9B.1 RAINFALL VARIABILITY AND CONVECTION IN AFRICAN EASTERLY WAVE REGIME

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1. Introduction

Using NCEP/NCAR reanalyses, NOAA OLR and observed IRD rainfall over West Africa from 1979 to 1990, we investigated the variability of rainfall and convection over Niamey (Niger, West Africa) during African Easterly waves activity. After detecting on each year the dates of 3-5-day wave activity and considering thresholds on the associated observed rainfall and convection, we have identified two classes of convective events. The first one defines the so-called *wet convective events* that are associated with cold top clouds and strong rain amount at the surface. The second class is the class of *dry convective events* associated to cold top clouds and weak observed rain amount at the surface.

2. Wet and dry events in easterly waves.

Figure 1 shows for a wet year (1988, Fig. 1a), a normal year (1989, Fig. 1b) and a dry year (1984, Fig. 1c), the evolution from June to September of the wave regimes characterized by a wavelet analysis with Morlet wavelet on the meridional wind at 700 hPa, the NOAA OLR and the observed daily IRD rainfall at Niamey grid point (Torrence and Compo, 1998).
Wavelet analysis (shaded) confirms that most of the disturbances over SAHEL have a period lying between 3 and 5 day. The maximum in the 6-9-day band period is associated to another wave regime occurring mainly in the beginning and in the end of the rainy season (Diedhiou at al., 1999). If we consider all the days affected by a 3-5-day wave regime, we note that it is difficult using the number of waves per year, to distinguish wet (1988) and dry (1984) year over SAHEL. These three years was quite equally affected by the same number of 3-5-day waves. In 1989 (Fig.1b), wet regimes occur from the 1st to 10 August and around 7 September; these waves are associated to cold clouds and high rainfall heights. This is the common case. The wave regimes between 8-16 June and around 21 August 1989 are associated to dry events with cold clouds (OLR between 180 and 200 W/m2 for the first case and less than 160 W/m2 for the second) and quite no observed rainfall at the surface. As the modulus of the wavelet is positively correlated to the variance of the wave, this means that the variance of the wave, considered only from the fluctuations of the meridional wind, is not a good indicator of the rainfall variability.

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The wave regime around 16 July 1989 is not associated to convection and observed rain at the surface. This means that one can has wave without convection (cold cloud). The strong wavelet modulus associated to this last wave regime is a good example of the non-correlation between the variance of the wave and the rain height and suggest that the dynamic is not sufficient to explain the rain height associated to the wave.

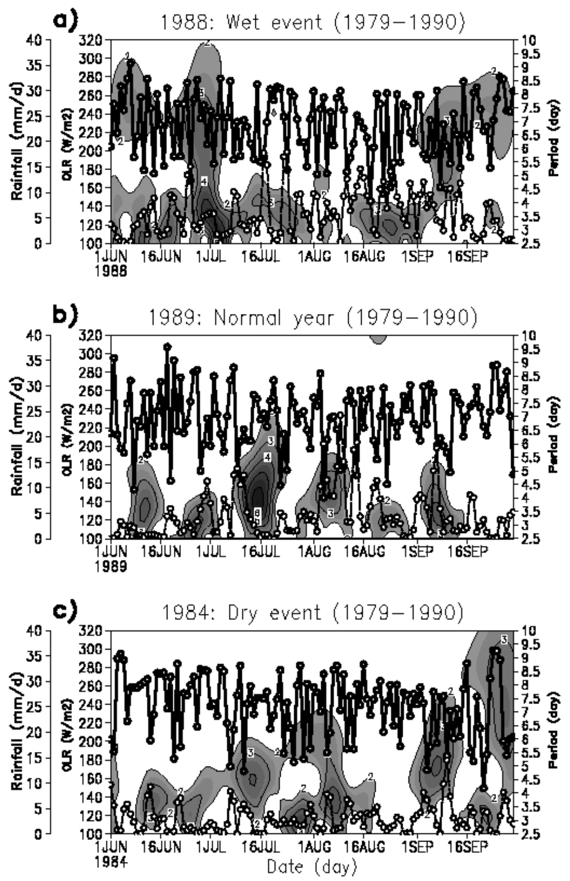

Figure 1: June to September evolution of the different wave regimes (wavelet modulus on the meridional wind at 700 hPa, shaded), the NOAA OLR (line) and the observed daily IRD rainfall (dashed line) in 1988 **(a)**, 1989 **(b)**, 1984 **(c)**.

On 14 August 1989, we observe strong convection (OLR less than 170 W/m2) and high rain heights (up to 15mm); this means that convection can occur without wave. However, strong convection could be associated to weak rain height: on 19 June 1989, OLR is also less than 170 W/m2 but the observed rain height amounts around 5mm.

3. The associated composite patterns.

During these 12 years, considering all days that waves occurs, we note that we have 30% of waves without convection, 48% with dry convective events and 22% with wet events.

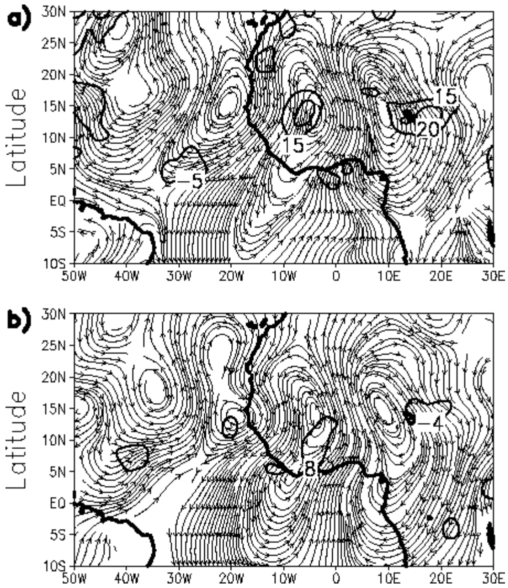

Figure 2: Mean composite wave pattern and associated OLR anomaly for the wet wave **(a)**, the dry wave **(b)**.

The associated perturbed wind fields and OLR anomaly for these two cases are displayed on figure 2. These patterns are similar to the mean structure of the well know 3-5-day wave. For all the cases, we note a well-marked trough extending meridionaly from 30°N to 10°S, with a southeast - northwest tilt north of the AEJ and southwest - northeast tilt south of it (Reed and al.,1977). This is consistent with a zonal momentum transport from the jet to the wave and consistent with a development of these waves from a barotropic instability of the Jet. The coldest clouds associated to the deeper convection are find in the case of wet wave (Fig.2a). The area of maximum convection is found ahead of the trough, in the northern flux and is found mainly over the Sahelian area. Dry convective event (Fig.2b) is a little bit higher than the mean and extends over Guinea Coast. Its maximum is located in and behind of the trough in the southern flux.

Figure 3 displays the vertical cross sections on Niamey longitude (2.5°E) of mean zonal wind. The pattern of zonal wind (Fig. 3a) is different in wet and dry regimes. In the lower levels, the latitudinal extension, the magnitude of the westerlies and the thickness of the monsoon are greater in wet wave regime than in dry wave regime. The AEJ magnitude is weaker in wet regime but at 200 hPa, the TEJ magnitude is greater than in dry regime. The patterns of the associated vertical velocity (not shown) are also different; in wet regime, the core in the ITCZ of upward motion in the upper levels are greater, while, in wet regime, it is mainly the dry convection over the heat low, north of the AEJ, which is higher.

The vertical profiles of mean meridional filtered wind variances are shown in Figure 3b. In wet regime, the magnitude of the variance is greater in the mid troposphere while in dry regime, the maximum of variance is found in the lower levels over the desert. The instability of the AEJ can produce two variances maximum, one in the mid troposphere south of the "shear" jet resulting mainly from the barotropic conversion of energy, and one north of the "desert" jet in the lower layers mainly resulting from the temperature gradient and baroclinic instability (Thorncroft, 1995).

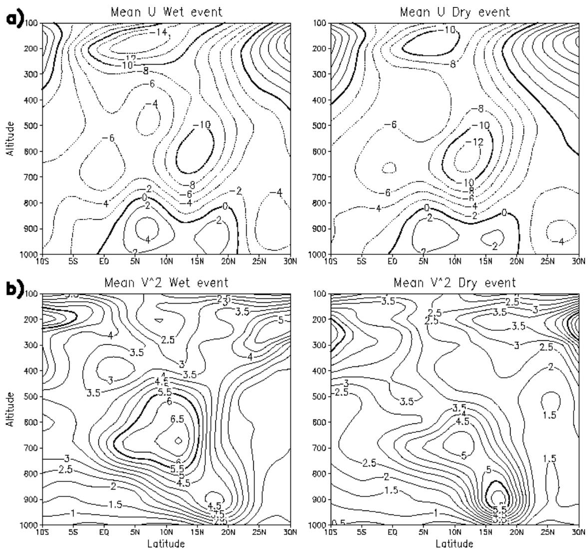

Figure 3: Vertical cross sections over Niamey longitude (2.5°E) of zonal wind (a) and variances terms v-v **(b)**.

4. Perspectives.

This work needs to be completed by a case study using radiosounding data in order to investigate the differences in the vertical profiles of these waves. This study has shown the necessity to well define the wave efficiency and shows the non correlation between the easterly wave activity and the seasonal amount of rainfall over West Africa. In summary: Convection and rainfall can occur without any easterly waves present. Not all easterly waves are associated with rainfall.

5. References:

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