4B.2 CHARACTERIZATION OF THE DIURNAL CYCLE OF THE WEST AFRICAN MONSOON AROUND THE MONSOON ONSET

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1. INTRODUCTION

Rainfall over West Africa is linked to the meridional migration of the Inter-Tropical Convergence Zone (ITCZ). Although the diurnal cycle of deep convection in the ITCZ has been widely studied, showing a enhancement in late afternoon and a peak in the evening (Yang and Slingo 2001, Mohr 2004), very few studies have documented the diurnal cycle of the basic features of the West African Monsoon (WAM), such as the monsoon flow and the Saharan Heat-Low (SHL), and how the different processes interact at this time-scale. This study investigates the diurnal cycle of the West African monsoon (WAM) and its seasonal modulation with particular focus on the monsoon onset period.

2. MATERIAL AND METHODS

A composite analysis around the monsoon onset date (Sultan and Janicot 2003) is applied to the 1979-2000 NCEP/DOE and ERA40 reanalyzes at 0000, 0600, 1200 and 1800 UTC. We then performed an Extended Empirical Orthogonal Function (EEOF) analysis of the four daily values of composite atmospheric fields in order to highlight the dominant spatial and seasonal patterns of the WAM diurnal cycle. The detailed analysis of the two first leading modes reveals interesting features in both the WAM seasonal and diurnal cycles.

3. RESULTS AND DISCUSSIONS

3.1 The two leading modes

The dominant mode characterizes the progressive installation in July-August of the Hadley-type circulation with deep convection around 10°N surrounded by two subsiding branches at 5°S and at 25°N (Fig.1). This circulation is maximum in July and August and shows a distinct diurnal cycle. It is maximum during daytime (1800 UTC in NCEP/DOE reanalysis) and minimum at night (0600 UTC in NCEP/DOE reanalysis). In the lower levels, it is associated with an intensification of the southwesterly winds between 15°N and 20°N and dry convection at 20°N overnight.

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The second mode describes mainly the onset stage of the monsoon. The Saharan Heat Low (SHL) circulation with strong south-westerly winds between 10°N and 15°N and dry convection at 15°N, maximum at night (0000 and 0600 UTC in both NCEP/DOE and ERA40 reanalyses), is very active during May and June. This mode is coherent with the results of Sultan and Janicot (2003) showing that the two months preceding the monsoon onset is characterized by a strong influence of the SHL dynamics controlling the circulation in the low and mid-levels. After the monsoon onset, this circulation weakens substantially leaving place to a northward shift of deep convection from 5°N to 10°N.

3.2 The nocturnal jet

In the lower levels, the main feature of the diurnal cycle of the monsoon is the nocturnal jet already studied in August 2000 by Parker et al. (2005). Both in ERA40 and NCEP/DOE reanalyzes, the monsoon winds are the strongest at night and the weakest during the day. The nocturnal jet experiences a seasonal northward migration. The northward progression appears to be faster after the monsoon onset and is associated with nocturnal jet intensification. The origin of such diurnal cycle of the low level winds is known (but only recently investigated at such large spatial scales). During the day, convective turbulent mixing is large, whereas in late afternoon, radiative cooling inhibits thermal turbulence so the surface pressure gradient imposed by the SHL induces a geostrophic response of the winds accelerating towards low pressure, thus forming the nocturnal jet (Blackadar 1957).

3.3 The upper levels

In the upper levels, the maximum of upward motions in the ITCZ is followed 12 hours later by an ascent anomaly in the SHL region. This interaction may be caused by the strong ascending motion in the ITCZ generating a gravity wave that propagates northward and reaches the SHL region 12 hours later (Peyrille and Lafore 2006). This 12 hours lag between upward motions in the ITCZ and in the SHL region can be seen in NCEP/DOE reanalyzes and less clearly in ERA40 reanalyzes before and after the monsoon onset (Fig.1).

The diurnal cycle of the vertical velocity in the deep convection area appears to be different in

NCEP/DOE and ERA40 reanalyzes. NCEP/DOE (ERA40) reanalysis shows a distinct diurnal cycle of deep convection in the ITCZ with a peak of upward motions at 1800 UTC (0000 UTC) in July and August at 10°N. Before the monsoon onset, the diurnal cycle of NCEP/DOE and ERA40 deep convection peaks at 1200 UTC at 5°N (Fig.1).

4. CONCLUSION

As the composite approach smoothes the details of the synoptic features and introduces some noise induced by the uncertainty of few days in the detection of the WAM onset, the present study can not go further in the understanding of the processes linking the SHL, the nocturnal jet and the northward migration of the ITCZ. Such processes should be analyzed through case studies using for instance the four atmospheric soundings per day in West Africa performed during the intensive field experiment of the AMMA (African Monsoon Multidisciplinary Analyses) program in 2006.

5. REFERENCES

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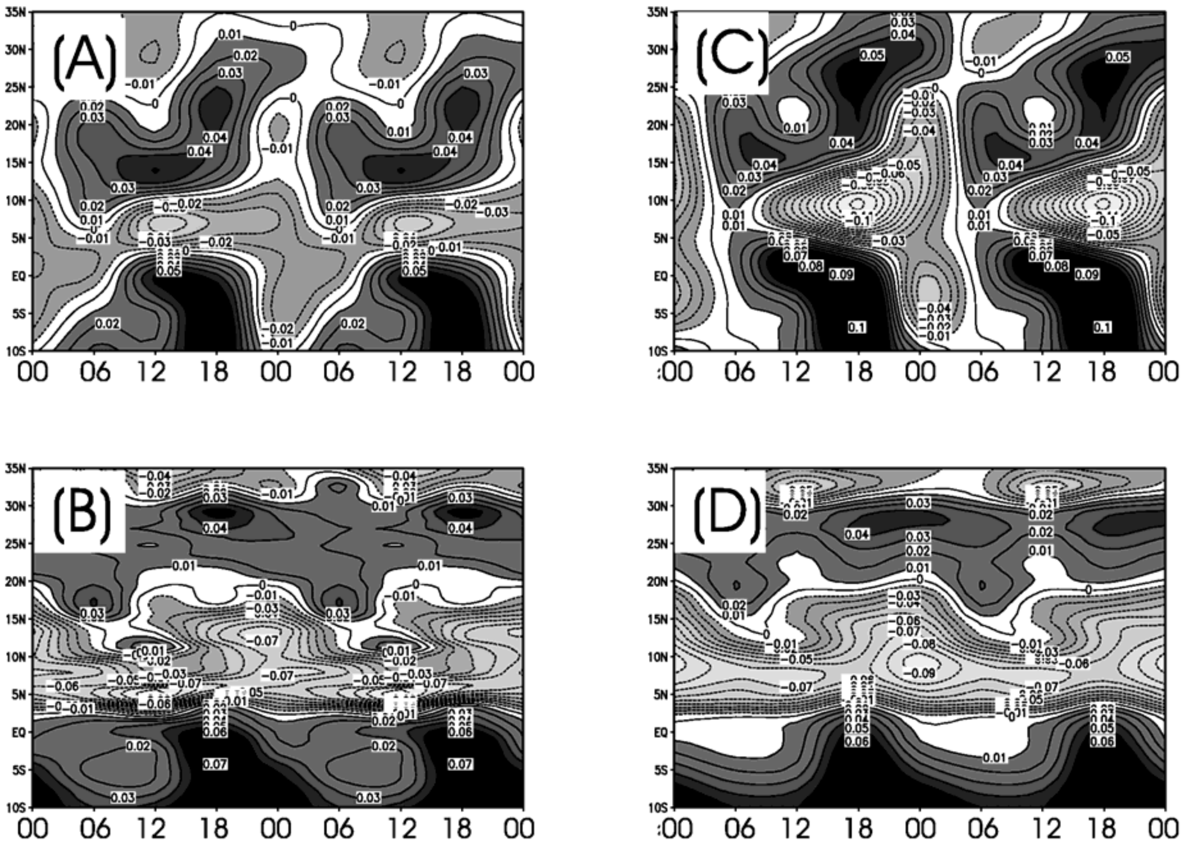

Figure 1 : Mean vertical wind velocity (Pa/s) at 400 hPa in average between 10°W and 10°E over the pre-onset period (i.e. May-June) in NCEP/DOE (a) and ERA40 (b) reanalyses. The average over the post-onset period (i.e. July-August) is shown in (c) and (d) using respectively the NCEP/DOE (c) and ERA40 (d) reanalyses. Negative (positive) values depict upward (downward) wind.