

**Press report**

**AMMA**

**African Monsoon  
Multidisciplinary Analyses**

**RESULTS AND PROSPECTS**



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## Summary news release

**The Second International AMMA Conference will be held in Karlsruhe from 26 to 30 November 2007. More than 300 scientists are expected to attend. Five days of scientific sessions will provide the opportunity to assess the first intensive observation campaign of 2006. A review will be made of the advances of knowledge on the mechanisms behind the monsoon, the links between this region's climate and the global climate, and of applications of such research for development and the questions it generates.**

### **The results of AMMA**

The key results of the programme give an opportunity to put the spotlight on the large-scale research work of AMMA and its implications for the problems climate change raises in West Africa. The interactions of a hitherto little-studied region with the global climate will be used to refine the climate scenarios at the global scale but also to elaborate precautionary measure and prepare for the consequences of climate change. Africa is a "hot spot" of climate change, owing particularly to its vulnerability. Cutting down the uncertainty of modelling systems would help improve climate prediction for these regions with a view to devising appropriate adaptation strategies.

- Eastern Atlantic Ocean plays an important role for the onset and intensity of the West African Monsoon.
- In west Africa, smoke from biomass burning and wind-blown mineral dust reflect and absorb sunlight and also exert their own distinct type of greenhouse effect.
- New observations illustrate how the wetness of the soil can affect the development of storms
- Remote atmospheric connections in the Tropics and between the different monsoon systems have significant impacts on the rainfall regimes in these vulnerable areas.
- For the first time detailed measurements were performed in close vicinity of large mesoscale storm systems to investigate their impact on transport and chemistry of ozone
- Water vapour and ice crystals measurements over thunderstorms suggest hydration of the stratosphere by fast overshooting of tropospheric air over land regions
- Land productivity and vulnerability in a changing climate
- By strengthening the research community in West Africa and developing regional collaboration, AMMA helps policy makers to develop and implement adaptation strategies in order to meet the needs of West African nations to cope with climate change and variability.
- Instrumentation and renovation of radio-sounding network
- Devastating epidemics are common place in the region. Approaches are in development which combine climate and remotely sensed information along with an in depth knowledge of the diseases and the socio-economic controls to devise systems that will be able to predict regions at risk to such events in the future. This work involved an integrative multidisciplinary approach and is starting to show interesting results for Rift Valley Fever, meningitis and malaria in the region.

## **From regional variability to global climate change**

Climate modelling is used as a tool for forecasting changes in the climate and its importance is due to utilization of these predictions in political decision-making. In the latest IPCC (Intergovernmental Panel on Climate Change) report, the working group emphasized that "Africa, because of low adaptive capacity and projected climate change impacts" faces an important risk with the changing climate<sup>1</sup>. As this region is currently the one which yields the most contradictory results in 50-year climate projections, no reliable scenarios are available to plan adaptation strategies. The first results of AMMA's special observing period provide information for refining these models by allowing more accurate representation of the dynamic structure of the monsoon and thus for determining its variability with greater precision. The ensuing models will incorporate these new data in order to reduce the uncertainty in global climate prediction for 50-year periods.

## **Program prospects**

Now the scientific community of AMMA, with strength gained from the dynamism generated at international level, is planning to continue the research programmes beyond 2010. In order to do that, the observation network for weather and climate monitoring updated by AMMA should be kept operational to allow continual exploitation and utilization of the AMMA databases.

The improvement of models will be progressive and subject to a time-lag in relation to the campaigns of intensive observation: the data have to be analysed, conclusions have to be drawn before models can be improved, with permanent feedback between these models and the observations require for continual progress to occur. Imperatively, it must not be forgotten that the models serve not only to predict climate 10 or 30 years ahead, but also at seasonal scale or even for 10-day weather forecasting, periods of time that are critical for agriculture and hence for food resources.

To follow up, it is essential to continue to work on the transfer of knowledge, tools and skills, and on what will be acquired from the AMMA project. The benefits from using climate and meteorological predictions are to be found where human vulnerability, climate and weather predictability and decision-making capacity meet. The information on the forecast must correspond to a real perceived need in order to allow viable decisions to be made. This is why AMMA must now take up a new challenge, that of integrating the question of maintaining a scientific community focused on West Africa and around the issues concerning the monsoon and its impacts. Future plans therefore envisage the effective use of AMMA data around the linking themes Societies-Environment-Climate, maintenance of a strong mobilization of the international community geared to these subjects and a long-term strategy for the observation system. The studies on impacts and applications, such as weather forecasting, climate prediction and early-warning systems in relation to health, agricultural and water resources, must continue to develop. Prediction must therefore be done at the appropriate scales and in sufficient time to be able to guide decisions. To do this, it is crucial to continue to build up the capacity of the African scientific community. For effective communication of the forecasting information, dissemination must be taken on by the local research institutions. Also, the African scientific community must become the prime partner of African decision-makers, politicians and agency officers.

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<sup>1</sup> IPCC summary for policy makers of the AR4 synthesis report (November 2007)

## Origin of AMMA

**The AMMA programme (African Monsoon Multidisciplinary Analyses)**, launched in 2001 by French researchers, now involves over 140 European, African and American laboratories. AMMA is an international multidisciplinary programme which was initiated to gain better understanding of the reasons behind disturbances to the African monsoon. Improved knowledge of the mechanisms of the African monsoon should help devise better systems for predicting its variations and consequences on the climate at local, regional and global scales and also its impact on the people, on their health, agricultural resources and water resources. The ultimate objective is to improve climate and meteorological prediction models, and thereby enhance forecasting systems for daily to interannual scales.

The African monsoon is a vital source of rain in the Sahel regions. The average annual rainfall in Niamey is the same as for Brussels but the whole amount of this water falls in just 3 months. Farming is therefore only possible around this rainy season. The monsoon also plays a significant role at the global scale. West Africa is one of the principal sources of heat at continental scale. In this capacity that region influences the atmospheric circulation of the entire Earth. The region is also a significant source of aerosol particles which, transported over long distances, exert impacts on global climate changes. For 30 years now, West Africa has been hit by drought of an intensity and duration unprecedented in the 20<sup>th</sup> Century. The origin of this major crisis is related to the remote Pacific ocean variability and to global warming

2006 was a year of intensive observations (Special Observing Period). The monsoon is a system controlled by the coupling between ocean, atmosphere and continent. Hence powerful methods were deployed for the first time to analyse the interactions between these three spheres. More than 800 persons, researchers and technicians, worked in the field to conduct the observations, six research aircraft made over 500 flight hours, three types of instrument-equipped balloon were launched and three research ships performed campaigns in the Gulf of Guinea and the tropical Atlantic.

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# Theme 1

## Mechanisms of the African monsoon: new insights from AMMA

### I- Ocean and interactions with the West African Monsoon

*Eastern Atlantic Ocean plays an important role for the onset and intensity of the West African Monsoon.*

The Gulf of Guinea is the region of the tropical Atlantic Ocean where the variability of sea surface temperature (SST) is highest, displaying seasonal amplitudes of up to 7°C. This variability is primarily due to equatorial upwelling and the presence of a "cold tongue" in boreal summer. The SST cooling linked to the establishment of the seasonal cold tongue has been shown to correlate with the northward migration of the Inter-Tropical Trade Winds Convergence Zone and thus to influence the regional climate and the West African Monsoon (WAM). One goal of AMMA is to better understand the mechanisms and processes responsible for the SST and air-sea exchanges variability in the Eastern tropical Atlantic and their impact on the Monsoon. This will allow to improve coupled ocean-land-atmosphere models which is a necessary step to increase the predictability of the monsoon at all scales, including the interannual variability

Several AMMA oceanographic cruises<sup>2</sup> allowed to observe ocean in depth over contrasted years in term of heat storage as indicated by SST variations contributing to marked monsoon differences.

New mechanisms have been proposed to explain this inter-annual variability. Large variability has been particularly found in characteristics of the equatorial cold tongue, with far colder temperatures in 2005 than in 2006, mainly resulting from a time shift in the development of the cold tongue. Stronger than usual wind bursts from the south-eastern trades have been found responsible for the rapid and early intense cooling of SST in mid-May 2005. Easterlies in April-May were also observed to be stronger in the western tropical Atlantic in 2005 than in 2006, which favorably preconditioned the oceanic subsurface conditions for the wind-burst efficiency to cool the ocean and the setup of the cold tongue. It is noticeable that preliminary results from the AMMA program indicate that both the WAM and the cold tongue appeared earlier during 2005 and later in 2006.

The analyses in progress will help in elucidating the mechanisms contributing to the onset of the cold tongue and its influence on the WAM system. A better understanding of these mechanisms will allow to improve the parameterization of dynamical processes in play in the ocean and at the air-sea interface, and thus the numerical prediction of climate in West Africa. One socio-economical benefit should be a better prediction of the monsoon onset date and meridional extension, one of key information for Sahelian agricultures.

The impressive amount of data acquired during the AMMA experiment still have to be analysed and combined with ongoing dedicated numerical studies. Further research is need to better understand the processes that are at play between the ocean and the atmosphere linking SST gradients in the Gulf of Guinea and the monsoon flow.

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<sup>2</sup> Coordinated French, German and US cruises in early summer 2006 and French cruises in early summer and fall for 2005, 2006 and 2007

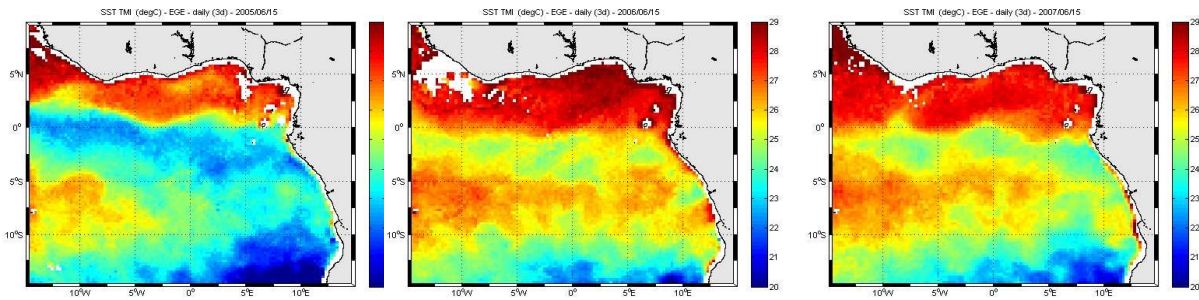


Figure: SST measured by TRMM/TMI on June 15, 2005 (left), 2006 (middle) and 2007 (right).

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## **II- Smoke and dust affect weather and climate in west Africa**

*In west Africa, smoke from biomass burning and wind-blown mineral dust reflect and absorb sunlight and also exert their own distinct type of greenhouse effect.*

It is not just increases in carbon dioxide that affect the regional and global climate; dust and smoke from biomass burning play an important, but poorly quantified role. The Sahara desert is the largest source of mineral dust emissions in the world. Similarly, the burning of agricultural waste during the dry season makes the African continent the largest emitter of smoke in the world. Fundamental questions on how significant the interaction of dust and smoke with sunlight and the strength of their distinct greenhouse effect can only be answered by understanding the chemical, physical, and radiative properties of the both types of aerosol and assessing how the two types of aerosol mix and interact with one another.

A combination of aircraft and surface based observations taken throughout the year indicate that both smoke and mineral dust reduce the amount of sunlight received at the surface. The presence of dust appears to cool the planet, while the presence of smoke can act to either cool or warm the planet depending on the exact absorption properties. During the dry season the sunlight at the surface is reduced by around 5% by mineral dust and by 5% due to smoke. However, in an extreme dust event during March 2006 sunlight at the surface was reduced by more than 50%. Smoke is frequently injected to elevated altitudes above the dust layer during the dry season which has implications for the climatic impact of each aerosol type. There is evidence that the presence of dust modifies the evolution of smoke particles resulting in the smoke particles being more absorbing than if the dust wasn't there.

Simplistically speaking, smoke is almost exclusively a human emission while dust is almost exclusively of natural origin. However, dust emissions may change as a feedback process if the climate changes owing to overgrazing, dynamical changes caused by natural processes or human induced climate change. That the dust appears to affect the evolution of smoke and make it darker than in non-dusty regions means that the natural dust aerosol is more climatically important than previously thought. Smoke may warm the climate more than predicted by climate models which do not yet include the effects of mixing of dust with smoke.

The observations of aerosols in west Africa involved several surface sites which were making concurrent measurements of aerosol in-situ properties and also their effects upon sunlight received at the surface and their distinct greenhouse effect. Instrumentation upon aircraft was used to make in-situ measurements and measure the effects on reflected sunlight.

The measurements have aided the development and validation of numerical weather prediction models that forecast dust events and plumes of smoke from burning of agricultural waste. Encouraging agreement with a observations of dust storms has already been achieved. In addition the measurements will aid the future development of climate models which predict the future climate both in west Africa and globally

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### **III- How one storm can influence another through soil moisture**

*New observations illustrate how the wetness of the soil can affect the development of storms*

It has long been known that moisture in the soil has the potential to affect weather. Dry soils warm and dry the lowest 1km or so of the atmosphere relative to wet soils through differences in surface evaporation. Storms can be very sensitive to temperature and moisture in these lowest levels, which means that in principle, soil moisture can influence rainfall, and therefore subsequent soil moisture – a feedback mechanism. Such feedbacks are not well represented in current weather prediction models, primarily through lack of observations. However, different models tend to agree that West Africa, with its strong variations in soil moisture, is a region of the world where such feedbacks are particularly important. The AMMA field campaign therefore provided an unprecedented opportunity to observe how the atmosphere responds to contrasts in soil wetness.

Observations from AMMA have shown that surface evaporation after rainfall is very strong, but that the soil near the surface typically dries out before the next storm arrives. The impact of the soil wetness on the atmosphere was very clear in measurements from aircraft flying above patches of wet and dry soil. Even over a wet strip as narrow as 20km, the air temperature can be as much as 2 degrees Celsius cooler than over the surrounding drier soil. Such gradients in temperature were found to influence the wind, as predicted by models, though never clearly observed before. These winds can provide a trigger for the development of new storms. An example of this process occurred during one of the research flights, when a major storm developed on the flight track. The storm subsequently travelled over 1000 km across Mali, bringing intense rainfall.

The data taken during the AMMA campaign are being used to improve our models of the land surface and atmosphere. More accurate simulation of soil moisture in many regions of the world will reduce uncertainty in both short term weather forecasts and predictions of climate change.

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## Theme 2

# Influence of African climate on global change

### I- Remote connections between the monsoons

*Remote atmospheric connections<sup>3</sup> in the Tropics and between the different monsoon systems have significant impacts on the rainfall regimes in these vulnerable areas.*

The monsoon areas are very sensitive to climate hazards due to their large population, the relative importance of agriculture in their economy, and the strong sensitivity of their water resources to a short or sporadic rainy season. At the regional scale, vulnerability to climate hazards is a combination of geophysical and humans factors. Climate variability is a key component of the problem and in this respect the monsoon systems as in West Africa or South Asia appear as "hot spots" given their great importance in the Tropics. The physical mechanisms that contribute to their variability is still not completely known as well as their mutual influence.

At seasonal to interannual timescales atmospheric circulation in the Tropics and especially the monsoon systems are very sensitive to oceanic surface temperature anomalies<sup>4</sup>. For instance the African monsoon is enhanced when a La Niña event occurs in the Pacific (as in summers 1999, 2000 and to a limited extend 2007) or when the Mediterranean sea is warmer or the equatorial Atlantic colder than normal.

Specific patterns of atmospheric convection variability have also been highlighted in the Tropics at intra-seasonal time scales (between 10 and 90 days). In particular the so-called Madden-Julian Oscillation (MJO) modulates a high fraction of rainfall variability in the Asian monsoon. This leads to a transmission of eastward and westward atmospheric signals through a rather narrow band along the equator which reach Africa and impact significantly the convection and the rainfall regime in the African monsoon. Such an event has been detected at the end of June 2006 during the AMMA field experiment and could be at the origin of the delay of the African monsoon onset. Moreover, late withdrawal of the African monsoon with significant rains up to mid October in 2002 occurred during the positive phase of the MJO. It is demonstrated that the positive phase of the MJO is related to stronger tropical cyclone activity and bursts in the monsoon system. It has also been shown that the convective activity over the northern part of India during the summer monsoon modifies the vertical circulation over the Mediterranean basin and could indirectly modulate the northward extension of the African monsoon over the Sahel.

Farmers require predictive information about the occurrence of intra-seasonal events (onset and withdrawal of the monsoon, occurrence of dry spells during the rainy season). Large efforts are being put into improving the simulation and predictability of the different monsoon systems and their mutual influences since presently both weather and climate forecast models have deficiencies to represent the related processes and to provide valuable forecasts. The AMMA field campaign and the researchers initiated will enable to improve this predictability through a better quality and a longer range of the forecasts. This will also provide a more unified view of rainfall variability in the whole Tropics.

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<sup>3</sup> Remote connections means that a meteorological or climate anomaly somewhere has an impact on a remote area through a reorganisation of the atmospheric chain.

<sup>4</sup> Temperature anomalies are defined relative to a long-term mean (typically 30 years).

## **II- West African storms and ozone**

*For the first time detailed measurements were performed in close vicinity of large mesoscale storm systems to investigate their impact on transport and chemistry of ozone*

The distribution of ozone and its precursors in the tropics is strongly influenced by large storms. Ozone is the third important greenhouse gas and has a crucial impact on the cleansing capacity of the troposphere as precursor of highly reactive oxidants. An important objective of AMMA was to investigate the impact of large mesoscale convective systems on the ozone budget over West Africa. These systems are very intense organized storm systems with an extension of several hundreds of kilometres.

The AMMA field campaign provided the first detailed description of the chemical composition over West Africa from the ground up to 20 kilometers. This unique data set will significantly improve our knowledge on the emission sources and the chemical processing of air during transport over West Africa and the large scale export of ozone.

The fast vertical transport of air by mesoscale convective systems and the formation of nitrogen oxides, a major ozone precursor gas produced by lightning in the thunderstorms, were studied with a multitude of research aircraft, ozone balloon sondes, ground-based instruments including a 3D lightning detection system, and satellite-based measurements. The aircraft flights included observations in the inflow air of the organised storm systems near the surface and in the outflow air at higher altitudes between 10 and 15 kilometers. In addition, biogenic emissions of nitrogen oxides from soils wetted by the large storms were studied in detail.

Strongly enhanced concentrations of nitrogen oxides from lightning were found in the upper level outflow of the intense storm systems. Observations in outflow air transported away from the storms over several thousands of kilometers showed efficient ozone formation in these air masses.

In the lower atmosphere a latitudinal ozone gradient over West Africa was found with lower concentrations to the south. This is partly due to a strong vegetation gradient including bare soil areas in the north with biogenic emissions of ozone precursors and forest in the south acting as ozone sink by deposition.

In a number of air masses, at altitudes between 3 and 5 kilometers, layers of enhanced ozone were found produced from biomass burning emissions. These had been transported into West Africa from southern Africa where the biomass burning took place.

The measured ozone distribution at higher altitudes (15-20 km) showed that West Africa was weakly influenced by transport from mid-latitudes at these heights during the campaign period and that the "tropical pipe", where the air moves slowly upwards determining the global distribution of stratospheric ozone, was located south of 10°N.



*Mesoscale storm system over Mali photographed from the Falcon research aircraft during the mission on 07 Aug. 2006 (Courtesy of Hans Schlager, DLR).*

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### **III-Stratospheric ice crystals geysers over continental thunderstorms**

*Water vapour and ice crystals measurements over thunderstorms suggest hydration of the stratosphere by fast overshooting of tropospheric air over land regions*

Water vapour is a key player of stratospheric climate and chemistry. It is the most important greenhouse gas controlling partly the temperature of the layer, as well as a source of chemical radicals and polar stratospheric clouds involved in stratospheric ozone depletion. Water vapour concentrations are reported to increase by 5-10% per decade at all levels between 15-26 km over the period 1980-2000, whilst a cooling of 0.5 K per decade was observed in the same layer. However, water vapour enters into the stratosphere in the tropics across the tropopause, the level of minimum temperature around 17 km where water vapour trapped by condensation. Thus the long-term increase of stratospheric water vapour is in contradiction with the observed cooling of the tropopause, casting doubts on the current understanding of mechanisms controlling stratospheric water vapour.

The impact of land based thunderstorms on stratospheric water vapour was explored in the summer 2006 during AMMA in cooperation with a new EU SCOUT-O3 integrated project. Water vapour and ice crystals above deep convective systems were observed by a series of radiosondes and balloon flights from Niamey in Niger and high altitude aircraft (Russian M-55 Geophysica) flights from Ouagadougou in Burkina Faso.

The measurements (Figure attached) fully confirm previous observations made in 2004 in Brazil during the HIBISCUS EU project. They allowed to emit the hypothesis that local hydration of the stratosphere was caused by geyser like injection of ice crystals above overshooting thunderstorms turrets up to 3 km above the tropopause. The number, the intensity and the geographical extension of meso-scale systems developing over West Africa in the summer and Equatorial Africa in the winter suggests that this continent could be the preferred location for this type of hydration at the global scale.

The AMMA observations demonstrate the existence of a hydration mechanism over land caused convective systems, contrasting with the currently accepted scheme of slow ascent and dehydration of tropospheric air in cold tropopause areas. The predicted growth of convective activity in the tropics associated to global warming may then result in an increase of stratospheric water vapour, a cooling of the stratosphere and possibly an enhancement of ozone depletion.

The question now is to determine the importance at the global scale of the overshooting hydration mechanism and its contribution to the water vapour and chemical composition of the stratosphere. Indeed, although fully captured by small scale Cloud Resolving Models suggesting local vertical winds of up to 300 km/h on the top of thunderstorms turrets, such mechanism is not yet represented by global meteorological or climate models.

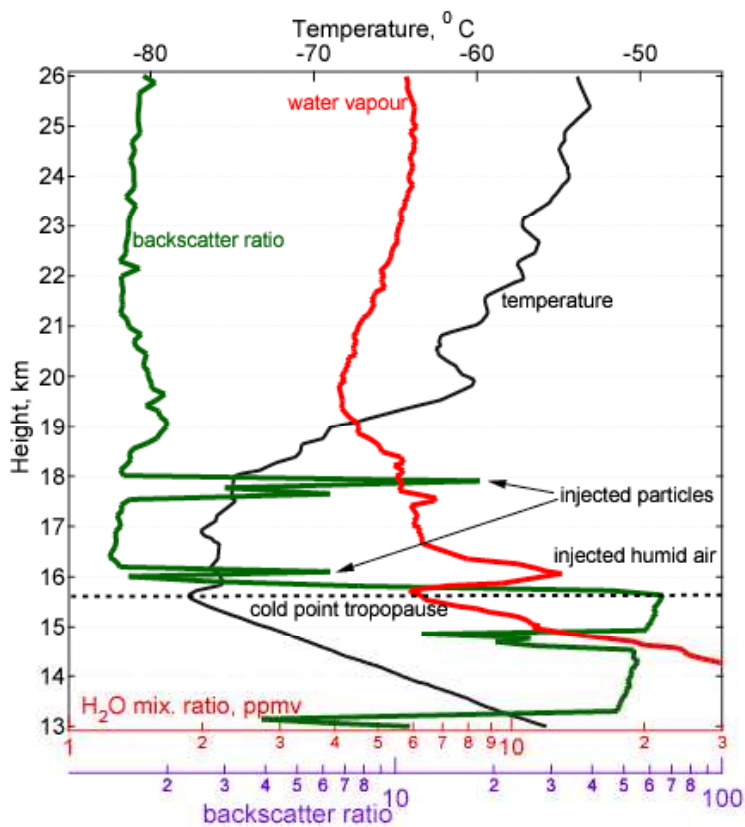


Figure 1. Sounding of temperature (black), water vapour (red) and backscattering ratio of ice particles (green) above a thunderstorm in Niamey on 23 August 2006. Enhanced water vapour layers are observed above the tropopause at 15.8 km coincident with ice crystals layers freshly injected in the lower stratosphere.

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## **IV-Land productivity and vulnerability in a changing climate**

The Western African region is characterised by a fragile equilibrium between the available natural resources and the food demand of an increasing population.

The Western Africa population estimated at 60 millions in 1950 has reached 230 millions in 2000 and is projected to increase to over 400 millions by 2030. In this context land agricultural, pastoral and forestry productivity represents a key issue for the sustainable development and political stability of the region. The production of these resources is directly related to climate variability and trends.

Furthermore, this man-environment system in the Sahel results from a range of interactions between climate variability and trend and changes in policies, in macro-economic variables and local management strategies. AMMA aims at analysing this complex system with a multi disciplinary approach and at different time and spatial scales taking into account the dynamic aspect of those interactions.

Land use has significantly changed during the last 30 years. Those changes have to be interpreted as the result of different driving forces:

1. changes in the hydrological regime in the region;
2. changes in the distribution of the population and on its pressure on natural resources;
3. changes in the adaptation and risk minimization strategies adopted by population.

The analysis carried out by the project at regional scale, based on remotely sensed images, are highlighting strong changes in natural vegetation distribution in many areas of the region both pastoral and agricultural. The understanding of the relationship between those changes and climate is essential to provide an up-to-date picture of the carrying capacity of the region as well as provide useful information for decision making based on the foreseen impact on lands of the projected climatic regimes.

At small scale, the intensive field campaign carried on by AMMA in representative sites, allowed the development of improved crop models for the prediction of agricultural yields of main food crops (sorghum, millet). Combined to the improved climate information provided by the geophysical research within AMMA, more precise estimates of the level of food security of the region will be achieved.

The results of AMMA will help to provide early information on crop strategies to be adopted at village and household level, and on vulnerability of the region to food insecurity. Furthermore it will help to validate the IPCC projections of impacts on dry tropics.

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## **Theme 3**

# **Applications of AMMA and the future of the project**

### **I- Meeting societal needs by strengthening collaborative research in West African monsoon**

*By strengthening the research community in West Africa and developing regional collaboration, AMMA helps policy makers to develop and implement adaptation strategies in order to meet the needs of West African nations to cope with climate change and variability.*

If the nations of West Africa are to cope with climate change and weather extremes, they will require high level expertise and, more generally, regional collaboration of the teams involved in environmental research. A critical mass of experts able to develop and maintain early warning systems and evaluate socio-economic consequences of a changing climate will be necessary to guide national policy makers. Strong scientific advice will also strengthen the position of West African nations in international negotiations on Climate change.

It has been AMMA's objective to ensure that scientists of all West African institutions participate in the building of the project. Just as in European countries, West African scientists have prepared their science plan and prioritized their objectives. They have participated in the selection of the instrumental sites and observation strategies. This strong collaboration has resulted in more than 25 institutions of West Africa being funded for their work in AMMA after successfully submitting research proposals to European agencies. The West African research community in AMMA is now recognized by its peers world wide.

AMMA is fostering the next generation of scientists working on environmental issues. North-South collaborations between universities has led to the strengthening of existing programmes and the establishment of new Masters and a joint PhD programme in fields as diverse as meteorology, hydrology or water management. More generally the research project has led to the exchange of human resources – young and experienced scientists and students – within the region and between African and European institutions. The strengthened bond between the academic communities of Africa and Europe will bring about new research proposals which aim at achieving our common aim of a sustainable development for West Africa.

A strong body of experts in West African countries will help decision makers in the region prepare for a changing climate and likely extreme events. Scientists and technicians will contribute to the development and long term maintenance of early warning systems. For the national economies advice will be provided on development strategies which are compatible with a changing climate. Finally these experts will help strengthen the position of West African nations in the post Kyoto Protocol negotiations by providing science based guidance and advices to African policy makers.

The mobilization for AMMA of the West African research community on environmental and socio-economic problems linked to climate change needs to be maintained over the long term. The value of this expertise needs to be recognized by the West African nations and it should encourage young students to engage in careers in this field of research.

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## **II- Instrumentation and renovation of radio-sounding network**

The observation's strategy of AMMA is articulated around two main considerations. First of all, the interannual variability of the western Africa monsoon is strong and still widely unpredictable. It is thus necessary to sample several contrasted years to better understand this variability. A regional network of observations has been thus built from 2002 till 2010. Secondly the system is multi-scale driven by complex interactions between local, regional and global processes. Nested networks have been designed to sample in the same time regionally and on some parts at high spatial and temporal resolution and through an annual complete cycle of the monsoon. Thus in 2006, on one hand the sampling time has been increased for most of instruments already setup and, on the other hand, the deployment of new instruments such as radars and lidars on the continent, the research ships on the ocean, balloons and research's flights based in Niamey, Ouagadougou and Dakar to follow clouds of aerosol and convective systems.

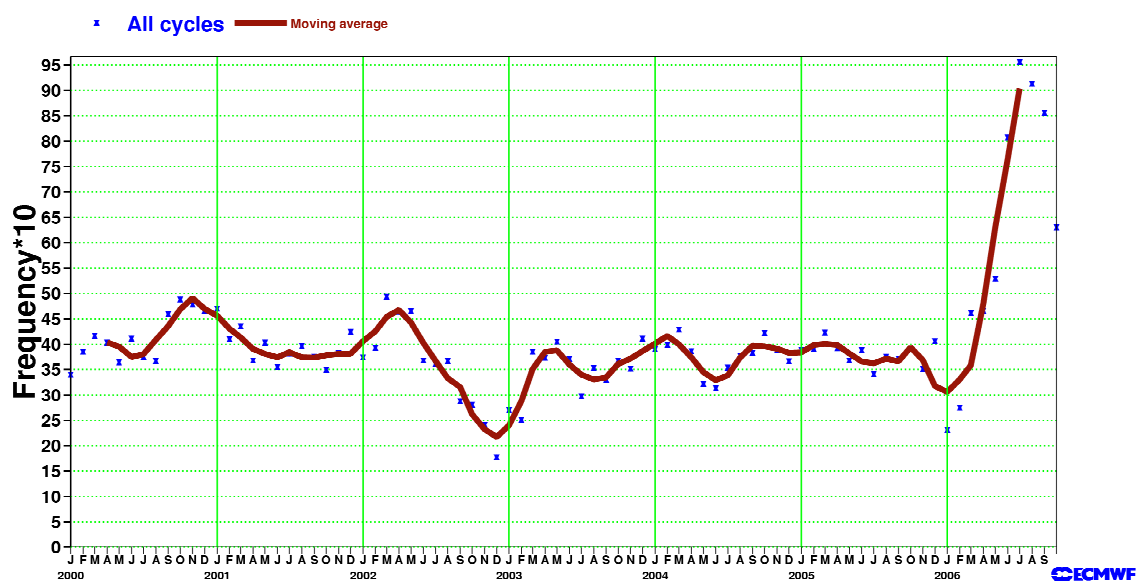
In this vast program - of an unequalled scale in Africa and anywhere else in the tropics - a particular attention was paid to the radio-soundings which are only observation in-situ of the atmospheric state variables performed along an international protocol one or two times a day over the whole globe. They provide the raw data indispensable to initialize the weather forecast models. The intensification of the radio-sounding operations during AMMA campaigns, opens the way to determine the minimum network to be maintained in operational to adequately monitor the fluctuations of the monsoon and facilitate their prediction. In this perspective, the network of radio-sounding managed in the region by ASECNA was reconditioned. AMMA emphasized critical zones where observations are rare, implemented modern telecommunication systems and improved the automation of the collection and exchange of data.

This operation was a success at several levels. Starting at the middle of 2005, a network of 17 stations working at the rate of 1 or 2 soundings a day was active. During the extensive observation periods, the cadence was increased up to 8 soundings by day, making the western Africa the region the best observed in the world over this period. During the period June to September 2006 some 7000 soundings were made in the region, representing the greatest density of upper air observations over the region since the GATE programme of 1974.

While previous years, 45 % of the data collected in the sub-region were received in the world meteorological centres, the AMMA program allowed a rate of success about 95 % in western Africa in spite of an increase of measures frequency in extensive period on 2006. This work mobilized the human resources of most of the national Meteorological Offices of the concerned countries and establishes a real success. These African institutions have now a modern network which can continue to work

Preliminary studies realized in the major numerical weather prediction centres have already shown that these additional radio-soundings contribute to improve weather forecasts in this region when they are assimilated in the models. It is thus important to continue this study to determine the optimal network, to observe and understand the variability of the climate in this region. The challenge is to set up a strategy of resources' mobilization, accepted and assumed by the African institutions to make durable this network.

## Monthly counts of Radiosondes received at ECMWF Temperature 700 hPa - AMMA



Number of atmospheric soundings received at the European Centre for Medium Range Weather forecast (ECMWF) for the AMMA region (status November 2006).

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### **III- Health – first steps to forecasting malaria, Rift Valley Fever and meningitis epidemics**

*Devastating epidemics are common place in the semi-arid regions of West Africa. Approaches are in development which combine climate and remotely sensed information along with an in depth knowledge of the diseases and the socio-economic controls to develop systems that may after further development be able to predict regions at risk to such events in the future. This work involved an integrative multidisciplinary approach and is starting to show interesting results for Rift Valley Fever, meningitis and malaria in the region.*

The sahelian region of West Africa suffers from a number of epidemic diseases which have a devastating affect on the population, livestock and the economy of the region. These diseases have well established or less certain relationships to the variability in the seasonal climate cycles, especially rainfall, in region. Epidemics are not driven by climate alone but have an underlying complex relationship with societal, economic and health support factors. In AMMA we have been working with both the scientists who use climate drivers from observations and models to predict disease risk and with scientists who investigate these diseases and their transmission on the ground in West Africa.

Detailed analysis is at an early stage for the health impacts groups but a number of inspiring results have already been disseminated that are beginning to lead to new avenues of investigation. The link between the strength of the dry Harmattan wind and meningitis epidemics (Fig. 1) has been established and this is leading to new work with a scientific focus combing real time observations and medium range (10 day) forecasts along with detailed examination of meningitis heath data. The dynamics of rainy season ponds have been examined using high resolution SPOT satellite imagery that allows the mapping of the Zone Potentially Occupied by Mosquitoes – ZPOM (Fig. 2) which has been established through field surveys in Senegal to help to develop the most effective control of the mosquitoes that transmit Rift Valley Fever. A dynamic malaria model has been integrated with seasonal lead time climate variable forecasts from an ensemble prediction system (Fig. 3). This is used to establish where the potential zone for malaria epidemics is simulated in the model and when compared with the real clinical datasets will allow integrated impacts model biases from the forecast or impacts model itself to be corrected.

The research is at a very early stage but the progress has accelerated greatly since the establishment of the AMMA programme which has attracted collaboration with other projects. Although we may not yet have effective early warning systems for these diseases, at the current rate of progress the future is looking very promising. In such a future the limited resources for disease intervention and heath care could be targeted to areas most at risk in the forthcoming season.

A very wide range of methodologies are used here including those associated with field data collection of mosquitoes and clinical samples from the people living in the region, followed up by biomedical analysis, through to the use of state of the art satellite imagery and state of the art long range forecasting systems that use a probabilistic approach. The new methodologies, currently in their development stages, in this project are those that focus on how to integrate. These are the methodologies that integrate the information from the different disciplines and these methods will ultimately be used to produce a timely epidemic forecast product that is beneficial to society.

AMMA is setting the approach that will be adopted by other integrated projects and will leave a legacy in the region which will continue this type of integrative interdisciplinary research in the future.

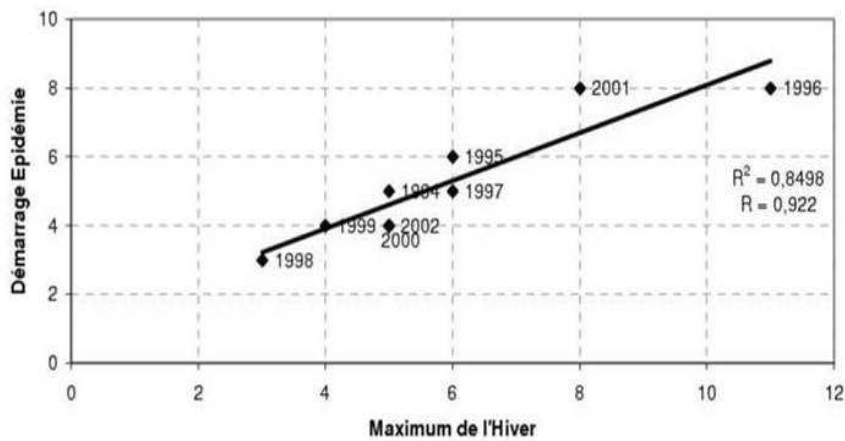


Figure 1: The role of climate in the epidemic onset of meningitis in Mali: the Harmattan winds seems to drive the epidemic onset of meningitis, *Sultan et al. (2005)*

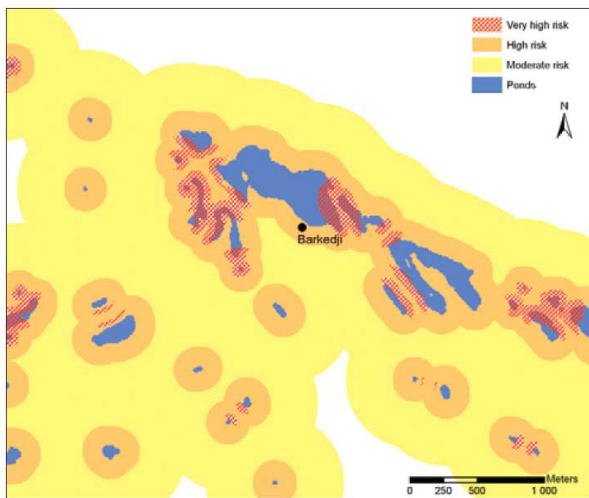


Figure 2 The areas of risk (Zone Potentially Occupied by Mosquitoes – ZPOM) around ponds where mosquitoes that potentially carry Rift Valley Fever are present, *Tourre et al, 2007*

ArcView conversion, data management, and analysis tools enable the display of an improved, three-zone ZPOM for potential Rift Valley fever risks. The very high risk zones are red-hatched to identify underlying pond limits.

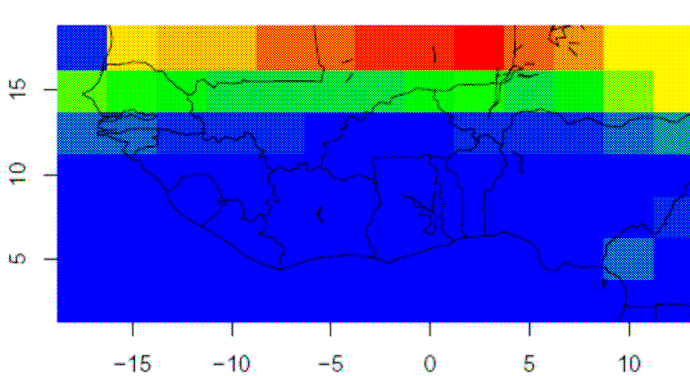


Figure 3. Long-term coefficient of variation in Liverpool malaria model monthly incidence for West Africa grid, 1980-2001, May forecast months 4-6 driven by DEMETER ensemble prediction system (63 model members) with bias-corrected temperature. Areas of high variance, especially on the northern edge, indicate areas that are potentially prone to epidemics. *Anne Jones unpublished Ph.D. thesis, University of Liverpool 2007.*

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# Tools

## Website

All information about AMMA :  
**[www.amma-international.org](http://www.amma-international.org)**

Africa : [www.ird.ne/ammanet](http://www.ird.ne/ammanet)  
Europe : [www.amma-eu.org](http://www.amma-eu.org)

## Photo library

**Pictures from 2006 press journey:** <http://www.insu.cnrs.fr/gallery2>

User: ammacom

Password: cotonou

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**Video library's catalogue:** <http://videotheque.cnrs.fr>

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**Video library's catalogue:** <http://www.ird.fr/indigo/>

## Film

**La calebasse et le pluviomètre / *The Calabash and the Pluviometer*** (2007, 60')

This documentary was written and directed by Marcel Dalaise.

CNRS Images has produced a 60-minute documentary in collaboration with AMMA on the objectives of the project and the intensive field campaign conducted in 2006.

A copy on DVD (available in French) can be ordered and purchased directly from CNRS Images.

Notice: [http://videotheque.cnrs.fr/doc.php?id\\_doc=1817](http://videotheque.cnrs.fr/doc.php?id_doc=1817)

Clips: <http://www.amma-eu.org/sections/news/la-calebasse-et-le6032>

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# Partners

## Founding agencies



European Commission



## Supporting agencies



## African regional centres



**And with the participation of:**

**Algeria :**

Office National de la Météorologie

**Belgium :**

Université Catholique de Louvain

**Benin :**

Centre National de Télé-détection et de Surveillance du Couvert Forestier  
Direction Générale de l'Eau  
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Université d'Abomey-Calavi

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Direction de la Météorologie Nationale  
Direction Générale de l'Hydraulique  
Direction Générale de l'Inventaire des Ressources Hydrauliques  
Institut de l'Environnement et de Recherches Agricoles  
Université de Ouagadougou

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**Denmark :**

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Rheinische Friedrich-Wilhelms-Universität Bonn  
Universität Bremen  
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