

## SIGNATURE OF LARGE-SCALE MODELS ALONG A MERIDIAN TRANSECT OVER WEST AFRICA : AMMA-CROSS

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### I. Context

West Africa is characterized by well defined strong meridian surface gradients (illustrated in Fig. 1), coupled to specific atmospheric circulations, such as the African easterly jet (AEJ) which is present during the monsoon season. The location of the AEJ itself is strongly constrained by meridian surface temperature and moisture gradients (*Thorncroft & Blackburn QJRMS 1999*). In particular, inter-annual variability of the West African monsoon (WAM) is accompanied by changes in these basic structures. Synoptic variability in turn is dominated by African easterly waves which are dynamically linked to the AEJ. The structure and variability of these basic large-scale features involve complex interactions with soil, surface, turbulent and convective processes occurring on different scales. Finally, the WAM exhibits specific seasonal variations, with an abrupt monsoon onset to be compared to a more progressive latitudinal retreat (*Sultan & Janicot J. Climate 2003*).

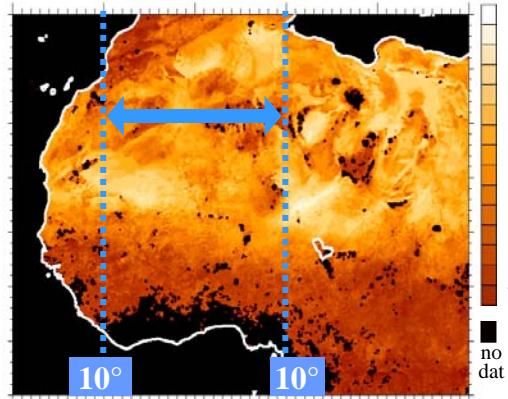


Figure 1: Shortwave albedo 1<sup>st</sup> decade of June 1997  
(POLDER-1, POSTEL, AMMASAT).

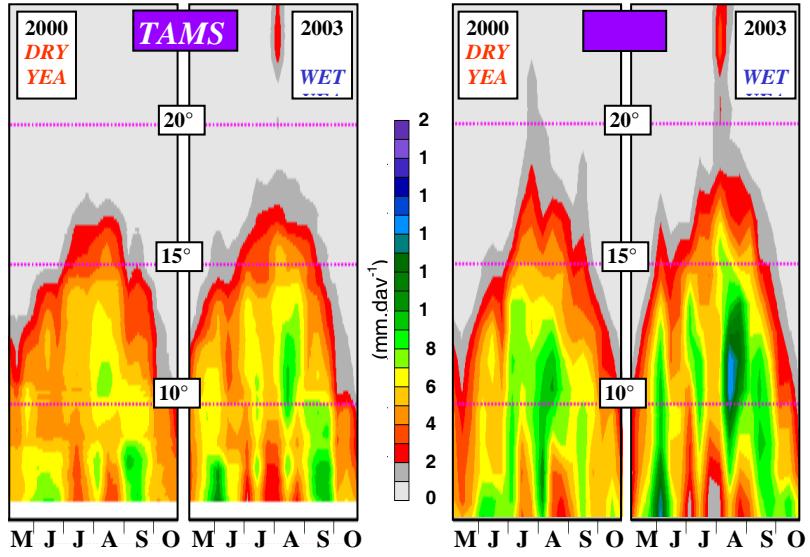
While current numerical weather prediction (NWP) analyses seem able to reasonably capture these large-scale atmospheric features, the extent to which large-scale models are able to properly reproduce these observations remains unclear, and likely sensitive to changes in the physical parametrizations.

The objective of this starting study is therefore to get a more precise view concerning the ability of the large-scale models involved in the AMMA project to simulate these fundamental features of the WAM. Beyond, we also want to explore and compare the mechanisms and feedbacks involved in the WAMs as depicted by these models.

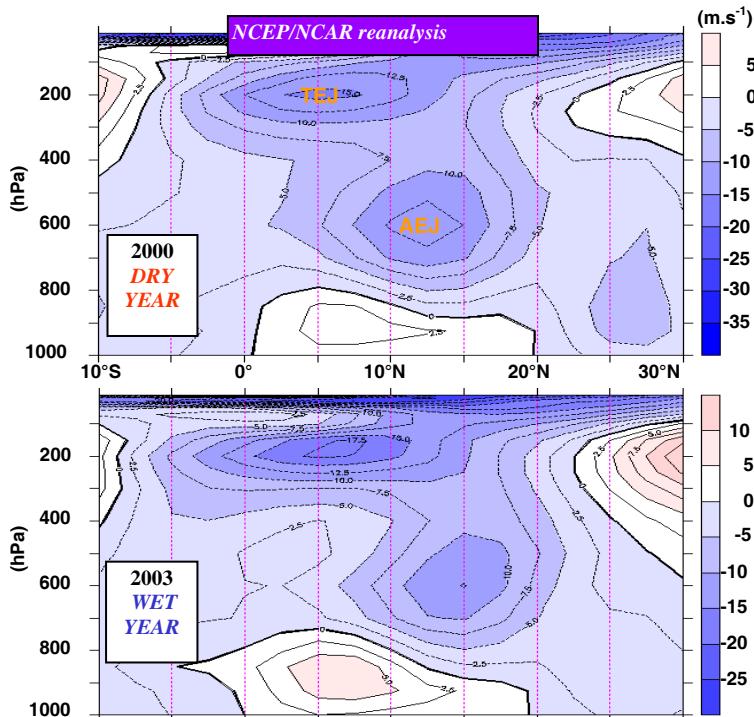
To do so, we follow an approach proposed by *Siebesma et al. (QJRMS 2004)*, and apply it to the Western African region: we define a North-South cross-section, over which we compare model behaviours with analyses and observational products, with the help of dedicated diagnostics.

## II. Case-study and specifications for models and simulation diagnostics

The meridian cross section spans 10W to 10E (Fig. 1), and extends from 20S to 40N. Two recent contrasted years: 2000 (year of the JET2000 experiment) and 2003 (MOZAIC data available for chemistry) have been chosen. They present distinct northern migration of the monsoon, with significantly more (less) rainfall North (South) of 8N in 2003 (Fig. 2). This is accompanied by typical changes in the dynamical structures such as seen on the August average zonal wind (Fig. 3): for instance, in 2003, the monsoon flow is thicker, the AEJ weaker and located further north, while the TEJ is stronger, when compared to the same monthly mean for 2000. Note however that in 2003 the Eastern Atlantic sea surface temperatures (SST) anomaly was positive towards the Equator and South of it, i.e. the 2003 WAM does not fall in the category of wet years previously identified, that are characterized by similar rainfall patterns, but by an opposite correlation with SST anomalies. Figure 2 also underlines the significant differences existing between available rainfall datasets (here TAMSAT and GPCP products, GPCP overestimates rainfall rates compared to TAMSAT).



**Figure 2:** May to October time-latitude series of rainfall as given by TAMSAT & GPCP products for the two selected years, [10W-10E] average decadal values.



**Figure 3:** 2000 & 2003 August [10W,10E] average zonal wind, from NCEP/NCAR reanalysis.

Time-varying SST fields been provided to modellers (files & information available from <http://amma-mip.lmd.jussieu.fr/>), and a list of model outputs has been defined: it consists in time-latitude-height and time-latitude series of daily-mean fields averaged between 10W and 10E. These include atmospheric fields (winds, temperature, humidity, convective heating...), surface and top of the atmosphere variables and quantities such as heat, water and radiative fluxes. Reanalyses and data products over [10W, 10E] are available as figures at <http://www.cnrm.meteo.fr/amma-moana/transect/index.html> (contact [florence.favot@meteo.fr](mailto:florence.favot@meteo.fr) for pw).

### **III. Models, simulations, discussion of preliminary results**

So far, preliminary simulations from three general circulation models (GCMs) ARPEGE-Climat, ECHAM4 & LMDZ4 have been realized. They differ in many respects. For instance, even if the radiation scheme is the same among two models, their treatment of aerosols is distinct (which may affect the heat low properties and AEJ, *Tompkins et al. GRL 2005*). Soil initialization methods and the associated spin-up duration also vary according to the land-surface scheme that is used. Beyond these first simulations, we are planning to perform additional simulations, with increased resolution and/or updated parametrizations.

All the simulations reasonably depict the broad seasonal migration of rainfall. The differences among them concern in particular: the range of the northern monsoonal extension of rainfall, the rainfall retreat phase, the magnitude of intraseasonal variability. Differences appear between rainfall observational products and the reanalyses and among reanalyses as well. At the same time, while all GCMs are able to produce an AEJ, simulated AEJs differ in their latitudinal position and strength. These distinct behaviours of models are quite robust along the monsoon season. Differences among simulations are not restricted to the monsoon season though.

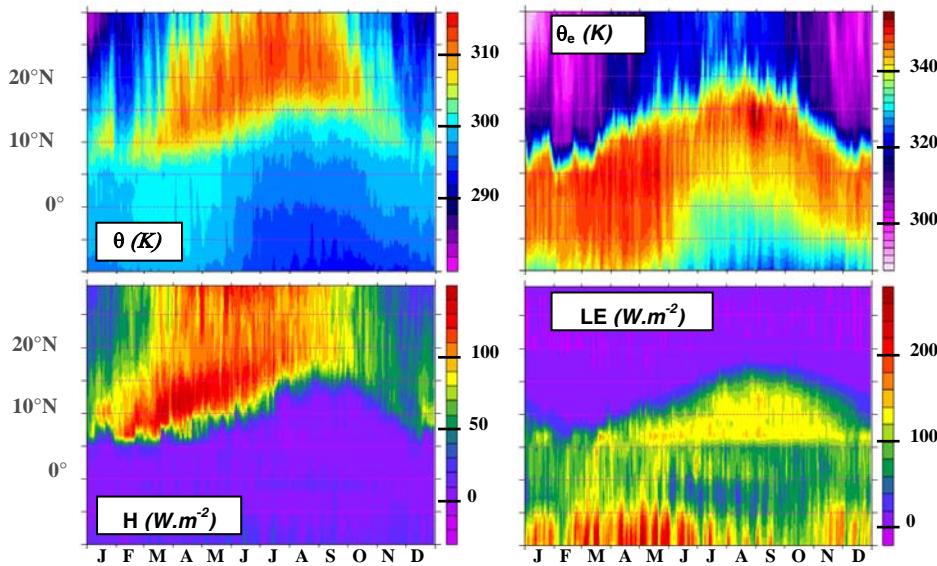
In addition, these results are found to be sensitive to the convection scheme (LMDZ4) and to the vertical resolution (ECHAM4). For LMDZ4, differences among runs performed with different convection schemes are larger than among ensemble runs all performed with the same convection scheme.

Finally, the contrasted rainfall regimes between 2000 and 2003 seem to be captured by ARPEGE-Climat.

### **IV. Perspectives**

Further work will involve in particular the analysis of surface and TOA variables, heat, water and radiative fluxes, and how they are related to convective activity and cloud cover. (Fig. 4 shows the seasonal variation of some of them as depicted by the NCEP/NCAR reanalysis). The surface flux climatology database developed within AMMA should be particularly helpful for this study as well as AMMA-SAT and ISCCP products. Links with the chemistry-transport modelling studies should also be strengthened through our choice of years (simulations available).

A complementary and coupled study AMMA-MAPS will allow to assess how representative this cross-section analysis is and to relate it to the synoptic and intra-seasonal variability simulated by models versus observed over West Africa. (see <http://amma-mip.lmd.jussieu.fr> for further information.)



**Figure 4 :** NCEP/NCAR reanalysis, year 2000 seasonal latitudinal variation of 10W, 10E daily mean potential temperature  $\theta$ , equivalent temperature  $\theta_e$  close to the surface, and surface sensible and latent heat fluxes  $H$  &  $LE$ .

## SIGNATURE DE MODELES DE GRANDE ECHELLE LE LONG D'UN MERIDIEN EN AFRIQUE DE L'OUEST : AMMA-CROSS

L'Afrique de l'ouest présente de forts gradients méridiens en surface, qui se combinent avec des circulations atmosphériques spécifiques, telles le jet d'est africain (JEA) qui se développe pendant la mousson. La position du JEA est elle-même fortement contrainte par les gradients méridiens de température et d'humidité à la surface. En particulier, la variabilité inter-annuelle de la mousson en Afrique de l'ouest (MAO) s'accompagne de modifications de ces structures de base. La variabilité synoptique est à son tour dominée par les ondes d'est africaines, qui sont elles-mêmes reliées au JEA. La structure et la variabilité de ces phénomènes de grande échelle résultent d'interactions complexes avec les processus intervenant au niveau du sol, de la surface, et les processus convectifs, interactions qui se manifestent à différentes échelles. Finalement, la MAO présente des variations saisonnières particulières, comme un saut de mousson rapide en début de saison, tandis que le retrait de la mousson est plus progressif.

Ces structures de grande échelle sont relativement bien vues par les analyses issues des systèmes numériques de prévision du temps. Cependant, il n'est pas évident que les modèles de grande échelle soient capables de les reproduire correctement, étant donné que ces structures sont probablement sensibles aux paramétrisations physiques utilisées.

L'objectif de cette étude est de fournir des éléments plus précis concernant la capacité des modèles de grande échelle à reproduire ces structures fondamentales de la MAO. Pour ce faire, nous avons défini un transect nord-sud en Afrique de l'ouest, couvrant la bande de longitude [10°O, 10°E], avec lequel nous comparons, pour les années 2000 et 2003, le comportement des modèles avec les analyses et des produits d'observation, via des diagnostics adaptés. Le cas d'étude et des résultats préliminaires seront présentés à la conférence.



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**Analyses Multidisciplinaires de la Mousson Africaine**

## **African Monsoon Multidisciplinary Analyses**

**1<sup>st</sup> International Conference**  
Dakar, 28<sup>th</sup> November – 4<sup>th</sup> December 2005

### **Extended abstracts**

Isabelle Genau, Sally Marsh, Jim McQuaid, Jean-Luc Redelsperger,  
Christopher Thorncroft and Elisabeth van den Akker (Editors)

AMMA International

**Conference organisation:**

Bernard Bourles, Amadou Gaye, Jim McQuaid, Elisabeth van den Akker

**English and French editing :**

Jean-Luc Redelsperger , Chris Thorncroft, Isabelle Genau

**Typesetting:**

Sally Marsh, Isabelle Genau, Elisabeth van den Akker

**Printing and binding:**

Corlet Numérique  
14110 Condé-sur-Noireau  
France  
numeric@corlet.fr

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Convective wind system with aerosols, named “haboob”, Hombori in Mali,  
West Africa.