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THE ROLE OF THE INTRA-SEASONAL TIME SCALE VARIABILITY IN THE WEST AFRICAN MONSOON

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1. INTRODUCTION

The variability of the monsoon intensity over West Africa at intra-seasonal time scales has been studied mostly in regard to synoptic variability associated to easterly waves located in two spectral windows 3-5 days and 6-9 days. A more precise investigation focused on the 10-60 days variability (Janicot[1] and Sultan, 2001) has been performed over the 1968-1990 period using different datasets : the daily rainfall amounts from IRD(Institut de Recherche pour le Developpement) the NOAA Outgoing Longwave Radiation (Grueber and Krueger, 1974) and the NCEP/NCAR Reanalyses (Kalnay et al., 1996).

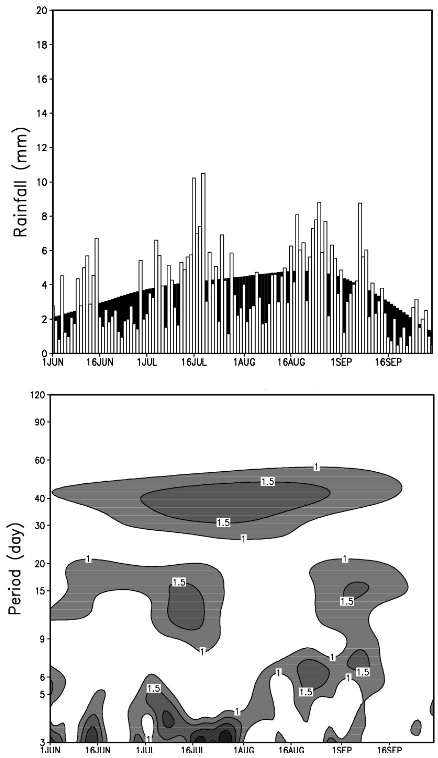

__Figure 1.__ (Top) Daily rainfall time series (mm) from June to September 1968 averaged over the grid points from 10W to 10E and 12.5N and 15N (white) and in black the corresponding index filtered above 60 days. (Bottom) Wavelet analysis of the daily rainfall time series from June to September 1968 averaged over the grid points from 10W to 10E and 12.5N and 15N.

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2. RAINFALL FLUCTUATIONS AT INTRA-SEASONAL TIME SCALE

Spectral analyses such as Wavelet and Fourier transforms applied each year to a daily sahelian rainfall index depict the occurences of intra-seasonal modulation of convection localized in two different spectral windows : between 10 and 25 days, and between 25 and 60 days. The figure 1 shows an exemple of these two patterns of intra-seasonal variability by computing a wavelet analysis on the daily rainfall averaged over the grid points from 10°W to 10°E and from 12.5°N to 15°N for the rainy season of the year 1968. The regional mean has reduced the variance of the day-to-day fluctuations to highlight the intra-seasonal signal centered around 15 days and around 40 days.

To describe the influence of the 10-60 days variability on the rainfall seasonal cycle, we have filtered the data using a non-recursive filter to compute an intra-seasonal index as the ratio of the 10-60 days filtered rainfall to the seasonal cycle where only periodicities greater than 60 days are retained. For the year 1968 (not shown) the rainfall index points out several intra-seasonal modulations up to 50% of the seasonal cycle both for wet and dry sequences suggesting the existence of enhanced and weakened phases of the West African monsoon.

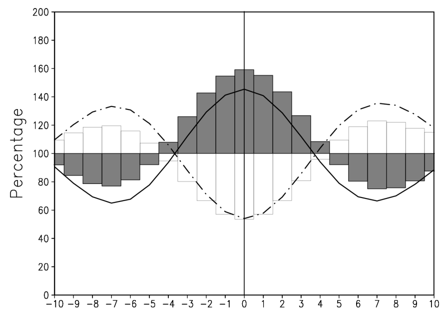

__Figure 2.__ Time series of wet (dark bars) and dry (white bars) composite sequences averaged over the periods June-September 1968-1990. These values (bars) represent the ratio of the daily rainfall where periodicities lower than 10 days are removed to the seasonal-filtered rainfall signal where only periodicities greater than 60 days are retained (in percentage). The black lines represent the similar ratio but filtered to remove periodicities greater than 25 days.

A composite analysis over the 1968-1990 period based on the dates (t0) where this index is maximum (minimum) and greater than 30% of the seasonal rainfall cycle has been performed to define wet (dry) sequences. Both of the composite mean wet and dry sequences (bars in Fig.2) last 9 days and belong to a quasi-periodic oscillation characterized by a period of 15 days. In regard to this dominant periodicity we performed the same composite analysis by using a 10-25 days (lines in Fig.2) to better fit the predominant variability of the intra-seasonal rainfall modulations.

3. THE ENHANCED AND WEAKENED MONSOON PHASES

To characterize the atmospheric circulation associated to these enhanced and weakened monsoon phases, we performed the same composite analysis on the raw wind field at 925hPa and the NOAA-OLR (Fig.3). The mean composite spatial pattern, computed as the difference between the wet and the dry phases, points out a westward propagation of both convection and wind field anomalies. The atmospheric structure shows a westward travelling cyclonic circulation centered around 20°N characterized by a speed of about 4° per day, followed by positive anomalies of northward fluxes and convection, consistent with an increase of moisture advection from the Atlantic Ocean as well as from the Guinea Gulf.

The composite study applied to mid and upper winds shows a significant increase (decrease) and northward extension of upward velocity during the enhanced (weakened) monsoon phases in the ITCZ coincident with a decrease (increase) of the dry convection in the heat low and a decrease (increase) of the African Easterly Jet.

CONCLUSIONS

The origin of such fluctuations is still unknown and more must be done to understand the mechanisms involved in. Similar results based on wind fluxes from the Guinea Gulf have been recently published by Carton and Grodsky (2001), suggesting a close interaction with land surface processes. The similarity between the atmospheric pattern associated to this 10-25-day oscillation and the one characterizing the 6-9-day easterly waves (Diedhiou et al., 1999) can also suggest that these rainfall fluctuations could be linked to a particular perturbation of the synoptic easterly wave regime.

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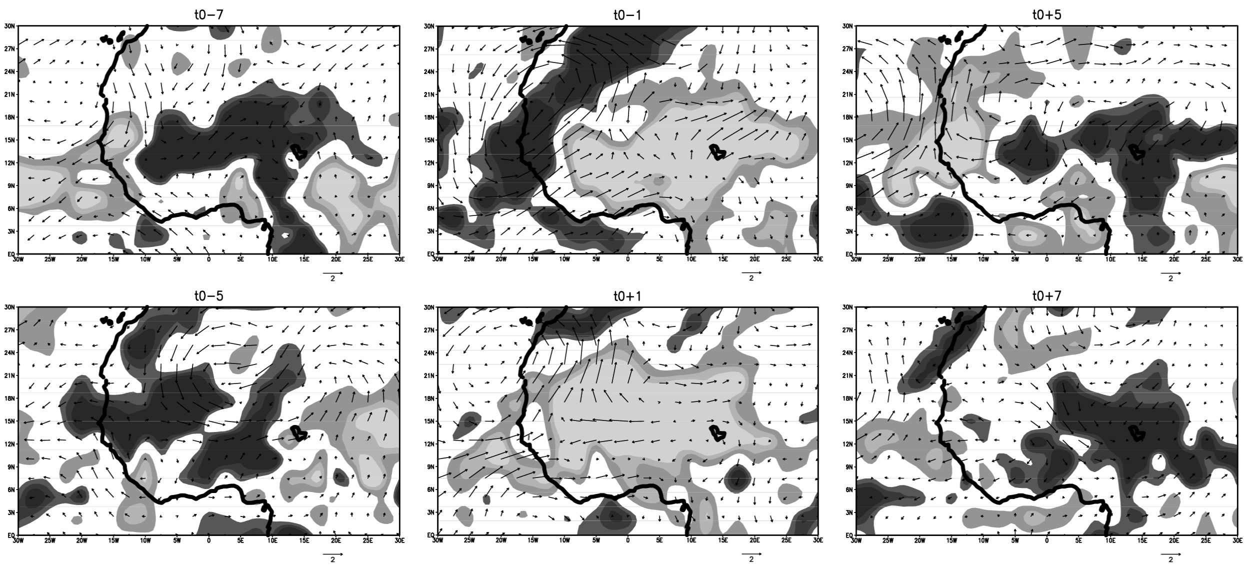

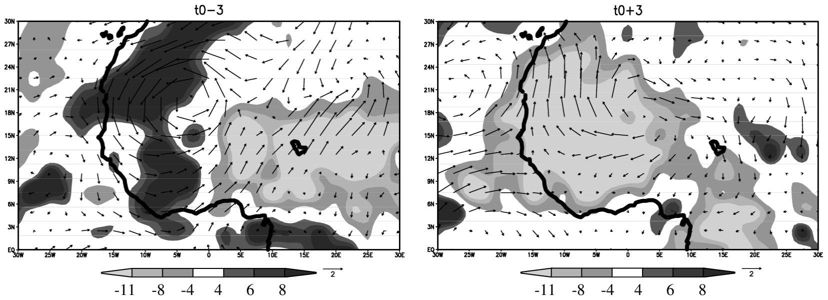

Figure 3. *The composite time sequence of the raw 925hPa wind field (vectors) and OLR (shaded) from t0 minus 7 days to t0 plus 7 days, computed as the difference between the wet and the dry sequences. The wind scale is displayed below the figures (m/s) and the OLR difference is expressed in W/m².*