6A.4 WEST AFRICAN MONSOON PROJECT

Jean-Luc Redelsperger*, & Colleagues from around 15 french laboratories
CNRM/GAME, CNRS & Météo-France, Toulouse, 31057, France.

1. INTRODUCTION

In preparing the 5-year plan for atmospheric and oceanic research studies, the French community selected the West African Monsoon (WAM) as a major research topic. During the last 20 years, many advances have been made in fields such as hydrology, convective systems, atmospheric chemistry, statistical forecast of seasonal rain. Nevertheless, major features are still no well understood. Also, General Circulation Models poorly simulate the African monsoon climate and its variability. Weather forecasting is still challenging in this region. The main difficulty is actually its strongly marked aspect of multi-scales and multi-processes.

A review on various aspects of African Monsoon including the standing issues is available on http://medias.obs-mip.fr:8000/amma/. To address these issues, the French community has proposed to set-up at international level a combination of coordinated research actions. The international community has given back a strong positive feedback on this initiative. The presentation will describe the current scientific objectives for a comprehensive study of West African monsoon and its different components: atmospheric dynamics, continental water cycle, atmospheric chemistry, and continental and oceanic surface conditions. Emphasis will be made on the monsoon dynamics and the water cycle.

2. MOTIVATION

Rainfall over West-Africa is notoriously unreliable, especially in its northern part. The famines that struck the Sahel in the 70's and 80's have prompted a number of authors to investigate possible mechanisms responsible for these dramatic events. In fact, these events are part of a longer drought that lasted continuously from the end of the 60's. This unusual dry spell was not limited to the Sahel but was felt down to the Guinea Coast as well.

This drought is but one manifestation of the climate variability of West Africa, spanning a large range of scales from intraseasonal to decadal. Given its strong impact on human activities at the regional scale and its climatic effects at larger scale there is an imperious need for a better understanding of this variability and for improved seasonal forecasting skills. As a matter of fact, we currently have considerable difficulties in analyzing, simulating and forecasting that variability. The central reason of these difficulties lies in the complex interactions between the atmosphere, the biosphere and the hydrosphere that are controlling the dynamics of the WAM and the life cycle of the associated rain producing systems. Recent modeling works have shown that the oceans, the vegetation and the topography very likely play an important role in the establishment of a monsoonal circulation over West Africa.

While atmospheric dynamics act as the ultimate direct controlling factor on rainfall, the human behavior might have a significant, however indirect, influence as well. It was early pointed out that overgrazing was causing an increase of albedo in the Sahel impacting on the Hadley circulation. Lately, authors stressed that the degradation of the vegetation cover over Sudano-Guinean West Africa might have a still larger impact on the rainfall regime of the region.

Beyond these regional motivations, one has also to consider the role of tropical Africa in a more global context. This role has generally received little attention, though it is one of the major heat source of the earth climate, characterized by a strong meridional migration, which impacts on the annual cycle of other tropical and mid-latitude regions. The significant correlation existing between Atlantic hurricanes and West Sahelian rainfall is but one example of the links between the WAM and the climate of other regions. Similarly, the African monsoon region appears critical for the global chemistry in the emission of ozone precursors and of aerosols and their redistribution over the whole troposphere. Trace gas and aerosol emissions in the tropical Africa are strongly affected by human activities. Biomass burning in savanna and forest ecosystems is the most important source of atmospheric pollution emitting huge amounts of reactive gases and particles that have a direct impact on regional radiative budget. The savanna burning over Africa is estimated to correspond to 0.7 GT Carbon by year (i.e. around 20 % of the global biomass burning). Atmosphere dynamics and chemistry, vegetation dynamics and the continental water cycle are thus closely interrelated and have to be studied in conjunction.

3.OBJECTIVES

Water and energy budget-To quantify them in the boundary layer in relation with the evolution of surface conditions

-To understand the role of spring to summer evolution of moist static energy gradients in the PBL & of their intraseasonal persistence on monsoon dynamics

-To improve the performances of statistical & dynamical forecast models

Convection and its environment

i)To document the different types of convective systems, their life cycle & their coupling with surface conditions, ii)To analyze the processes leading to

* *Corresponding author address:* Jean-Luc Redelsperger, CNRM/GAME, 42, Av. G. Coriolis, 31057 Toulouse, France; e-mail: redels@meteo.fr

to convective organization (mesoscale vortices, waves, cyclogenesis, …) iii)To analyze retroactions within the whole monsoon system

Land surface

i)To quantify the role of land surface on 1-100 year variability, ii)To document the seasonal scale memory, iii)To analyze the two-way interactions between land surface & convection

Oceanic surface

i)To investigate the role of Gulf Guinea on the monsoon from intra-seasonal to interannual scales, ii) To document the variations of oceanic circulation in Gulf of Guinea & budgets of heat, salt and momentum

Continental water cycle

i)To document the rainfall variability over a range of scales in order to link its structure to the atmospheric structures and to partition it as function on the surface conditions ii)To provide a global and coherent framework to derive rainfall regimes from atmospheric models, iii)To understand the hydrologic variability from convective scale to seasonal cycle, iv) To link the water fluxes to observed behavior of West African catchments iv) To develop approaches to couple global and regional atmospheric models with hydrologic models

Atmospheric chemistry

The issues for this part are not given here but are related to the emission and deposition of chemical species, the budget of HOx in the upper troposphere, the heterogeneous chemistry in convective clouds, the role of aerosols on the cloud structure and radiative balance and the troposphere-stratosphere coupling

4. STRATEGIES

To address the issue of numerous space-time scales involved in the WAM, the project strategy from observational, modeling & assimilation perspectives, is designed as a multi-year program structured in 3 observational periods and 5 space scales, to which will correspond different numerical modeling approaches.

The Long term Observation Period (LOP) aims at studying the interannual variability of the main aspects of the WAM. Another objective is to collect the data required to better identify in the long term WAM variability the parts controlled by large scale factors and the land cover changes. Regional observations - satellite data since the late 60's and ground rain and streamflow observations since the beginning of the 20th century – and mesoscale observations started in the 90's, are available to that end.

The Enhanced Observing Period (EOP) serves as a link between the LOP and the SOP. Its main objective is to document over a climatic transect the seasonal cycle of the surface conditions and of the atmospheric state variables at convective-to-synoptic scales. The EOP duration should be of 2 or 3 years, in order to capture the memory effects from one season to the next (through continental and oceanic conditions) and the conditions prevailing during two contrasting years.

The Special Observation Periods (SOP) in 2005 allows to get detailed observations of some specific processes during most of the rainy season and to evaluate and improve the accuracy of analysis based on the smaller number of in-situ observations gathered during the EOP and the LOP.

The « supra regional scale » includes the West African sub-continent with neighboring land and sea surfaces. It is the relevant scale to study the local teleconnections of the WAM with oceanic processes over the Atlantic ocean (Linking with PIRATA). This is also a scale of linking with the other tropical regions of Africa.

The regional scale corresponds to West Africa, (6 10^6 km²). Global water and energy budgets between continent and atmosphere must be conducted at this scale to encompass all the local specificities of the meridian climatic and land cover gradient between the Guinean gulf and the rims of the Sahara. That should be performed in using mainly modeling and assimilation approaches and spatial observations.

The sub-regional scale comes mostly from operational limitations in monitoring the entire regional scale. This scale is related to the concept of transects. A North-South transect should be built from the existing CATCH window, extending it South to the gulf of Guinea and North to the Sahara. A East-West transect should be considered from the eastern Atlantic to the central Sahel (Niamey). This transect is already equipped with PIRATA, meteorological radars, radiosondes and surface stations. The sub-regional scale is also relevant for characterizing the West-African rainfall regimes and their variability.

The meso-scale (10^4 km² to 4.10^4 km². is typically related to hydrometeorological observations focusing on rainfall field characterization and nested catchment water budgets. It is also a relevant scale to study the dynamics of the convective systems. A few observatories are already well and specifically documented for environmental and hydrology Two such sites have been operated for several years within the CATCH window.

The local-scale (few 10^2 km²) is dedicated to heavy monitoring of surface processes within the 2 meso-scales sites.

In order to address the objectives of the project, an improved understanding of processes involved in each component of the WAM is obviously needed. Nevertheless, their interactions at different space-time scales are a critical area of investigation. This requires a synergistic approach cutting across disciplines and across spatial and temporal scales. In this context modeling and assimilation will be the major tools to integrate the various measurements carried out at various spatial and temporal scales. Downscaling or upscaling models will be important in relating the measurements carried out over various space scales.to improve the meso-β scale description of low-level conditions. A strong emphasis is also dedicated to use of satellite data. Careful attention to enhancing interdisciplinary work and communication will also be sought.