THE ATMOSPHERIC DYNAMICS OF THE WEST AFRICAN MONSOON ONSET AND ITS OCEAN COUNTERPART

B. SULTAN, S. JANICOT, A. LAZAR and C. MENKES

LOCEAN / IPSL, France

Introduction

Precipitation in the Sahel is produced by one rainy season during the northern summer monsoon over West Africa. The onset of these rains, linked to the northward migration of the Inter-Tropical Convergence Zone (ITCZ), is an important parameter for a large community of users like meteorologists, farmers, water resources managers... The aim of this study is to document the onset stage of the West African monsoon by using OLR data and NCEP / NCEP2 reanalyses and to describe its ocean counterpart by using TMI SST data and an oceanic simulation.

The onset stage of the West African monsoon

Previous works has described the onset stage of the West African monsoon by using combined daily rainfall and OLR data on the period 1968-1990 (Sultan and Janicot 2003). The monsoon onset is characterized by an abrupt latitudinal shift of the ITCZ in late June from a quasi-stationary location at 5N in May-June to another quasi-stationary location at 10N in July-August. Composite analyses based on NCEP reanalyses shows that this northward shift is associated with an enhanced Saharan heat low dynamics, increasing inland zonal moisture advection. This increase can favorize the occurrence of strong westerly winds events like the westerly jet previously noticed by Grodsky et al. (2003). We extend this work by using NCEP2 reanalyses for the 1979-2002 period. We show that the heat low dynamics around the onset date might impact the coastal upwelling forcing with a maximum of wind speed and curl at the time of the monsoon onset over the Mauritania-Senegal coastal area and a sudden decrease after the onset date.

The oceanic counterpart in SST observations

By applying the same composite analysis but to TMI SST data over the 1998-2003 period, we investigate the SST changes around the monsoon onset. These changes from the 15 days before and the 15 days after the onset of the monsoon are highlighted by the Figure 1. The SST difference shows an enhancement of SST in the eastern half of the Atlantic Ocean between 5°N and 20°N maximum over the Mauritania-Senegal coastal area. This warm SST anomaly is located where the wind speed (Fig.1) and curl (not shown) decrease is the stronger. The warming might be induced by the latent heat loss decrease and by ocean stratification changes due to the decrease of the wind curl in the western part of the Heat low circulation. Figure 1 shows also a cooling in the Guinean Gulf and in the southern part of the Atlantic Ocean that is not coherent with the atmospheric changes around the onset date. This meridional SST dipole over the Atlantic with warm anomalies north of the ITCZ location and cold anomalies southward could be favourable to the northward migration of the ITCZ.

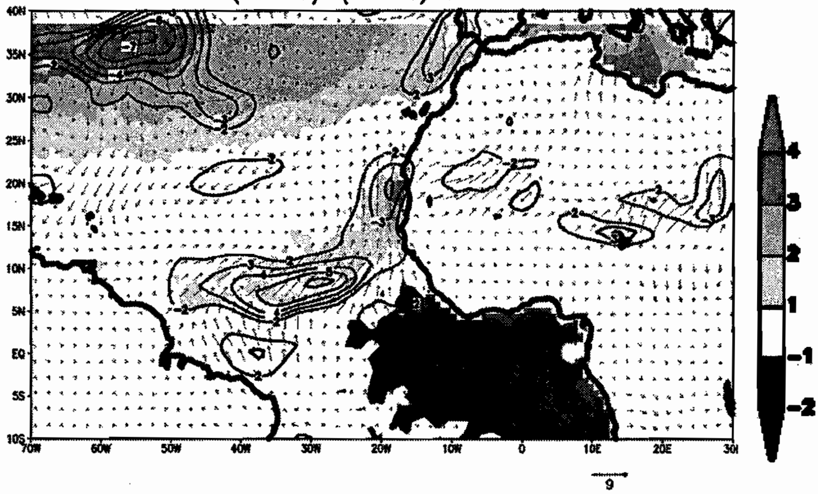

Figure 1: SST (shaded) and wind modulus (contour lines) differences between t0+15 days and t0-15 days

The oceanic counterpart in a numerical simulation

We analyse this SST response in an oceanic general circulation model by using the OPA/ORCA model of LODYC/IPSL forced by ERS-ECMWF based bulk formula over the 1992-2000 period. Since the ocean model and the surface bulk fluxes are able to represent the observed SSAT dipole describing below, we examine the respective contribution of both oceanic and atmospheric dynamics to this SST dipole through a mixed layer heat budget. The analysis of the mechanisms of mixed layer temperature change around the onset shows a significant contribution of both atmospheric and oceanic forcings. Each physical process at play (e.g. upwelling, horizontal transport, latent heat flux, etc....) is analyzed in terms of positive or negative feedbacks on the northward migration of the ITCZ. Concerning the oceanic dynamics contribution, the horizontal processes tend to push the ITCZ poleward while the vertical processes tend to stabilize it. Concerning the atmospheric forcing, the experiment shows that latent heat fluxes contribute to cold SST in the Western half of the Atlantic and in the Guinea Cost and solar heating contributes to warm SST in the Eastern half of the Atlantic and along the Equator. It is also interesting to notice that the atmospheric forcing is strongly influenced by the mixed layer depth suggesting a feedback between oceanic and atmospheric processes.

References

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LA MISE EN PLACE DE LA MOUSSON EN AFRIQUE DE L'OUEST : LES DYNAMIQUES ATMOSPHERIQUES ET OCEANIQUES

Les pluies au Sahel apparaissent lors d'une unique saison pendant la mousson d'été en Afrique de l'Ouest. Le démarrage de ces pluies, en liaison avec la migration saisonnière de la Zone de Convergence InterTropicale (ZCIT) est donc un paramètre important pour l'agriculture et la gestion des ressources en eau.

En utilisant des données de pluies et d'OLR sur la période 1968-2002, on montre que la migration saisonnière de la ZCIT est caractérisée par un déplacement rapide d'une première position d'équilibre à 5N en Mai-Juin à une autre position d'équilibre à 10N en Juillet-Aout. Une analyse composite des champs de réanalyses NCEP montre que ce déplacement rapide, lié à la mise en place de la mousson en Afrique soudano-sahélienne, s'accompagne d'un renforcement de la circulation associée à la dépression thermique saharienne et à un renforcement des advections zonales d'humidité sur le continent.

En utilisant les données de SST (TMI) on montre que la mise en place de la mousson est caractérisée par un dipôle thermique sur l'Atlantique qui est favorable à la migration vers le Nord de la ZCIT. Une simulation du modèle OPA/ORCA du LOCEAN/IPSL forcé par ERS et les réanalyses ECMWF permet d'analyser les contributions océaniques et atmosphériques de ce dipôle en décomposant les différents termes du budget de chaleur dans la couche mélangé océanique.

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Extended abstracts

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AMMA International Project Office
IPSL/UPMC
Post Box 100
4, Place Jussieu
75252 PARIS cedex 5

Web : http://www.amma-international.org/
Email amma.office@ipsl.jussieu.fr

Tel. +33 (0) 1 44 27 48 66
Fax +33 (0) 1 44 27 49 93

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