Epidemic meningitis in Africa and environmental risk: a consultative meeting

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## Contents

- Acronyms .................................................................................. 2
- Executive Summary ................................................................. 3
- 1. Introduction ........................................................................ 4
- 2. Proceedings ......................................................................... 6
- 3. Outcomes and Next Steps ...................................................... 23
- 4. Conclusion ........................................................................... 25
- Annex A: Meeting Agenda ......................................................... 26
- Annex B: List of Participants ...................................................... 29
- Annex C: MERIT Leaflet ............................................................ 32
Acronyms

ACMAD  African Centre of Meteorological Application for Development
AMP    Agence pour la Médecine Préventive
CIESEN Center for International Earth Science Information Network
CERMES Centre de Recherche Médicale et Sanitaire
CNRS  Centre National de la Recherche Scientifique
GEO    Group on Earth Observations
HCF    Health and Climate Foundation
IFRC   International Federation of the Red Cross and Red Crescent Societies
IRI    International Research Institute for Climate and Society, Columbia University
LSHTM London School of Hygiene & Tropical Medicine
LSTM   Liverpool School of Tropical Medicine
MCC    Meningitis serogroup C conjugate vaccine
MCM    Meningococcal Meningitis
MERIT  Meningitis Environmental Risk Information Technologies (Project)
MVP    Meningitis Vaccine Project
NDVI   Normalized Difference Vegetation Index
SDSWS  Sand and Dust Storm Warning System
WHO    World Health Organization
WHO/MDSC World Health Organization Multi-Disease Surveillance Centre
WMO    World Meteorological Organization
WMO    WMO Sand and Dust Storm Warning System
Executive Summary

In collaboration with the World Health Organization, the World Meteorological Organization, the International Research Institute for Climate and Society, the Health and Climate Foundation, and other leaders within the environmental and public health communities, the Group on Earth Observations Secretariat hosted a Meningitis Environmental Risk Consultative Meeting in Geneva from 26–27 September 2007.

The purpose of the meeting stemmed from expressed interests of the public health community to: 1) find a common platform between relevant communities to address meningococcal meningitis epidemics in Africa in the context of perceived environmental, biological, economic and demographic influences; 2) gain a greater understanding of the current knowledge and active research surrounding the epidemic risk indicators; and 3) communicate the information needs of the public health community to the research community to enhance epidemic meningitis control strategies in Africa.

While there are many interacting factors considered in the design of public health strategies, an increased understanding of the specific environmental and social risk indicators would support efforts towards eradicating meningococcal meningitis epidemics across Africa’s Meningitis Belt. By applying advances in Earth observations data with epidemiological knowledge of the disease trends, the public health community will be better informed to determine populations at highest risk of an epidemic outbreak, to improve current reactive immunization strategies and to shape future proactive campaigns utilizing longer lasting vaccinations to reduce the risk of future devastating outbreaks.

Recognizing these opportunities, the meeting was held as a means to further align the scientific advances being made within both the research community (in terms of the influences of temperature, humidity levels, aerosol concentrations, population trends, economic status, etc on the vulnerability of a region to an epidemic) and the public health community (in terms of the quality, effectiveness and affordability of vaccines).

In addition to providing a forum for information-sharing between the relevant communities, the meeting generated active discussions to define future research parameters and to determine how to transition from research to operations through the use of information systems and technology.

Recommendations

The two-day meeting is considered an important early step in a long-term collaborative process and resulted in the following key recommendations being made:

1. That the recently formed Meningitis Environmental Risk Information Technologies ‘MERIT’ Project continues to be developed to provide an effective collaborative framework around which the outcomes from the meeting will progress.

2. That a comprehensive technical review of existing research surrounding meningitis epidemics and Earth observations be conducted.

3. That a follow-up meeting be held within six months; this has tentatively been scheduled for May 2008 in Africa.
1. Introduction

The Meningitis Environmental Risk Consultative Meeting was organized with an overarching objective to improve public health outcomes in the African ‘Meningitis Belt’ (Figure 1) by determining how to improve the integration of knowledge of risk indicators of meningitis epidemics into successful early warning systems and control strategies.

The goal of the meeting was to develop an action plan for the relevant sectors of this emerging Community of Practice concerned with meningitis epidemics in Africa to work together to affect better public health outcomes.

Figure 1: The African ‘Meningitis Belt’

1.1 Meeting Objectives

The specific objectives of the meeting included:

a. To develop an across-the-board understanding of the public health problem arising from epidemic outbreaks of meningococcal meningitis in Africa and current control measures.

b. To facilitate information-sharing of the environmental factors that appear to influence epidemic outbreaks of meningococcal meningitis.

c. To highlight the information needs of public health practitioners and policymakers in Africa to support meningitis control strategies, particularly surrounding the implementation of the new conjugate A vaccine over the next ten years.

d. To identify future research projects to add value to the ongoing development of meningitis response and control strategies in Africa.

e. To establish a set of recommendations for enabling collaborative and long-term engagement between relevant sectors to increase the effectiveness of meningitis strategies in Africa.
1.2 Meeting format

(Refer to Annex A for Agenda)

Day 1 consisted of a series of presentations by the different communities represented, with the objective of establishing a comprehensive understanding of the current situation of meningitis epidemics in Africa and enabling information-sharing of current research and operations.

Day 2 was structured around interactive discussions within small working groups, with the objective of refining research efforts and improving the integration of research into operations and control strategies. A wrap-up plenary session in the afternoon enabled groups to report on the recommendations resulting from the morning discussions.

An informal session was held on Day 3 for organizers and others interested to assess the meeting outcomes and determine the next steps.

Note: Copies of presentations and notes from the working group sessions are available and can be downloaded at: ftp://ftp.wmo.int/Projects/GEO/HEALTH/Meningitis/20070926-27_GEO_MeningitisMeeting/
2. Proceedings

2.1. Linkages between Health and Earth observations communities

2.1.1. Introductory remarks were delivered by José Achache, GEO Secretariat Director, David Heymann, World Health Organization Assistant Director General Communicable Diseases, and Omar Baddour, World Meteorological Organization Chief World Climate Data and Monitoring Programme Division. The opening comments conveyed a shared recognition of emerging opportunities for engagement between the environmental, climate and public health communities to increasingly align Earth observations with public health objectives. With the meeting focus on the reduction of meningitis epidemic risks in Africa through strengthened application of environmental and climate information, across the board support was expressed for the development of mechanisms to achieve closer interaction and establish effective joint projects on a permanent basis between the health, environment and climate communities.

2.2. Current and future landscape of meningitis epidemics in Africa

2.2.1. Surveillance of meningitis in Africa and response strategies: Where are we today? What are the expectations of the public health community?

Eric Bertherat, World Health Organization (WHO)

A detailed overview was provided of current operations and information requirements of the public health community related to: the impact of the Neisseria meningitides bacteria responsible for epidemic outbreaks in the Meningitis Belt; transmission of the bacteria; health and economic costs of epidemics; WHO strategy in the Meningitis Belt which is currently primarily reactive; epidemic thresholds; enhanced surveillance methods; capacity constraints; low performance of polysaccharide vaccines; and opportunities for moving towards future preventative strategic approaches through the deployment of the new conjugate A vaccine, with plans to reach 300 million people across the Meningitis Belt over the next 10 years.

The periodicity and dynamics of epidemics vary spatially and depend on factors including population susceptibility, introduction of new strains, environmental, socio-demographic and immunological factors. WHO has a particular interest in the relationships between seasonal climatic factors and meningitis epidemic outbreaks; the potential application of this information to help define high-risk areas and improve the strategy for implementation of the new conjugate vaccine; and the potential long-term expansion of the Meningitis Belt in the coming decades with climate change.

Specific questions from a public health position include:

- What can be expected from the scientific research community, in terms of environment, socio-demographics, mathematical analyses, etc.

- To what extent will this additional knowledge be able to improve the current control strategy, moving from reactive response to preventative vaccination strategies.
What does the possible expansion of the Meningitis Belt mean for currently unaffected populations?

2.2.2. The impact of introducing the Meningitis A conjugate vaccine

Marc LaForce, Meningitis Vaccine Project PATH

The Meningitis A (Men A) conjugate vaccine will be introduced to the Meningitis Belt region in 2008, beginning in Burkina Faso and progressing to other countries within the region until 2020.

The Men A conjugate vaccine will provide comprehensive coverage of 1-29 year olds and is expected to: 1) eliminate all Meningitis A epidemics; and 2) eliminate all endemic meningitis due to Group A Neisseria meningitis. The vaccine will not eliminate acute meningitis cases which are particularly important in the group less than two years of age where most cases of acute bacterial meningitis are due to Hemophilus and pneumococci. It was noted however that this may be the beginning of a new era which seriously addresses acute meningitis problems.

Conjugate vaccines are more effective than polysaccharide vaccines as they induce higher concentrations of antibodies which can prevent acquisition of carriage, thus inducing herd immunity. The Men A conjugate vaccine is affordable with a transfer price under 50c per dose, 40-60 million doses / year.

2.3. Statistical applications, population dynamics, socio-economic and climatic factors

2.3.1. Statistical linkages between infectious diseases and the environment

Peter Diggle, University of Lancaster

Two case studies were presented to illustrate statistical analyses of environment-related health issues. The first, the African Programme for Onchocerciasis Control (APOC) was designed to predict Loa loa prevalence from spatially sparse community-level surveys. The second, Particulate Matter and Perinatal Events Research (PAMPER) was designed to construct predictions of black smoke levels over a 30-year period.

Key discussion points:
- Environmental determinants of health vary: continuously; in space; and in time.
- Assigning a spatially and/or temporally averaged exposure to an individual at risk is at best a pragmatic approximation.
- Models of the association between exposure and health outcomes should acknowledge the statistical uncertainty in exposure estimates.
- Model-based geostatistical methods can be used:
  i. to estimate a spatially and temporally continuous exposure surface;
  ii. from spatially and/or temporally sparse data;
  iii. with accompanying estimates of precision.
- Reliance on area-level data to analyse individual-level risk-factors is challenging.
- Epidemiological relevance of point exposure in space-time:
  i. Ambient versus indoor?
  ii. Integration over space and/or time?
  iii. Integration over tracked movements of individuals at risk?
- Importance of making proper allowances for imprecision in exposure estimates.
- Integrated analysis of exposure and health outcome data:
  i. Is possible in principle (APOC Loa loa study);
  ii. But computationally challenging for large data sets.
- Real time spatial prediction feasible using spatio-temporal models in conjunction with Monte Carlo algorithms

The discussion also highlighted the value of using surveys and questionnaires of susceptible or affected populations to supplement more costly methods such as taking blood samples, such as Rapid Assessment Procedures for Loa loa (RAPLOA) when resources are constrained. For example, spatially dense surrogate outcomes (RAPLOA) were used in combination with spatially sparse primary outcomes (parasitology) to improve spatial prediction in the APOC study.

The dynamic flexibility of models means that the methods described in these studies could be modified or manipulated for use in meningitis studies.

2.3.2. Methods to estimate populations at risk

Gregory Yetman, Center for International Earth Science Information Network (CIESEN)

An overview was provided of available methods to estimate population distribution and dynamics, in the context of studies to determine populations at risk of disease outbreak.

The presentation highlighted limitations of using census data which can create simple models, but which do not give accurate insight into population movements over time and geographically. Improvements in time estimates and data quality are being made through different methods of mapping populations, such as: gridded population of the world; accessibility modeling (based on road networks); weighted interpolation (population surface, Landscan – lights at night, elevation/slope, distance to roads, distance to rivers, land cover); Global Rural Urban Mapping Project (GRUMP – hybrid approach that uses administrative data as ‘truth’ and reallocates based on city lights and points); and detailed urban extents from satellite data which provides high definition. The last method has been used in a malaria mapping project conducted by Oxford University, however noted that this is an expensive and data intensive method.

Where practical, running the analyses with multiple population surfaces offers the potential to provide an assessment of the variability of population estimates. At
this stage, with limited systematic data on global or regional population migration, it is difficult to model and predict population movements (such as Hajj pilgrimage) however this could be achieved in the future. Potential approaches include:

- Updating administrative boundaries based on survey data or reports and produce model outputs appropriate for application;
- Re-allocating population surfaces using weighted interpolation based on population movement estimates;
- Modeling population as a network, similar to hydrologic modeling with sources and sinks.

2.3.3. A socio-economic study of meningitis epidemics

*Anaïs Colombini, Agence de Médecine Préventive (AMP)*

An overview was provided of a socio-economic study which is being conducted in Burkina Faso and Niger, in partnership with WHO and the Meningitis Vaccine Project (MVP), with objectives to:

- Provide evidence that meningitis causes poverty;
- Contribute to advocacy for resource mobilization;
- Contribute to improve communication on meningitis with population;
- Contribute to decrease meningitis morbidity / mortality.

The study has involved the collection of quantitative data (budgetary, materials, epidemiological) and qualitative data (organizational, anthropological). The study is due to be completed by end of 2007 and results are expected to determine the costing and financing of meningitis health care, meningitis sequelae health care, surveillance and response, and immunization campaigns at the levels of country, partner, community and family.

In response to the presentation, it was suggested that long-term and ongoing costs of sequelae cases for households are included in the study which currently spans one year, to help evaluate the true economic burden of meningitis outbreaks.

2.3.4. Climate of the Meningitis Belt

*Sylwia Trzaska, International Research Institute for Climate and Society (IRI)*

An overview was provided of research conducted at the IRI and University of Niamey, designed to predict the probability of meningitis epidemics, using rainfall, dust data and atmospheric circulation over the Meningitis Belt.

The study analysed atmospheric dust production on seasonal, interannual and multidecadal time scales, with results showing increased dust levels in recent years due to reduced rainfall and changes in vegetation. Dust concentrations vary in time and spatially, and are influenced by Harmattan winds and the West African monsoon. A northward progression of meningitis appears to be linked to highest temperatures in the region of convergence between the Harmattan and southwesterlies. This region shows highest dust concentrations however it is not
necessarily the region of lowest humidity. The end of an epidemic is linked to the arrival of moister, cooler and cleaner air.

The presentation highlighted the difficulties and inherent challenges of forecasting due to differences in scale of data and downscaling from General Circulation Models to predict the probability of meningitis epidemics at the local level. The research indicates that the West African monsoon, which is impacted by sea surface temperatures has a strong influence on rainfall patterns, creating strong precipitation gradients at the sub-regional scale. However at finer scales there appears to be a northward retreat of precipitation over time with complex distribution of rainfall at high resolution. At a regional scale there appears to be strong decadal variability.

Significant uncertainty still remains about longer-term climate change and how it will impact the Sahel. Models that were successful in reproducing the late 20th century drought in Sahel do not agree on future climate projections for this region.

The discussion which followed focused on the need for climate predictions to be produced at a finer scale to be useful for immediate planning of meningitis control. This need is recognized by the research community and some seasonal predictions are already being conducted, however challenges arise from the non-uniform coverage of rainfall stations in Africa and inaccuracies resulting from downscaling to the local level. It was noted that satellite images, water bodies and vegetation at 250m spatial resolution are available free of charge through the internet.

2.4. **Key elements of the disease in the African Meningitis Belt**

2.4.1. **Mechanisms of transmission and disease**

*Brian Greenwood, London School of Hygiene & Tropical Medicine (LSHTM)*

An overview was provided of the transmission pathways of the menigococci bacteria, which can lead to infections in host carriers and which can progress to epidemic outbreaks in susceptible populations. The presentation highlighted the environmental factors that appear to influence specific steps of the transmission - infection pathway.

Factors for consideration include:

- The infectiousness of a carrier depends on the density of carriage, duration of carriage, and respiratory infection.
- There is an association between meningococcal and influenza, coughing and sneezing.
- Meningococcal bacteria are fragile and very sensitive to how they are transmitted. There is a known relationship between bacterial survival and humidity however this has not yet been studied with meningococcal bacteria.
- Immunity in the blood can result from natural exposure, passive protection, immunity passed from mothers to new-borns, vaccination and genetics. As noted earlier, conjugate vaccines are more effective than polysaccharide
vaccines as they induce higher concentrations of antibodies which can prevent acquisition of carriage and induce herd immunity.

- Temperature, dryness, dust, smoking etc impact the integrity of the mucosa in the pharynx and can facilitate the colonization and invasion of the bacteria into the blood stream.

Topics for future research include:

- The impact of environmental factors on meningococcal survival in droplets;
- The impact of environmental factors on mucosal immune defense;
- The influence of the environment on the immune response to vaccination.

2.4.2. Environmental risk indicators of meningococcal meningitis

Madeleine Thomson, International Research Institute for Climate and Society (IRI)

Over the last 10 years there has been increasing interest of the environmental factors which appear to influence outbreaks – as indicated by the Meningitis Forecasting Project for Africa (1998-2002) funded by the Meningitis Research Foundation. Outputs from this project demonstrated that while the distribution of epidemics is dependent on a wide variety of factors including immunological susceptibility, bacterial strain, demographic and socioeconomic factors (substantial population movements particularly around Hajj Pilgrimage, dense populations), and the presence of other infections, environmental factors also appear to play an important role. Environmental factors can influence:

- the spatial distribution of epidemics which can be modelled at the Pan African scale simply from seasonal absolute humidity and landcover;
- expansion of the Meningitis belt; recent analysis of reported epidemics indicated that there appears to be a southward shift in the distribution of epidemics over time, with new areas affected south of the current belt area consistent with changes in the regions climate/environment in many areas e.g. Southern Province in Ethiopia.
- the seasonal pattern of epidemics; this has long been associated with the long dry season of the Sahel when the Harmattan winds blow and the air is dry and dusty and the onset of the season appears to be triggered by climate.

Despite these strong linkages between environmental factors and epidemics the role that climate plays in the year to year variation in occurrence and magnitude of epidemics is still an important area of enquiry. Simple relationships are unlikely given the confounding issues of immunity and strain characteristics.

It was pointed out that models could only be developed on the basis of sound epidemiological data, and appropriate climate and environmental information – where uncertainties in the data are explicitly recognized.

In this light, it is important to consider whether climate is a vulnerability indicator or a driver of epidemics. This question may change the structure of future
research studies. A hypothesis is that changes in environment and climate may make some regions more susceptible.

Opportunities exist for improvements in:
- understanding the aetiology of meningitis disease
- epidemiological data in quality, time and space
- environmental and climate data in quality, time and space
- analytical techniques
- health-climate community partnerships focused on operational outcomes.

Research at partnership levels has changed significantly recently, for example WHO and partners have established a good dataset for Niger, Burkina Faso and Mali. There is also potential to integrate weekly district level case data with population data, for example from CIESEN.

The discussion highlighted the importance of considering the epidemiological factors as well as the environmental factors in the models. Consideration needs to be given to the respective risk factors in specific cases. For example, during the 1995-6 epidemic in Niger a new strain of the bacteria was introduced; there is a need to consider why this strain appeared at this time yet not in other years.

Another research focus would be to look at the rate the atmosphere is drying, not necessarily the humidity levels. With large scale datasets it is now possible to start considering these questions.

Discussions and questions were raised concerning aerosol composition and the potential influences of biomass burning in the area on meningitis outbreaks (although the impact of biomass burning has been much more closely related to pneumonia). Damage to the pharynx is caused by chemical, dust and pollutants, not just Harmattan dust.

It was noted that this could be further investigated as TOMS satellites can now detect the size range of pollution and dust particles. The AMMA project is also looking at dust and biomass burning in the region.

It is suspected that biomass aerosols are mostly generated from cooking which would not lead to a seasonal fluctuation in aerosol concentrations. However biomass burning through agricultural practices during the dry season from November to March is significant and could influence dust loads in local areas.

It was noted that while dust is an interesting issue the substantive evidence to date is that absolute humidity is a key climate variable that should be included in any model, unless superceded by an improved humidity related variable.

2.5. **Research projects, case studies and emerging opportunities**

2.5.1. **Long-term epidemiology of meningococcal meningitis in the African Meningitis Belt: dynamics and impact of vaccinations**

*Helene Broutin, Fogarty International Center, U.S. National Institutes of Health (NIH)*
An overview was provided of a study which will compare Meningitis dynamics over a long time series and at different spatial scales to achieve a better mechanistic understanding of the epidemiology of meningococcal meningitis during recent decades (emergence, diffusion, persistence). The study has been designed to: detect global patterns versus speciality; understand the impacts of vaccination; and provide recommendations for adapted vaccination strategies. The study addresses simple yet crucial questions in terms of prevention and control strategies, including:

- For which population size does the disease persist in time? Consideration will be given to both epidemic and inter-epidemic periods, to establish the link between epidemics.
- Can sources of infection be identified? Consideration will be given to whether the first cases of an epidemic appear to occur constantly in the same locality or district.
- Are there similar routes of transmission of the disease in all countries?
- Does there appear to be synchrony of epidemics between countries? Are there regular waves of cases?
- What are the interactions between the different serotypes? For example: periodicity of epidemics, route of transmission.

This type of study will establish a better understanding of the spatio-temporal epidemiology of the disease and will be useful to develop a simple mathematical model of the meningitis dynamics including epidemiological components (population size, genotype, vaccine status) in addition to environmental parameters.

At a global scale, an inter-country analysis of meningococcal meningitis dynamics in nine African countries has been performed to compare pluri-annual periodicity of the disease and to detect potential global synchronism between countries. Results from this study showed a high diversity of meningococcal meningitis patterns over the 30 years period of time under study and few synchronisms between countries were detected. This first large-scale study highlights the importance of a global survey and intervention to access to a whole picture of the epidemiology of the disease in order to improve control strategies.

At a local scale, a preliminary study based on national meningitis data from Mali is currently under validation.

2.5.2. Epidemiological and population structure studies in *Neisseria meningitides*

*Ana Belen Ibarz Pavon, Oxford University*

An overview was provided of findings of two meningitis studies in the United Kingdom.

The first study, ‘Meningococcal disease in the United Kingdom and the investigation into meningococcal carriage after the introduction of the serogroup C conjugate vaccine (MCC)’ showed that the introduction of the MCC vaccine in the United Kingdom substantially reduced the prevalence of the disease-causing
strains of ST-11 complex among the general population. Key results of the vaccine campaign included:

- The expression of the capsule among ST-11 complex strains was significantly reduced, more so than in any other serogroup C associated clonal complexes.
- No vaccine escape variants were detected nor has there been any indication of their emergence seven years after the vaccination campaign.
- The reduction on carriage of the ST-11 complex strains is consistent with the observation that herd immunity plays a key role in protecting unvaccinated people and young infants, among whom protection from the vaccine wanes rapidly.

The second study, ‘Geographical, temporal and vaccine-induced population structure’ indicated evidence of population structuring between pre and post-vaccine isolates through F-statistical analyses. It also showed that higher levels of gene flow restriction were observed among different schools and postal districts than among different cities around the UK.

2.5.3. Case study: Environmental and epidemiological determinants of epidemic meningitis at the local level in Ethiopia

Luis Cuevas, Liverpool School of Tropical Medicine (LSTM)

Findings were presented from a study conducted in Ethiopia which was designed to develop forecasting methods to predict meningococcal epidemics at the local level and expand the understanding of the dynamics of epidemics.

The environmental factors which were considered in the study included precipitation, aerosol index, NDVI, temperature, absolute humidity and meteorological data. Compared with malaria studies, the study of meningitis epidemics can be difficult due to the relatively poor correlation between environmental factors and meningitis. The study found that the association of district level epidemics with environmental factors was less clear cut than large scale models.

A district can receive a vaccine when smaller regions within it cross an epidemic threshold, so some areas are vaccinated yet have not reported cases. What is not clear is how large the area around an affected district should be vaccinated.

There is a need for further research into the effect of vaccination on neighbouring areas and districts.

2.5.4. Case study: meningitis environmental risks studies in Niger

Isabelle Jeanne, Centre de Recherche Médicale et Sanitaire (CERMES)

An overview was provided of meningitis and environmental risks studies conducted in Niger with the following objectives: 1) To analyse data (epidemiological and environmental, climatic) to determine health and climate links; 2) To analyse the health and climate links to increase knowledge of transmission according to climate variability; 3) To transfer this knowledge into
operations and development of tools (adaptation, monitoring, early warning systems).

The collection of epidemiological and environmental data at the 44 sites in the study has been successful through multidisciplinary collaborations.

2.5.5. **Case study: interaction between dust clouds and meningitis epidemics in the Sahel**

*Hans Wackernagel, Ecole des Mines de Paris*

An overview was provided of a study on the interaction of dust clouds and meningitis epidemics in the Sahel, with a view to the development of early warning systems.

Meningitis due to meningococcus may cause severe epidemics in Africa. In 1996, there were 200,000 cases and 20,000 casualties reported for the whole Sahel zone; in 2007 there were over 20,000 cases reported for Burkina Faso. The privileged hypothesis in the present study is that of a link between dust clouds and the start of an epidemic. The meningitis data in the present study (1992-2003) stems from health centres in different regions of Mali. The dust clouds in the Sahel were identified by processing images from the Meteosat geostationary satellite. The spatial and temporal co-occurrences of meteorological events and meningitis epidemics have been analysed with geostatistical tools taking account of delay effects between the former and the latter.

The present work prepares the ground for Meteosat Second Generation (MSG) studies, which will rely on data with better space-time coverage and with more climatological parameters, such as temperature and humidity, whose sudden variations in pre-Monsoon periods are important factors. Eventually this could yield to the development of derivate products providing forecasts of meningitis in the Sahel, leading ultimately to a better design of vaccination campaigns.

A proposal is for data assimilation including climate drivers to develop meningitis early warning systems. The Geostatistics group at Ecole des Mines has developed, together with INSERM UMR-S 707 (Paris), an epidemics' early detection and assessment prototype system based on the weekly data collected by the French Sentinelles network (www.sentiweb.org). The system performs sequential data assimilation using particle filtering and uses a stochastic SIR (Susceptible-Infected-Removed) model to integrate regional epidemiological information.

Given that WHO is now systematically collecting meningitis case data for several countries in the sub-Saharan region, the system could be adapted to this context and be extended to include climate drivers of meningitis epidemics.

2.5.6. **Preliminary results from meningitis surveillance data modeling in Niger**

*Ariel Beresniak, World Health Organization (WHO)*

WHO has commissioned an advanced statistical modeling project to be conducted on meningitis surveillance data collected in Niger, to assess whether meaningful information can be extracted to better inform epidemic response strategies.
Niger was selected for the project as it is one of the Sub-Saharan countries suffering from meningitis epidemics with an established network for collection and reporting of meningitis data for epidemiological purposes. Suspected meningitis cases and meningitis mortality have been routinely reported to Health Districts on a weekly basis for 20 years. These data provide a unique historical record for the analysis of epidemic meningitis. However, this specific information network is unable to predict outbreaks, and epidemic response has always been initiated on a reactive basis. The key question being addressed by this project is to ascertain whether the surveillance database could be modeled in such a way as to extract meaningful information for epidemic response strategy.

A systematic advanced statistical analysis has been carried out by firstly describing the data. Reported case and death data have been cumulated week by week in order to study the distribution parameters over the year (average, variance, max, skewness and kurtosis); principal components analyses have then been performed.

Secondly, the district data have been analyzed using three clustering techniques: centroids methods; non hierarchical descending method; and ascending hierarchical method.

Finally, the data has been explained using a Bayesian network constructed to study potential links between each districts.

The initial results suggest some district similarities and non similarities according to meningitis reported cases and mortality data.

After having confirmed the existence of data structure, a Bayesian network was designed to explain the data. This original approach applied to the meningitis database has identified the districts which influence the others, with detailed conditional probabilities. That means that if a district ‘A’ is in epidemic alert, the model calculates the probabilities that other districts ‘B’, ‘C’, ‘D’, etc would also be in epidemic alert.

This systematic approach has enabled the testing of a pilot methodological approach, a customized Bayesian network, with the objective of applying meaningful public health information. The Bayesian network is a relevant approach to analyze meningitis surveillance data in Africa as it allows interactions between districts to be calculated, which could contribute to prepare an adequate response.

Mapping presentations are necessary to better understand and interpret the results. The same approach applied to a regional level would allow it to be validated and the development of a coherent epidemic response could be assessed.

The project’s next steps will be to extend the pilot model to other contiguous countries, perform regional analyses, improve model accuracy in to include other parameters (climate, strains, socio-economical parameters, etc), and detect potential epidemic intensity cycles over time.
2.5.7. **Case study: spatio-temporal patterns of meningococcal meningitis in Burkina Faso, Mali and Niger and relationships to climate**

*Sylwia Trzaska, International Research Institute for Climate and Society (IRI)*

The purpose of the meningitis-climate study in Burkina Faso, Mali and Niger was to identify which environmental factors can be used as predictors of meningitis outbreaks in order to develop an early warning system based on forecast and monitoring products of the environmental factors.

The conclusions have been categorized into three parts: 1) seasonal cycle; 2) interannual variability; and 3) climatic signal and prediction potential in Niger.

Firstly, the results for a seasonal cycle on the district scale suggest that epidemics are linked to surface atmospheric conditions. Key findings are that:

i. The epidemic season coincides with highest maximum temperature and dust in the low level wind convergence;

ii. Epidemics progress northward with the seasonal cycle;

iii. The epidemic season terminates when high humidity/low dust air mass reach the region.

These seasonal cycle results are consistent with previous studies. A focus of future studies will be to establish thresholds.

While there is insufficient length of data (nine years) for achieving robust results of interannual variability, the study showed that this can be approached from analyzing annual (or peak) cumulative incidence values for each district.

In Niger, the climatic signal offers potential for prediction of epidemics. Climatic anomalies in Equatorial and South Atlantic provide predictive value for epidemic and non-epidemic years. The reversed anomalies between North Tropical Atlantic and Central Sahel provide predictive value for dipolar years.

Further predictability studies have been planned. An interest in investigating what type of aerosols are on the ground was also noted.

2.5.8. **The influence of climatic factors on the incidence of Meningococcal and Pneumococcal Meningitis in Northern Ghana**

*Penelope Vounatsu, on behalf of the Navrongo Health Research Centre, Ghana and the Swiss Tropical Institute.*

An overview was provided of a meningitis-climate study in the Kassena-Nankana District in northern Ghana, which has experienced epidemics every 8 to 12 years for the last 100 years. The study was conducted between February 1998 and November 2005 to investigate how levels of colonization with different bacterial serogroups change over time and how the pattern of disease relates to such changes.

The climate study component was designed to identify environmental factors that can be used to predict the timing of both meningococcal and pneumococcal outbreaks – using epidemiological and meteorological data (weekly means of relative humidity, maximum and minimum temperatures, wind speeds and total
rainfall provided by the Navrongo meteo station). Statistical analyses included negative binomial models, Akaike’s criterion and Bayesian methods.

The results indicated that: outbreaks of pneumococcal meningitis started earlier than meningococcal meningitis; concurrent weekly increases in maximum temperature and decreases in total rainfall appear to influence the incidence of meningococcal meningitis; concurrent weekly decrease in total rainfall appears to influence the incidence of pneumococcal meningitis; and the duration of preceding absence of rainfall appears to be the best predictor of meningococcal and pneumococcal meningitis incidence.

2.5.9. **Connection of climate information to epidemic early warning with experiences from the AMMA and ENSEMBLES projects**

Andy Morse, University of Liverpool

There are two major EU integrated projects that have a role in the work required to move towards epidemic early warning.

Firstly, the ENSEMBLES project is developing ensemble prediction systems from seasons to centuries. For the purposes of understanding meningitis environmental risks, the work on seasonal to decadal scale is most important. Here there are health applications in development for epidemic diseases in Africa driven by seasonal forecasts with six month lead times.

Secondly, AMMA is an integrated West African monsoon experiment integrating climate science work on rainfall variability in the region with empirical observations of epidemic diseases. There is also a strong interest in health impacts work within the THORPEX, particularly the THORPEX-Africa plans.

There are many challenges associated with integrated climate and disease studies in Africa due to a lack of meteorological observations at about eight times less than WMO guidelines. At the same time however there is a strong focus on Africa and climate impacts within the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report. Additionally, there is also a lack of long-term, high quality clinically confirmed disease datasets, with accessibility challenges for the wider research community for datasets that do exist.

There are a number of technical and structural issues that need to be addressed to progress the integration of epidemic diseases models with long-range and medium-range forecasting systems. These include: 1) climate model post processing, including bias correction; 2) weighting methods and downscaling; 3) operational forecast models which often lack an adequate climate dataset that is essential for impacts work; 4) training and interaction with the biomedical community to encourage the production of predictive models; 5) complexities of epidemic disease and consideration of climate drivers as well as socioeconomic and biomedical controls (further research is required and these factors must be taken into account when issuing impacts forecasts); 6) improvements in integration of Earth observation products for the inclusion of environmental factors; 7) adequate funding opportunities to allow cross cutting and interdisciplinary approaches for integrating disease models within forecasting
system; 8) capacity building and training to develop the users of such integrated forecasting systems; and 9) systems need to be built to enable use of a variety of forecast and earth observation data sets.

2.5.10. Predicting Meningitis epidemics in West Africa by using climate dynamics

*Pascal Yaka, CNRS UMR PRODIG- Université Paris1 Sorbonne*

Although the seasonal and spatial patterns of meningitis cases which occur mostly during winter in the ‘Meningitis Belt’ are closely linked with climate variability, the mechanisms responsible for these observed patterns are still not well identified. This is particularly true for the linkage between epidemic intensity from year to year and climate variability.

A spatio-temporal analysis of annual cases of meningococcal meningitis reported from 1939 to 1999 in African countries provided by WHO and several climatic variables from NCEP/NCAR reanalyses has been performed to highlight the relationships between climate and meningococcal meningitis disease at the interannual scale. First, correlation maps were computed of atmospheric variables likely to influence meningococcal meningitis disease outbreaks (e.g. moisture, wind, pressure, temperature) and annual cases of meningococcal meningitis in afflicted countries, e.g. Burkina Faso and Niger. The results of these correlations then enabled the selection of relevant climatic variables to construct generalized linear models to forecast meningococcal meningitis intensity from year to year.

*In situ* data from national meteorological offices and NDVI data were also used to forecast meningococcal meningitis seasonal intensity at the health district level.

Meningococcal meningitis spatiotemporal dynamic analyses conducted at the health district level showed that socio-economic and population factors are prevalent in meningococcal meningitis transmission. This indicates that climate and environmental factors are not the only relevant element in meningococcal meningitis epidemics evolution.

The encouraging results of such simple models and different analysis enable the development of a survey and an early warning integrate system of meningococcal meningitis epidemics in African Sahelian countries.

2.5.11. An historical and scientific overview from AMMA to the MOUSSON Interdisciplinary programme

*Nicole Fourquet, CNRS - Université Paris7*

The MOUSSON Programme was created in October 2006 to build up a stronger collaboration between AMMA (CNRS) and social and human sciences, to increase the participation of those involved in the geographic and thematic grounds and to promote an interdisciplinary approach to studying the interactions between man and nature in relation with the seasons.

The MOUSSON Programme sets in place an interdisciplinary change in producing scientific approach of man-environment studies, applied to the Sahel. The first pilot project of MOUSSON was developed in response to a request from
the Met Services Burkina Faso to study whether it would be possible to build an early warning system for air pollution in the city.

As part of the project, a website (http://www.mousson.csregistry.org) was developed to provide information from specialists and from the citizens. A model of the programme was also established, which will be operational in 2008.

2.5.12. WMO Sand and Dust Storm Warning System

*Slobodan Nickovic, World Meteorological Organization (WMO)*

An overview was provided of the WMO Sand and Dust Storm Warning System (WMO SDSWS) which enhances the ability of participating countries to establish and improve systems for forecasting and warning to suppress the impact of sand and dust storms.

Sand and dust storm processes occur on a global scale, with numerous impacts on health, climate and the economy, with a possible link of meningitis and dusty weather.

To date, 48 re-analyses of dust and weather simulations have been made by the WMO Regional Centre for Sand and Dust Storms in Spain which presents an opportunity to perform correlation studies. The SDSWS is establishing a coordinated global network of forecasting centers delivering products useful to a wide range of users in understanding and reducing the impacts of sand and dust storms.

2.5.13. Present and future capabilities of the Sand and Dust Warning System for North Africa to provide knowledge on environmental risk indicators of meningitis epidemics

*Carlos Pérez, Barcelona Supercomputing Center*

It is thought that large dust plumes from the southern Sahara and the Bodele depression might be linked to meningitis outbreaks in the Meningitis Belt. Previous studies have analyzed the relationship between meningitis and environmental parameters obtained by satellite-based sensors and ground meteorological stations. Some satellite derived products (i.e. the atmospheric dust) provide good information of the integrated atmospheric column but do not give an accurate picture of the atmospheric conditions at surface level where meningitis outbreaks take place. On the other hand the spatial coverage of ground meteorological stations and sun-photometers is very poor in the Sahel region and their spatial representativeness is quite limited.

The combined information of satellite and meteorological/dust models could improve the studies conducted to investigate the link between meningitis and environmental factors over the Sahara and Sahel regions. The Sand and Dust Storm Warning System provides short term dust forecasts in the Sahel area. Refined calculations of dust allow a meaningful re-analysis of the correlation between meningitis and dust. Currently 50 years of dust model data are available for research.

Another important consideration is how long-term climate variations influence meningitis outbreaks. It appears that meningitis is influenced by certain
environmental parameters (dust, humidity, temperature) which are seasonally and interannually driven by fluctuating large scale climate patterns that could model the year-to-year meningitis epidemics variability. If these patterns are well understood and these findings are confirmed over a longer time period, they could constitute a very useful tool that will allow the health community to be prepared for meningitis epidemics in more efficient ways.

The interaction between dust/atmospheric modelers and the health community is crucial to understand the influence of atmospheric parameters on meningitis epidemics.

The following discussion raised a number of issues, including: the need to know the composition of the dust to determine whether specific linkages with meningitis incidence exist; the need for surface data, dust concentration, real time and continuous data in the Sahel; main limitations of dust models now are related to vegetation changes in the Sahel.

2.5.14. Environmental data and surveillance

Pietro Ceccato, International Research Institute for Climate and Society (IRI)

A number of the major human infectious diseases such as malaria, dengue, rift valley fever and Desert Locust that still plague the developing world are sensitive to inter-seasonal and inter-decadal changes in environment and climate. Monitoring variations in environmental conditions such as rainfall and vegetation helps decision-makers at Ministries of Agriculture and Ministries of Health to assess the risk levels of Desert Locust outbreaks or malaria epidemics. The IRI develops products based on climate forecast and remotely sensed data to monitor those changes and provide the information directly to the decision-makers.

The presentation outlined the experiences of the IRI in developing climate forecast and remote sensing products to monitor climate variability and its impacts on the dynamics of infectious diseases (malaria, rift valley), Desert Locust outbreaks in Sub-Saharan Africa.

It also illustrated how the IRI develops key research to provide i) evidence of the impact of climate variability on specific outcomes (human health) and ii) evidence that the information can be practically useful within decision frameworks.

2.5.15. Tools and information management, opportunities for integrating environmental-health data

Jason Pickering, World Health Organization (WHO)

OpenHealth is a public health decision-support system being developed by WHO that will make it possible to combine data from currently disconnected sources, sectors and geographical areas to enter, detect, monitor and analyze health events effective. A ‘systems of systems’ approach is being developed to enable communication between the various data management systems of organizations and countries and to encourage interoperability between health and environmental systems.
Potentially one of the central components in the development of a meningitis early warning system, OpenHealth enables real-time disease tracking and monitoring; analyses and integration of epidemiological, clinical, demographic and environmental data; and the routine production of risk maps. The factors responsible for meningitis risk can be calculated within modules embedded within OpenHealth using its own internal data archive and data acquisition portal.

Once it is implemented, OpenHealth will enable medical personnel, district medical officers, national health information managers, and WHO disease surveillance teams to have access to information on the various risk factors that influence the transmission of meningitis. This leads to significant potential for rapid response outcomes, prevention strategies and early warning systems to be developed.

2.5.16. An introduction to the MERIT project

David Rogers, Health and Climate Foundation

The Meningitis Environmental Risk Information Technologies (MERIT) project concept has recently developed as a means to provide effective and ongoing coordination of collaborative efforts between the various groups and communities engaged in meningitis-environment activities, to help strengthen meningitis control strategies.

The aims of the MERIT Project (see MERIT leaflet, Annex C) include:

- To improve the application of climate and environmental information to meet the needs of public health policy-makers in Africa;
- To enhance regional and national surveillance capabilities;
- To strengthen decision-making and public health policy development through institutional capacity building efforts.

The MERIT project will provide a common platform to seek funding support and achieve outcomes as identified in this meeting and ongoing, through efforts to increase the use of environmental information to support the distribution of the conjugate A vaccine over the next decade. Potential funding sources for the MERIT Project are still to be explored with several opportunities already identified.
3. Outcomes and Next Steps

The working group sessions on Day 2 identified specific needs and actions which will be the focus of ongoing activities following the meeting. Notes from these sessions can be downloaded at:

3.1. Needs

**Institutional** needs which have been identified include:

3.1.1. Partnerships which will assist efforts to reduce and possibly eliminate the burden of meningitis epidemics as a public health problem in Africa, through the integration of identified risk factors (environmental, epidemiological, biological, social, economic, demographic etc) into control strategies.

3.1.2. Stronger operational links between African institutions responsible for meningitis surveillance and interventions and other relevant disciplines such as climate, and reinforcement of their operational capacities.

3.1.3. Greater investment in public health surveillance and data collection in the Meningitis Belt region.

**Research** needs which have been identified include:

3.1.4. A document which will provide a framework for integrating environmental, social, economic and health information and identifying research needs through a ‘test bed’ structure. The ‘framework document’ will be reviewed on an ongoing basis to ensure its relevance to meningitis control strategies as they evolve. It will build on current research gaps and recommended future research projects identified during the meeting, including:

i. An in-depth study of the composition of dust and impacts on meningitis transmission, with consideration given to how to incorporate the broader field of information on climate and meningitis and respiratory disease.

ii. Investigation of the relationship between absolute humidity and meningitis transmission.

iii. Investigation of the impact of environmental factors on:
   - Meningococcal survival in droplets
   - Mucosal immune defense
   - Immune response to vaccination.

iv. Investigation of the nature of epidemics in new areas, such as the Great Lakes region.

v. Consideration of whether climate is a ‘vulnerability indicator’ or a ‘driver’ of epidemics.

vi. Investigation on the role of socio-economic-demographic factors on epidemics.

vii. Integration of the costs of long-term sequelae cases into economic studies of meningitis epidemics.
viii. Analysis of the effect of vaccination campaigns on neighbouring areas by distance.

*Operational* needs which have been identified include:

3.1.5. Development of a simple mathematical model, including the main determinants of epidemics, updatable at country level and allowing public health practitioners at the country level to:

   i. Be more proactive in control strategies such as developing an early warning system;

   ii. Define populations at highest risk for improving the introduction of the new conjugate vaccine.

3.1.6. Alignment of health information systems and environmental information systems through tools such as the WHO Open Health system and the IRI Data Library to enhance the user benefit of advancing scientific knowledge of environmental influences on meningitis epidemics.

3.1.7. Development of a coordinating body, such as the MERIT Project model, to support and progress collaborative efforts required to integrate the environmental, social, economic and health information in response to the needs identified by the public health community.

3.2. **Actions**

The identified actions to be implemented include:

3.2.1. Develop the MERIT Project concept and formation of a consultative group to ensure progress of the meeting outcomes and actions.

3.2.2. Produce a framework document to provide a comprehensive review of existing research and identify future research requirements and operations.

3.2.3. Build the capacity of the meningitis community through the development of training materials and workshops to understand and use climate/environmental and socio-demographic data in support of the analysis of meningitis surveillance data.

3.2.4. Progress in-depth capacity building discussions to determine the requirements and needs in both directions along the value chain from the ‘user’ to the ‘provider’ communities.

3.2.5. Encourage, sustain and support ongoing actions to improve and strengthen African Regional Centers (such as MDSC, ACMAD, and others) to produce, deliver and utilize relevant information, under the framework of the MERIT project.

3.2.6. Organize a follow-up meeting within the next six months in Africa.
4. Conclusion

The Meningitis Environmental Risk Consultative Meeting highlighted a number of opportunities to improve current reactive control strategies for meningitis outbreaks as well as design future preventive strategies in line with the deployment of the new generation vaccine.

While the public health community already applies elements of predictive modeling based on epidemic thresholds in determining vaccination strategies, the meeting clarified the specific needs for establishing a more in-depth and comprehensive understanding of the environmental, economic and social risk factors which are considered to influence meningitis epidemics.

In particular, the public health community is seeking direction from the scientific research communities to help determine which factors are the most important for inclusion in the development of simple mathematical and statistical models, risk maps and early warning systems. This information will enable decision-makers to determine which risk factors need to be considered during the emergence of an outbreak, and which risk factors offer the most predictive value for enhancing preventive strategies. The desired outcome of the integration of health needs with environmental-social-economic information is the development of a set of tools for the health community to implement alongside current systems for meningitis control, which will be monitored and evaluated over time.

In response to the requirements of the health community, a systematic review of the current knowledge and existing scientific research has been initiated. This comprehensive review will form the body of a framework document, identifying research gaps and shaping the transition from research to operations.

Furthermore, a collaborative framework is being established to enable effective coordination and interaction of all stakeholders to achieve the actions and next steps identified in this report. The MERIT Project concept as introduced at the meeting can be considered analogous to the formalization of a Community of Practice surrounding issues of epidemic meningitis outbreaks in Africa. The MERIT Project will focus on progressing outcomes of this meeting, facilitating communication and joint activities between participating groups and communities, and securing ongoing financial support to build capacity within areas of greatest need along the value chain.
### Day 1 Agenda

**09h00**
- **Welcome from Group on Earth Observations (GEO)**
  - José ACHACHE, GEO Secretariat Director
- **Introduction by the World Health Organization (WHO)**
  - David HEYMANN, WHO Assistant Director-General Communicable Diseases
- **WMO activities in support of health**
  - Omar BADDOUR, WMO Chief World Climate Data and Monitoring Programme Division
- **Meningitis overview - where we are today, surveillance overview, response strategies, expectations of WHO**
  - Eric BERTHERAT, WHO
- **Expected outcomes of the meeting**
  - David ROGERS, Health and Climate Foundation (HCF)

**10h30-11h00**
**Coffee Break**

**11h00**
**Presentations - Presenting the current and future landscape**
- **Introduction of conjugate vaccine - how will this change the picture of meningitis in Africa?**
  - Marc LAFORCE, Meningitis Vaccine Project (MVP) PATH
- **Statistics, linkages between infectious disease and environment**
  - Peter DIGGLE, University of Lancaster
- **Estimating populations at risk**
  - Greg YETMAN, Center for International Earth Science Information Network (CIESIN)
- **Socio-Economic study of meningitis epidemics**
  - Anais COLOMBINI, Agence de Médecine Préventive (AMP)
- **Climate of the Meningitis Belt**
  - Sylwia TRZASKA, International Research Institute for Climate and Society (IRI)

**12h30-14h00**
**Lunch**

**14h00**
**Discussion - Key elements of the disease in the African Meningitis Belt**
- **Mechanisms of transmission and disease**
  - Brian GREENWOOD, London School of Hygiene & Tropical Medicine (LSHTM)
- **Environmental risk indicators of meningococcal meningitis**
  - Madeleine THOMSON, International Research Institute for Climate and Society (IRI)

**14h50**
**Presentations (approx. 10 minutes each)**
- **Focused presentations on available data, ongoing research projects, case studies and emerging opportunities**
- **Long-term epidemiology of MM in the African Meningitis Belt: dynamics and impact of vaccinations,**
  - Helene BROUTIN, Fogarty International Center, NIH
- **Epidemiological and population structure studies in Neisseria meningitides**
  - Ana Belen Ibarz Pavon, Oxford University
- **Ethiopia Case Study**
  - Luis CUEVAS, Liverpool School of Tropical Medicine (LSTM)

**Questions**
<table>
<thead>
<tr>
<th>Time</th>
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<tr>
<td>15h30-16h00</td>
<td>COFFEE BREAK</td>
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<tr>
<td>16h00-18h20</td>
<td>PRESENTATIONS (approx. 10 minutes each)</td>
<td>Focused presentations on available data, ongoing research projects, case studies and emerging opportunities</td>
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<td>Niger Case Study</td>
<td>Isabelle JEANNE, Centre de Recherche Médicale et Sanitaire (CERMES)</td>
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<td>Modeling</td>
<td>Hans WACKERNAGEL, Ecole de Mines</td>
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<td>Niger 1985-2005: exploratory analysis of routine surveillance data</td>
<td>Ariel BERESNIAK, WHO</td>
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<td>West Africa climate and meningitis</td>
<td>Sylwia TRZAKSA, IRI</td>
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<td>Penelope VOUNATSU, Swiss Tropical Institute</td>
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<td>Connecting climate information to epidemic early warning – experiences from the AMMA and ENSEMBLES project</td>
<td>Andy MORSE, University of Liverpool</td>
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<td>MOUSSON Project</td>
<td>Nicole FOURQUET, CNRS- Université Paris7</td>
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<td>Climate and meningitis in West Africa</td>
<td>Pascal YAKA, CNRS UMR PRODIG- Université Paris1 Sorbonne</td>
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<td>Session Chair: David ROGERS, Health and Climate Foundation</td>
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<td>Session 2 outcomes:</td>
<td>A) Understanding of available data, current research projects, tools and information management opportunities</td>
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<td>18h20-18h30</td>
<td>Discuss agenda for Day 2, explain breakout activities, specific questions to be addressed</td>
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<td>18h30</td>
<td>RECEPTION – Meningitis Vaccine Project &amp; Serum Institute of India Limited</td>
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## DAY 2 AGENDA

### Session 3

#### 09h00-10h30 PRESENTATIONS

- **WMO Sand and Dust Warning System**
  - Slobodan NICKOVIC, WMO
  - Present and future capabilities of the Sand and Dust Warning System for North Africa to provide knowledge on environmental risk indicators of meningitis epidemics
  - Carlos PEREZ, Barcelona Supercomputing Center
  - Environmental data and surveillance
  - Pietro CECCATO, IRI
  - Tools and information management, opportunities for integrating environmental-health data
  - Jason PICKERING, WHO

*Questions (20 mins)*

 **Session Chair:** Eric BERTHERAT

#### 10h30-11h00 COFFEE BREAK

**Session Chair:** Eric BERTHERAT

#### 11h00-12h30 BREAK OUT SESSION I

Small groups of about 10 people, to address specific questions addressing:

- Prediction and forecasting opportunities to improve current intervention tools
- Identifying high-risk areas for conjugate vaccine deployment
- Impact of climate change / environmental change on extent of the Meningitis Belt

**Examples of questions:**

- Impact of climate change / environment on public health meningitis, is new research needed?
- How disease strategy could benefit from environmental forecasting
- Modelling - interaction of factors
- Define common platform for ongoing collaboration between research and user communities.

#### 12h30-14h00 LUNCH

#### 14h00-15h30 BREAK OUT SESSION II - Continuation of morning session

#### 15h30-16h00 COFFEE BREAK

#### 16h00-17h00 PLENARY SESSION

Break out groups reporting back to whole group.

Set of recommendations from each group.

**Session Chairs:** William PEREA, Madeleine THOMSON

**Session 4 outcomes:**

A) Determine specific areas of focus and ideas for moving forward

B) Explore health-epidemiological-environmental collaboration

C) Framework for sustainable and effective engagement between health-environmental communities

#### 17h00-17h30 PLENARY SESSION

Introduction of MERIT concept, David ROGERS, HCF

Resource and funding - needs and allocations.

Aims and objectives.

#### 17h30-18h00 WRAP UP SESSION

**Session Chairs:** William PEREA, Madeleine THOMSON

**Session 4 outcomes:**

A) Determine specific areas of focus and ideas for moving forward

B) Explore health-epidemiological-environmental collaboration

C) Framework for sustainable and effective engagement between health-environmental communities

#### 18h00 CLOSE OF DAY
## Annex B: List of Participants

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<thead>
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Annex C: MERIT Leaflet
Consultative Group on

Meningitis Environmental Risk Information Technologies

The MERIT Project

The Meningitis Environmental Risk Information Technologies (MERIT) Project, currently in the early stages of development, has evolved through the collaborative efforts of the World Health Organization (WHO) and members of the environmental, public health and epidemiological communities.

The project aims to extend current capabilities to more effectively combine environmental information with knowledge of epidemic meningococcal meningitis.

It is expected that this will have an immediate impact on public health outcomes in Africa through increasing the effectiveness of meningitis prevention and response control strategies.

Understanding meningitis epidemics

The bacteria which cause meningitis epidemics are transmitted from person-to-person through droplets of respiratory or throat secretions, often through coughing or sneezing. However, damage of the bacteria in the nose and throat is common and often benign. Only when the bacteria invades the blood stream does it become pathogenic.

Surveillance systems for epidemic meningitis in Africa have greatly improved since 1999. In 13 countries located in the "Meningitis Belt", epidemiological and laboratory data are now collected on a weekly basis at the district level. This data is then compiled and analysed at the regional level by the WHO Multi-Disease Surveillance Center (MDSC) in Ouagadougou.

Increasing our understanding of what drives these epidemics is important (see box over page). A high priority now is to combine existing knowledge with new information requirements identified by the health community to enhance current prevention and control activities.

Developing a solution

Created in 2001, the Meningitis Vaccine Project (MVP) www.meningovacs.org aims to use the new conjugate vaccine to eliminate epidemic meningitis as a public health problem in Sub-Saharan Africa.

In 2008, a ten-year vaccination programme will begin in the "Meningitis Belt" to protect the 350 million plus people at risk from epidemics. In the first phase, priority will be given to children and young adults in hyper-endemic areas; in subsequent years the vaccine will be provided through the routine childhood immunization programme (EPI). With around 50-50 million doses of the new vaccine produced each year, decisions on prioritization will continue over the next decade.

Successful identification of populations most-at-risk in general (based on historical experience) or on a year-to-year basis (based on changes in epidemic risk forecast indicators) is of vital importance if prevention and control efforts are to be targeted to maximize benefit.
Epidemic Drivers & Environmental Risk Indicators

Meningitis epidemics can be influenced by the arrival of new strains of the bacteria, carriage rates, immune status, social behaviour, population movements, living conditions, current health, and the climate – notably hot, dry, and dusty conditions which increase the throat and appear to make invasion easier. The environmental risk indicators appear to influence the spatial and seasonal distribution of epidemic outbreaks. While climate variability on a year-to-year basis may also impact the timing and occurrence of epidemics.

Taken together, all these factors can be used to predict the location of elevated levels of risk of epidemics.

MERIT Project Aims

- Improve the application of climate & environmental information to meet the needs of public health policy makers in Africa
- Enhance regional and national surveillance capabilities
- Strengthen decision-making and public health policy development through institutional capacity building efforts

What is needed now?

Through the MERIT project, opportunities exist to integrate valuable information into meningitis prevention and control activities through the development of:

- Risk maps of the current situation and future scenarios, based on projected changes in climatic and environmental factors;
- Early warning systems; and
- Improved impact assessment methodologies for prevention efforts.

For example, combining routine epidemic surveillance data including information on previous epidemic history and control measures, with information on historical or current climatic and environmental conditions may improve the targeting of preventative and reactive vaccination efforts.

Existing resources could be dramatically improved through collaboration between national, regional and international institutions to refine research efforts, increase access to data and influence the development and enhancement of health-environment networks.

Expected MERIT Project Outcomes

- Improved deployment of vaccines to populations at-risk by combining health and environmental information in “early warning systems”;
- Improved evaluation of the efficacy of the new vaccine used to control epidemics;
- Increased numbers of public health policy-makers capable of effectively using climate, environmental and other data in decision making;
- Increased number of multidisciplinary teams capable of delivering demand-driven operational research outputs for meningitis prevention and control.

For further insight into the meningitis situation in Africa today, download the ‘Kill or Cure? Meningitis’ documentary at [www.meningcure.org/files/video_meningitis_killer_or_cure.htm](http://www.meningcure.org/files/video_meningitis_killer_or_cure.htm)

For further information on the MERIT project, please contact Dr. Eric Bertherat, WHO HQ at bertherat@who.int