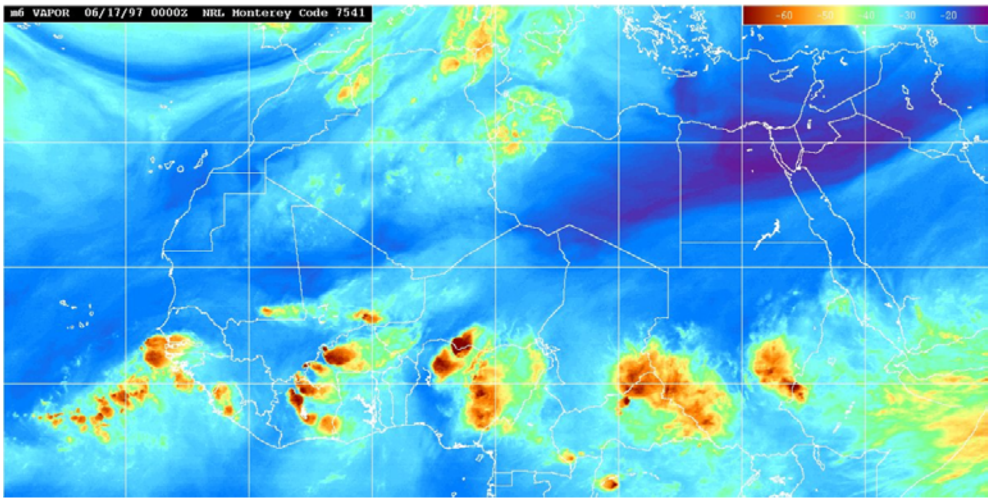
AMMA

International Science Plan



Executive Summary

Introduction to AMMA

African Monsoon Multidisciplinary Analysis (AMMA) is an international project to improve our knowledge and understanding of the West African monsoon (WAM) and its variability with an emphasis on daily-to-interannual timescales. AMMA is motivated by an interest in fundamental scientific issues and by the societal need for improved prediction of the WAM and its impacts on West African nations. Vulnerability of West African societies to climate variability is likely to increase in the next decades as demands on resources increase in association with one of the World's most rapidly growing populations. Vulnerability may be further increased in association with the effects of climate change and other factors linked to the fast growing population such as land degradation and water pollution.

Recognising the societal need to develop strategies that reduce the socioeconomic impacts of the variability of the WAM, AMMA will facilitate the multidisciplinary research required to provide improved predictions of the WAM and its impacts. The international AMMA project has three overarching aims:

- To improve our understanding of the WAM and its influence on the physical, chemical and biological environment regionally and globally.
- To provide the underpinning science that relates variability of the WAM to issues of health, water resources, food security and demography for West African nations and defining and implementing relevant monitoring and prediction strategies.
- To ensure that the multidisciplinary research carried out in AMMA is effectively integrated with prediction and decision making activity.

AMMA will promote international coordination of ongoing activities, basic research and a multi-year field campaign over West Africa and the tropical Atlantic. AMMA will develop close partnerships between those involved in basic research of the WAM, operational forecasting and decision making, and it will establish blended training and education activities for African technical institutions and schools.

At this time scientists from more than 20 countries, representing more than 40 national and pan-national agencies are involved in AMMA. In addition to international structure which has been set up, a network of African scientists linked to AMMA has been established (AMMANET) which will help to consolidate existing collaborations in Africa and to federate initiatives through a pan-African partnership. At this time, funding is largely secured in Europe (mainly in France, Germany, UK & the European Union) up to 2010. Other international efforts are underway to help mobilise the extra funding needed to achieve all the AMMA aims.

AMMA is endorsed by the World Climate Research Programme (WCRP) and continues to develop in association with CLIVAR and GEWEX[1]. AMMA has also been endorsed by two projects within International Geosphere-Biosphere Programme (IGBP): IGAC and ILEAPS. AMMA is working with other international projects and programmes to achieve its aims including GCOS, GOOS and THORPEX.

---

[1] All acronyms referred to in this summary are included at the end of this document

Major Issues

We are currently hindered in providing skillful predictions of WAM variability and its impacts. There are still fundamental gaps in our knowledge of the coupled atmosphere-land-ocean system at least partly arising from lack of appropriate observational datasets but also because of the complex scale interactions between the atmosphere, biosphere and hydrosphere that ultimately determine the nature of the WAM. The monitoring system for the WAM and its variability is inadequate with many gaps in the standard routine network and lack of routine monitoring of some key variables. While the next generation of satellites will undoubtedly help with routine monitoring and prediction efforts, more research is required to validate and exploit these data streams. Dynamical models used for prediction suffer from large systematic errors in the West African and tropical Atlantic regions; current models have problems simulating fundamental characteristics of rainfall such as the diurnal, seasonal and annual cycles. Finally, there is a lack of integrative science linking the work on WAM variability with work on food, water and health impacts. More effort needs to be made to integrate scientists working in these different areas.

Further motivation for a research project concerned with WAM variability and predictability comes from recognizing the role of Africa on the rest of the world. Latent heat release in deep cumulonimbus clouds in the ITCZ over Africa represents one of the major heat sources on the planet. Its meridional migration and associated regional circulations impact other tropical and midlatitude regions, as is exemplified in the known correlation between West African rainfall and Atlantic hurricane frequency. In addition to the large-scale interactions, we know that a majority of hurricanes that form in the Atlantic originate from weather systems over West Africa; however we know little about the processes that influence this and why only a small fraction of these "seedlings" actually become hurricanes.

The WAM system provides an ideal framework for considering scale interactions in a monsoon system: it possesses pronounced zonal symmetry with characteristic jets and associated well-defined weather systems. Research on such scale interactions and in particular those linking dynamics and convection with the land surface will be relevant to other monsoon systems and is needed in order to improve coupled atmosphere-ocean-land models used for weather and climate prediction. In order to carry out this research extra observations are needed.

West Africa is also an important source region for natural and anthropogenic emissions of precursors to key greenhouse forcing agents (e.g. ozone, aerosols). For example, Africa contributes around 20% of the global biomass burning fires. These emissions are modulated by the activity of the WAM but in contrast to other surface impacts they feedback directly on the climate. Long-range transport of trace gases out of West Africa has important implications for the global oxidizing capacity of the atmosphere (which controls the level of many greenhouse gases), global climate change and the transport of key constituents (e.g. water vapour, ozone depleting substances) into the stratosphere. The fires also produce huge quantities of particles, complex mixtures of organic materials and black carbon.

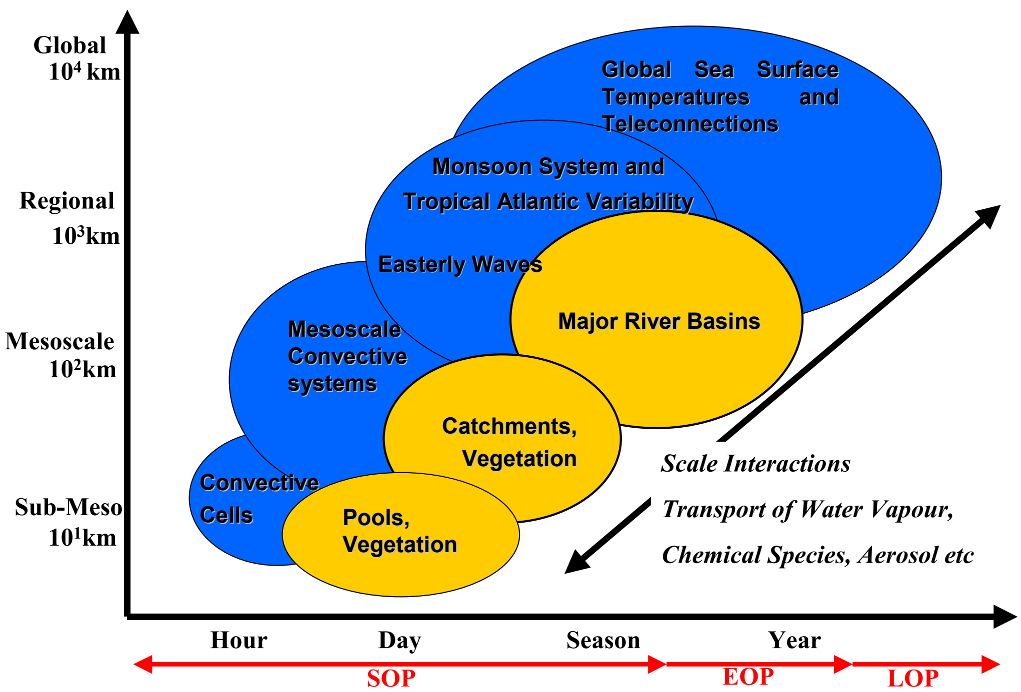
Tropical Africa is the world's largest source of atmospheric dust. Both the fire aerosols and dust play a major role in radiative forcing and in cloud microphysics, and thus are an important part of WAM system. A key priority is to determine the transport of trace gases and aerosols from the surface to the upper atmospheric layers and the subsequent transport by the WAM. It is thus necessary to study the dynamics and the chemistry of the atmosphere in the same framework.

The AMMA Programme

A project that deals with all the major issues raised above will require a major coordinated international effort involving a multidisciplinary approach to the West African monsoon linking observations, data analysis and modeling on a wide range of space and time scales.

- ***A Multiscale Approach***

To address the multiple scales that characterize the WAM the program is structured around 4 interacting spatial scales (see schematic below): ***(i) Global scale.*** This is the scale at which the WAM interacts with the rest of the globe; emphasis is given to improving our understanding of the role of global SST patterns on WAM variability; seasonal-to-decadal variability are the main time scales of interest ***(ii) Regional scale.*** This is the scale at which we consider monsoon processes and scale interactions; emphasis is given to improving our understanding of the interactions between the atmosphere, land and tropical Atlantic ocean (especially the Gulf of Guinea). It is important to study the role of land surface feedbacks on variability of the WAM at this scale including the key roles of vegetation and soil moisture. The annual cycle and seasonal-to-interannual variability are the main time scales of interest. ***(iii) Mesoscale.*** This is the scale of the typical rain-producing weather systems in the WAM. It is central for studying the variability of rainfields at the seasonal scale and the coupling between hydrology and the atmosphere at the catchment scale. ***(iv) Local scale or sub-meso scale.*** From an atmospheric point of view, this is the convective rain scale; it is central to the hydrology of the Sahel and of small watersheds to the south; it is the main scale of interest for agriculture.

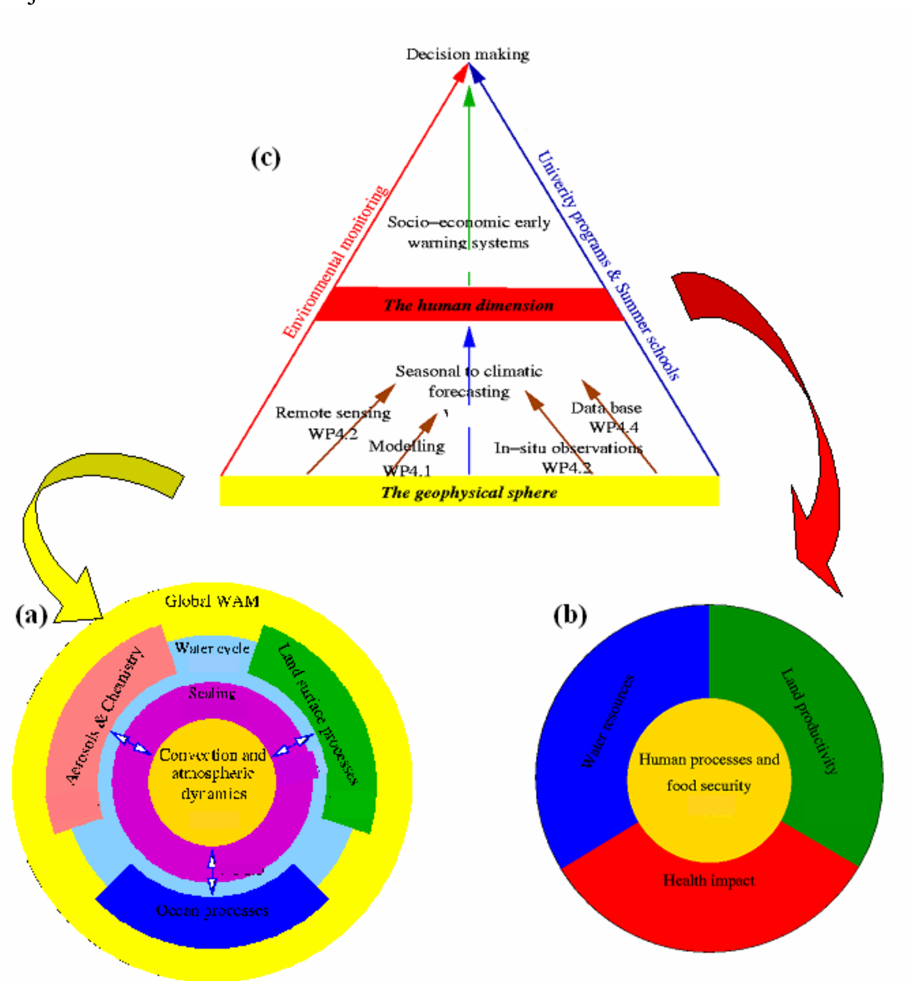


Simplified schematic of key phenomena together with their associated space and time scales. The arrow is included to highlight the importance of scale interactions and transport processes in the WAM.

AMMA emphasizes the importance of improved understanding of how these scales interact and combine to characterize the WAM and its variability, including how these interactions impact sources and transport of water vapour, aerosol and key chemical species (e.g. key greenhouse gases, ozone and aerosol precursors) in the West African region and globally.

- ***Integrative Science and Implementation of AMMA***

Key objectives and planned research activities for each scale have been formulated for AMMA. While it is convenient and appropriate to describe the research plans in terms of these different spatial scales, it is essential for an improved understanding to study the scale and process interactions. The implementation of AMMA is designed in this spirit. The AMMA project integrates the scales at which the geophysical and human processes interact. Furthermore the various disciplines involved in the study of the West African Monsoon need to be integrated to achieve the three overarching aims. This approach has guided the structuring of the scientific objectives.



Implementation of AMMA: Integrative science for the geophysical (a) and human dimension (b) Integration from this knowledge through various tools and for the exploitation by impact studies (c)

From the geophysical perspective, the fundamental science underpinning the AMMA project can be viewed as the various disciplines coming together within broader integrative science topics: i) the interactions between the WAM and global climate from a physical as well as a chemical perspective, ii) the water cycle of the WAM from the regional to the local scale and iii) the coupled atmosphere-land-ocean system and its multiple scales. To feed these integrative topics with sound disciplinary knowledge of the processes and their scale dependence detailed studies of the processes are needed: i) atmospheric processes with a focus on the convective processes which are key to the rainfall production, ii) oceanic processes as they contribute and depend on the WAM, iii) biophysical processes over the continent from the regional to the local scale and iv) aerosol and chemical processes in the atmosphere.

To study the human dimension of the variability and possible trends in the West African Monsoon AMMA aims to address the direct impact of the environmental conditions on three limiting conditions for the African societies: i) Land productivity, ii) water resources and iii) health impacts. This activity will be coordinated to achieve a better understanding of how weather and climate variability impact food security and human processes in the region.

To achieve the AMMA scientific objectives and to master the challenge of multi-scale and multi-disciplinary aspects, a consistent set of tools and methods adapted to the problem of the West African Monsoon will be used: i) models and data assimilation, ii) field campaigns, iii) satellite remote sensing and long-term atmosphere/land/ocean data collection and iv) data base. These activities are key to transferring knowledge from the geophysical community in AMMA to the activities in the human dimension. These tools will collect and consolidate knowledge, integrate the knowledge and materialize the predictive skill gained with this knowledge.

- ***The Field Programme***

AMMA is planned to be a multi-year project and involves 3 nested observation periods. It should be underlined here that the enhancement of observations during these periods will provide a unique opportunity to determine future operational monitoring necessary to improve weather and climate forecasts over the West African region. More than this, a high priority for AMMA is to establish this operational network of observations providing a visible legacy for the international AMMA programme.

- **The Long term Observing Period (LOP)** is concerned with observations of two types: (i) historical observations to study interannual-to-decadal variability of the WAM (including currently unarchived observations) and (ii) additional long term observations (2002-2010) to document and analyse the interannual variability of the WAM.

- **The Enhanced Observing Period (EOP)** is designed to serve as a link between the LOP and the SOP (below). Its main objective is to document over a climatic transect the annual cycle of the surface conditions and atmosphere and to study the surface memory effects at the seasonal scale. The EOP will be 2-3 year duration (2005-2007).

- **The Special Observing Period (SOP)** will focus on detailed observations of specific processes and weather systems at various key stages of the rainy season during three periods in the summer of 2006: (i) the dry season (Jan-Feb), (ii) Monsoon onset (15 May-30 June), (iii) Peak monsoon (1 July – 14 August) and (iv) Late monsoon (15 August-15 September).

- ***Satellites***

Satellite observations will strongly contribute to the objectives of the project by providing key variables of the surface – atmosphere system (e.g. Meteosat/MSG, ENVISAT, TRMM, AURA, AQUA-Train, TERRA). AMMA provides a unique set of integrated atmosphere/land/ocean observations for validation of the satellites. It will also provide the framework to build a reliable monitoring strategy combining satellite and in situ atmosphere/land/ocean networks, to make up for the low density of routine observations in and offshore Africa. Geophysical parameters and their uncertainties will be produced at different scales and gathered in a unique database allowing multiscale as well as multidisciplinary analysis of the WAM and its variability.

- ***Weather and Climate Prediction Models***

Models will be combined with observations to investigate the nature of the WAM at daily, seasonal-to-interannual and decadal timescales, including how the different scales interact. As throughout the AMMA program, the linkages between weather and climate variability will be emphasized. This approach is particularly pertinent to improving models for climate prediction since scale interactions and processes not handled well by GCMs used for climate predictions are best studied in the same GCMs at the weather system scale. Thus, while AMMA recognizes the need for different modeling strategies for studying and predicting weather and climate variability, it will seek to develop a strong synergy between them especially with respect to understanding representation of key scale interactions and systematic errors.

Final comments

AMMA has been carefully conceived to improve our fundamental understanding of the West African monsoon and its societal impacts and to make sustainable improvements to monitoring and prediction of the West African environment. Our activities are embedded within a 'Long-term observing period' (LOP) structure, which will ensure that our intensive activities are directed towards systematic improvements in monitoring and prediction over the coming decades. We will develop and upgrade two important land-based atmospheric monitoring systems (for the upper air and surface fluxes), and over the LOP we will transfer responsibility for these networks to the local African agencies. In addition, ocean monitoring systems surrounding West Africa that have been shown to improve both weather and climate forecasts will continue to provide data to these groups. These networks of observations are of enormous value both to global prediction systems and to local forecasting systems, based in Africa.

Acronyms used in this document

CLIVAR	Climate Variability and Predictability
GEWEX	Global Energy and Water Cycle Experiment
IGAC	International Global Atmospheric Chemistry
IGBP	International Geosphere-Biosphere Programme
ILEAPS	Integrated Land Ecosystem – Atmosphere Processes Study
GCOS	Global Climate Observing System
GOOS	Global Ocean Observing System
THORPEX	The Observing System Research and Predictability Experiment
WCRP	World Climate Research Programme

Contacts: **Co-chairs of AMMA International Scientific Steering Committee**

Jean-Luc Redelsperger jean-luc.redelsperger@meteo.fr

Chris Thorncroft chris@atmos.albany.edu