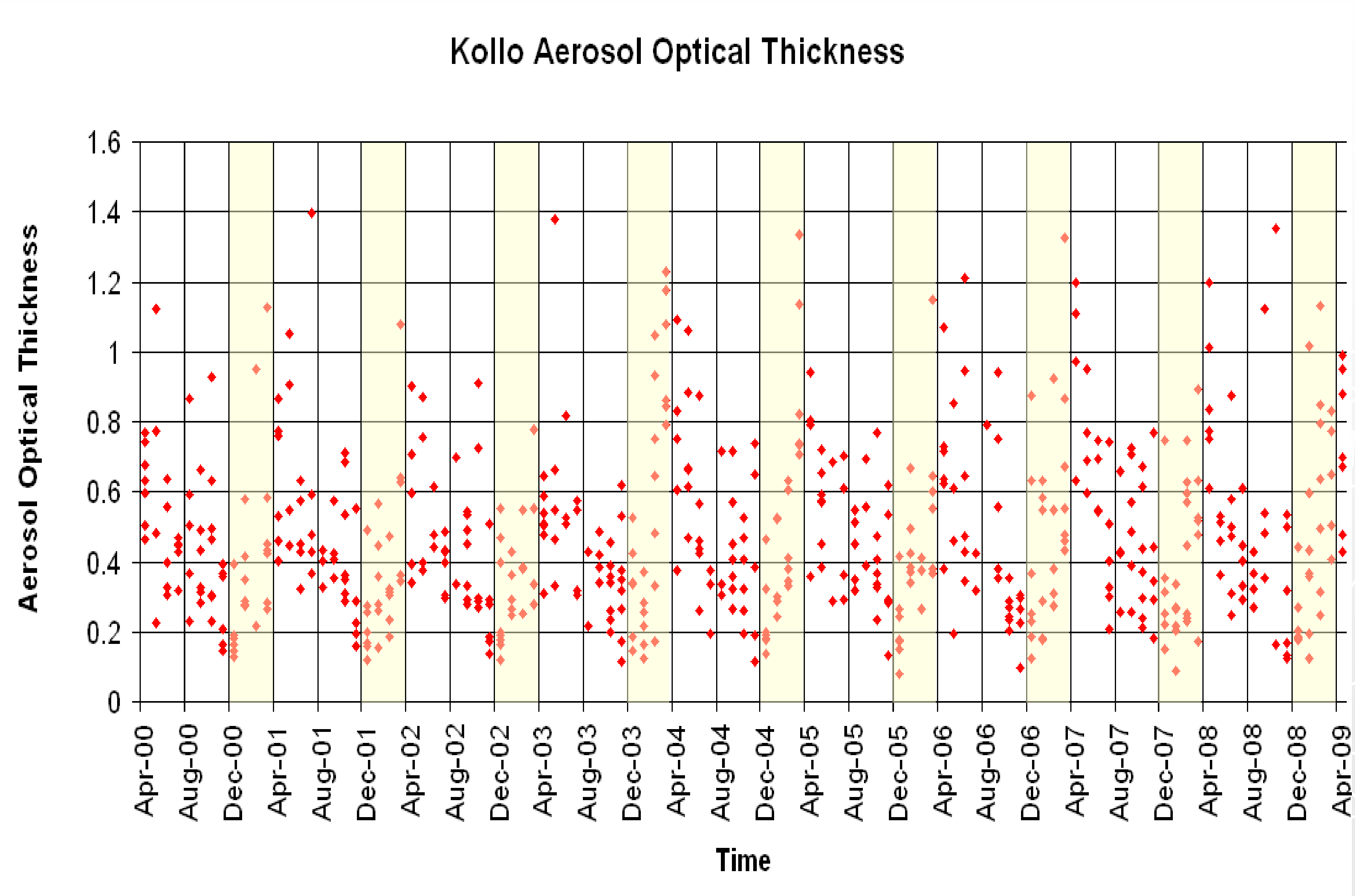
- **Angstrom Exponent,**
- **Aerosol Optical Thickness,**
- **Dust Fraction**

for the 38 districts (Niger) in relation to Meningitis data



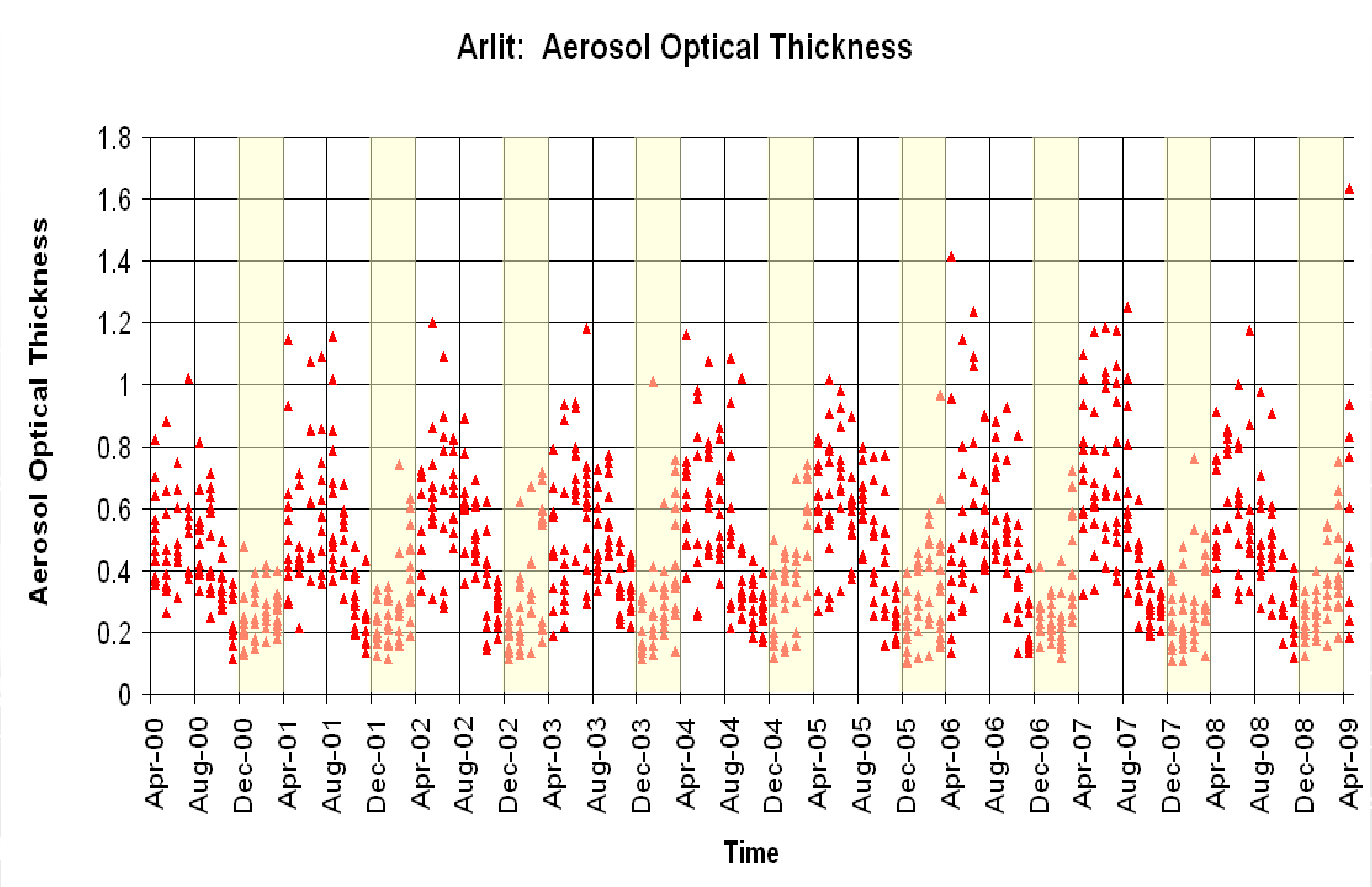
P. Ceccato, O. Kalashnikova

Monitoring Dust with MISR



P. Ceccato, O. Kalashnikova

Monitoring Dust with MISR

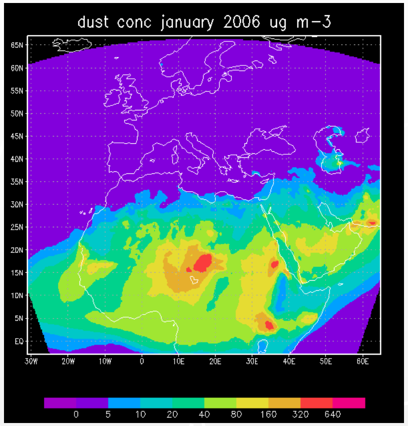


P. Ceccato, O. Kalashnikova

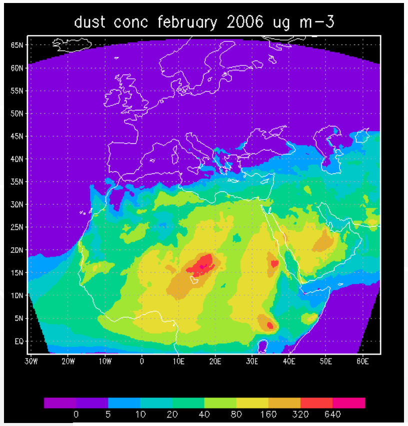
Model Validations

NMMb/BSC-Dust Simulations for year 2006

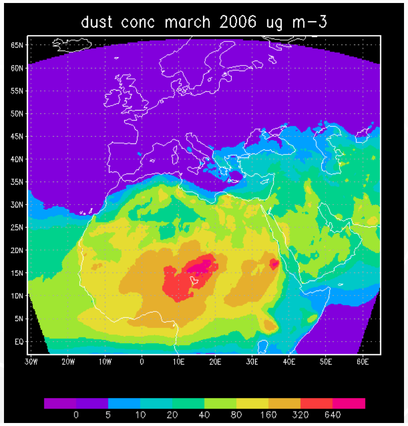
JAN 2006



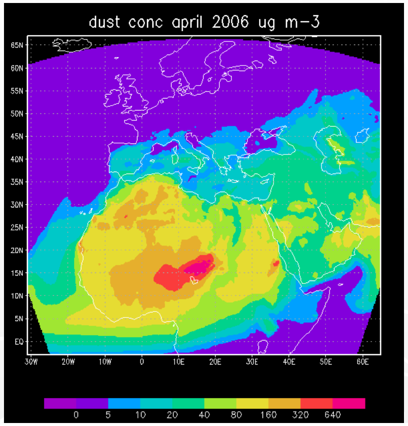
FEB 2006



MARCH 2006

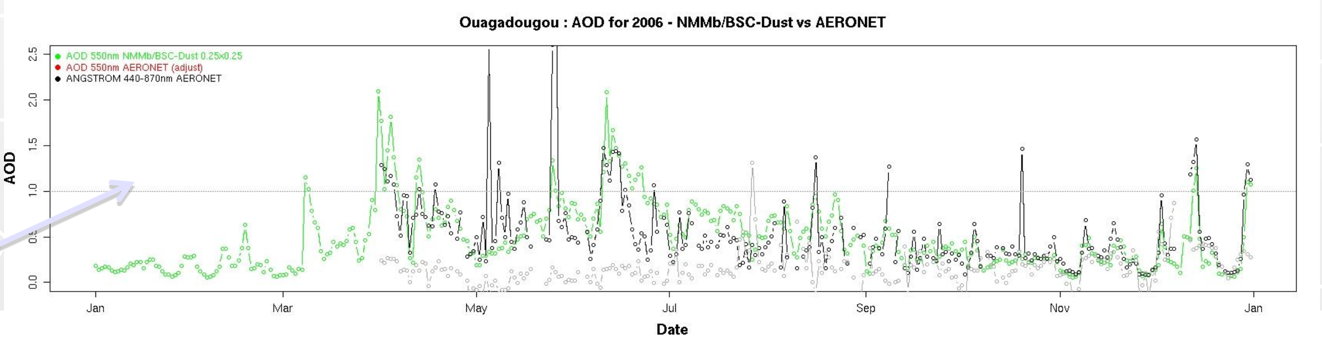


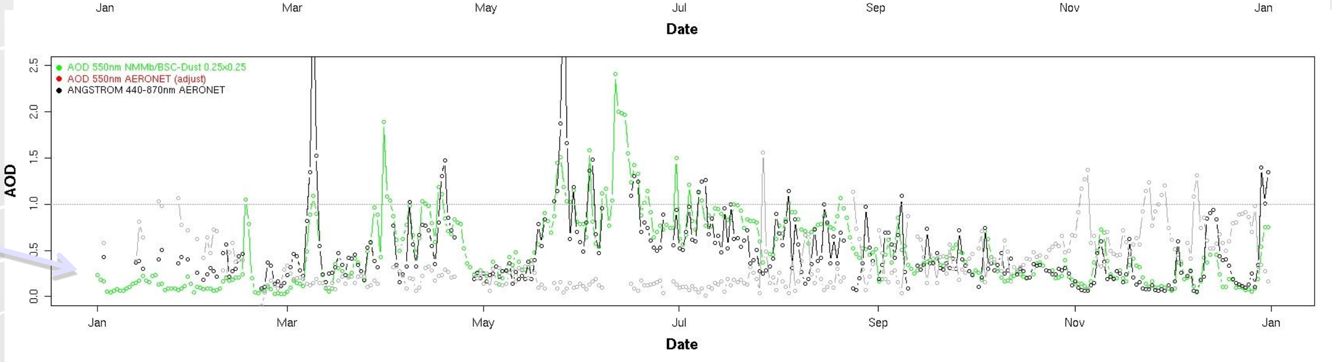
APRIL 2006



NMMb/BSC-Dust

Aeronet Sun photometer network





C. Perez

Model Validations

ModelE

- resolution: horizontal: 2.5 deg. longitude x 2 deg. latitude; vertical: 40 layers
- Soil dust aerosol model embedded; simulates emission, transport, and deposition of dust
- Nudged 3-dim horizontal wind field; nudging every 6 hours
- Simulation period: January 1979 to August 2010
- Data in IRI-libray:
  - Surface dust concentration (global; 6 hourly and monthly avge)
  - Dust aerosol optical depth (global; daily and monthly avge)

Where we are now…

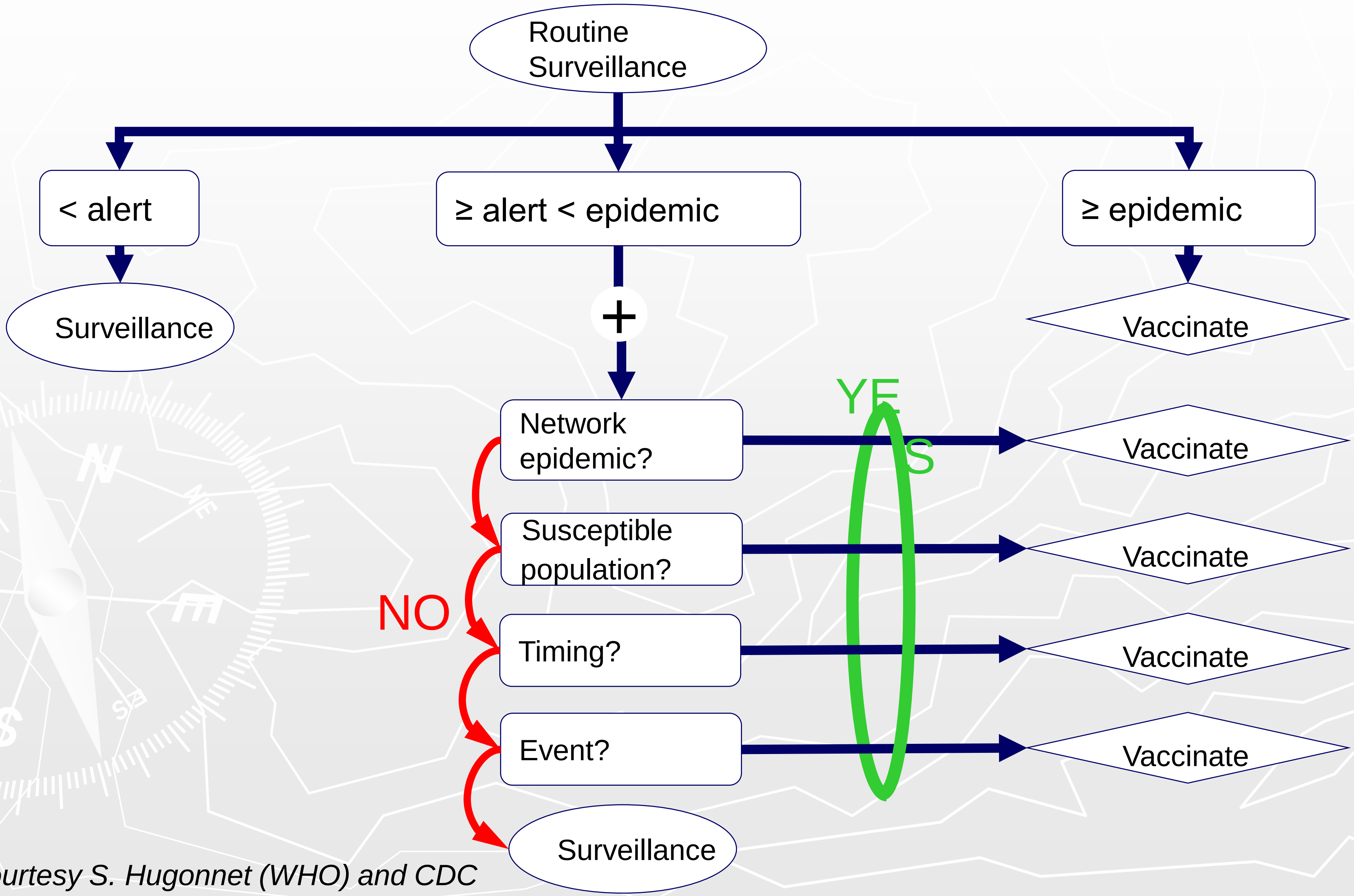
- All the data have been uploaded to Data Library
    - Metadata
    - Documentation
    - Discussion how to/not to use them
    - Derived products

- Tools enabling the extraction of information compatible with Epi data developed

- Some preliminary analyses started

☛To come: hard-core statistical modeling
include other epi information
evaluate following WHO model

Hypothetical decision tree adding an "alert+" action threshold



Courtesy S. Hugonnet (WHO) and CDC

Methods

Evaluate

1. Sensitivity, specificity of the enhanced alert criteria tested against the current strategy

2. Time difference in days between the time the decision to vaccinate was taken using enhanced alert criteria vs. the current strategy

Preliminary analysis of time gain/resource loss by including information about status of neighboring districts in Mali, Burkina Faso and Niger

Specificity/timeliness tradeoff: *lower response threshold*

Incidence cutpoint for Action	Specificity	Specificity (LL CI)	Specificity (UL CI)	Mean improvement in timeliness (weeks)
5	83.62	0.80778	0.86199	1.979592
6	89.21	0.86773	0.91342	1.612245
7	92.94	0.9087	0.94669	1.265306
8	96.4	0.94812	0.97618	0.489796
9	99.07	0.98089	0.99624	0.183673
10	100	0.9951	1	0

Courtesy S. Hugonnet (WHO) and CDC

Specificity/timeliness trade-off (REQUIRES 5/100,000 IN DISTRICT): *include neighboring districts in epidemic*

Neighbors in epidemic cutpoint for action	Specificity	Lower CL for specificity	Upper CL for specificity	Mean improvement in timeliness (weeks)
none	**85.22**	**0.82477**	**0.87682**	**1.891156463**
1	**93.34**	**0.91316**	**0.95018**	**0.972789116**
2	**97.07**	**0.95598**	**0.98155**	**0.544217687**
3	**98.93**	**0.97912**	**0.99539**	**0.238095238**
4	**99.87**	**0.9926**	**0.99997**	**0.074829932**
5	**99.87**	**0.9926**	**0.99997**	**0.040816327**
6	**100**	**0.9951**	**1**	**0.027210884**
7	**100**	**0.9951**	**1**	**0.006802721**
8	**100**	**0.9951**	**1**	**0.006802721**
9	**100**	**0.9951**	**1**	**0**
10	**100**	**0.9951**	**1**	**0**
Ignore neighbors	**100**	**0.9951**	**1**	**0**

Courtesy S. Hugonnet (WHO)and CDC

Specificity/timeliness trade-off (NO INCIDENCE REQUIREMENT): *include neighboring districts in epidemic*

Neighbors in epidemic cutpoint for action	Specificity	specificity (LL CI)	specificity (ULCI)	Mean improvement in timeliness (weeks)
1	80.03	0.76985	0.8283	2.435374
2	91.74	0.89541	0.93612	0.972789
3	97.2	0.95757	0.98261	0.414966
4	99.33	0.98453	0.99783	0.136054
5	99.6	0.98837	0.99918	0.081633
6	99.87	0.9926	0.99997	0.034014
7	100	0.9951	1	0.013605
8	100	0.9951	1	0.006803
9	100	0.9951	1	0
10	100	0.9951	1	0
Ignore neighbors	100	0.9951	1	0

Why are meningococcal meningitis rates so high in the Sahel? Investigating the role of mineral dust.

The burden of the disease

Meningococcal meningitis (MM), a bacterial infection of the meninges, occurs throughout the world but the countries in the semi-arid region south of the Sahara face attack rates that are several times higher than those seen in the rest of the world. This region, stretching from Senegal to Ethiopia, is called 'the Meningitis Belt'.

There, MM affects close to 400 million people in 25 countries. Annual incidence rates can reach 1,000 cases per 100,000 people. MM occurs every year and reaches epidemic levels every few years. The largest recorded outbreak, in 1996, caused 250,000 cases and almost 25,000 deaths. At least 50,000 persons suffered permanent disability.

The disease has a tremendous impact on the economies of countries in the Meningitis Belt, which are among the poorest in the world. The burden is estimated to be more than $11 million/year in diagnostic, tests and case treatment costs. Additional burden at the household level was estimated in Burkina Faso to be $90/case – 34% annual GDP/capita – and up to $154 more when permanent disability occurred.

Yet, no efficient preventive treatment exist. The WHO implements a reactive vaccination, together with case treatment, once the epidemic has started. Still, large epidemics occur every few years despite vaccinations.

While the Meningitis Vaccine Project seeks to rapidly eliminate the serogroup A MM (http://www.meningvax.org/), the completion of the vaccination and achievement of herd immunity will take ca. 10 years. Even then the expected immunity will not protect the population from other strains.

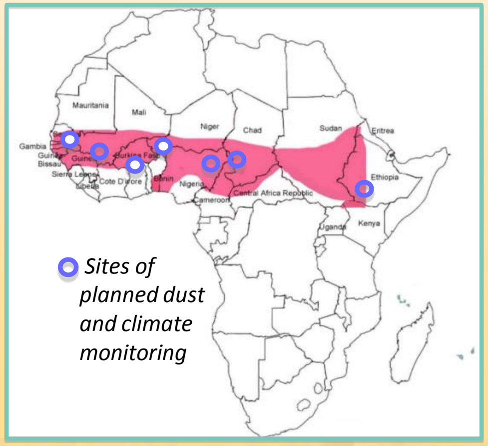
We still need to understand why meningitis rates are up to 20 times higher in the 'Meningitis Belt' than anywhere else.

The objectives

The existing data from the region are sparse and inadequate to clearly discriminate among various socio-economic, demographic, behavioral and environmental risk factors potentially playing a role in MM outbreaks.

We would like to complement the ongoing MenAfriCar study (http://www.menafricar.org/) with in situ environmental data collection in order to build a snapshot image of both, epidemiological state and environmental conditions across the Sahel. The project will also contribute to the ongoing MERIT initiative http://merit.hc-foundation.org/aboutMERIT.html.

Meningitis Belt



Our main focus will be on aerosol collection and analysis as their contribution to MM development has not been extensively investigated and very few data exist regarding dust concentrations, sources, particle size and shape and mineralogy. All of these may Influence human exposure.

By doing so we hope to answer the question: are the concentration and composition of mineral dust in the Meningitis Belt likely factors in meningitis development?

The project

We would like to deploy dust samplers (BGI FRM Omni) and portable meteorological stations (Climatronics) in 14 locations in 7 countries across the Sahel (one rural a urban in each country), where MenAfriCar is currently conducting the cross-sectional and longitudinal carriage studies along with socio-economic questionnaires.

Dust samples collected on a weekly basis will be stored and analyzed at Lamont-Doherty Earth Observatory at Columbia University. The results will inform us on the spatial distribution of aerosol characteristics, their evolution during the year and potential links to carriage status and/or disease development.

The estimated cost of the equipment per location is $9,000; the costs for logistics and travel are estimated at $1,000 and $3,000 per location respectively, for a total of $182,000.

A pilot deployment of the equipment by the IRI in 2 locations in the Sahel (Ghana and Niger) has been funded by the NIEHS and additional funds will be sought for sample analysis and further research. However, the time-frame of this campaign is too short to link the deployment to future research funds.

We are seeking timely funds to support the equipment and its deployment. The measurements should start in July 2010 and the equipment be deployed and local staff trained in June if the project is to be most effective.

The field campaign will take advantage of the partnerships, logistics and community buy-in developed in the frame of MenAfriCar. Once in place, the equipment could be used for longer term aerosol monitoring, beyond current campaign, provided the interest of local partners and availability of additional funds.

IRI, March 19, 2010

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