An evaluation of the applicability of West-Central Brazil summer monsoon indices

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INTRODUCTION

Different criteria have been used to identify the monsoon onset, demise and intensity over different monsoon regions. The use of a monsoon index is useful in studying the interannual variability of the monsoon activities.

The West-Central Brazil (WCB) was chosen to study because it includes a portion of the summertime rainfall maximum where the mean annual cycle of circulation is highly related to the South America monsoon system as identified by Gan et al. (2004). The WCB has as monsoon characteristics an upper level anticiclonic circulation, low-level cyclone and temperature maximum just before the rainy season. However, the wind reversal in low levels does not happen as in Asian monsoon, just the zonal wind changes its direction (Gan et al, 2004). Reversal can be seen if the annual cycle is removed (Zhou and Lau, 1998).

To identify some monsoon indices associated with the wind field that determine the onset and demise date and the intensity of the rainy season, is important because the skill of the climatic models to predict the precipitation is low in WCB. But the wind components have a better skill, and this region contains the headwaters of major rivers, such as Araguaia and Paraguay, which flow into the Amazon and La Plata basins, respectively.

OBJECTIVES

The aim of this study is to evaluate the applicability of some monsoon indices based on the wind to identify the onset and demise dates and the quality of the rainy season in the WCB. This information is important, since the skill of the climatic models to predict the wind related to WCB is better than the precipitation prediction.

DATA

The data used in this study are gridded daily precipitation analyses for Brazil, from the Climate Prediction Center and monthly long-term mean, monthly mean and pentad of the daily averaged fields of wind from the NCEP/NCAR reanalysis. The period used is July/1979-June/1997.

METHODOLOGY

As the onset of monsoon is associated with changes in the circulation features in lower and upper troposphere, we propose some indices associated with the vertical wind shear and the wind in lower and upper levels.

The first one the Meridional Wind Shear Index (MWSI)is the shear between 850- and 200-hPa averaged over 40W-30W and 10S-5S area. This index is chosen because the meridional wind in both levels is well correlated with the precipitation over the WCB, as we can see in the Fig. 1 and the MWSI represents the influence of the regional Hadley circulation. This index was first propose by Goswami et al. (1999) to the Indian subcontinent, northern Bay of Bengal and a portion of the south China.

The Zonal Wind Shear Index (ZWSI) is the shear between 850- and 200-hPa averaged over 60W-50W and 15S-10S area. This area was selected because the precipitation and the zonal wind at both levels are well correlated, as we can be seen in the Fig. 2.

The 850-hPa Zonal Wind Index (PZWI) is used because Gan et al. (2004) identified that the zonal wind is easterly during the dry season and westerly in the rainy season and this reversal occurs during the onset. They associated this index with the precipitation index to identify the onset and demise date. In their criterion the onset (demise) of the rainy season was defined as the first occurrence of 850-hPa westerly (easterly) winds along 60°W in the band 10°S-20°S together with rainfall rates greater (less) than 4 mmd^{-1} for at least 75% of the subsequent 8 pentads.

To evaluate of the influence the low-level jet on the precipitation in the WCB we define the 850-hPa zonal and meridional index (UVI) that is the sum of the 850-hPa zonal wind averaged in the 60W-50W and 15S and 10S area with the 850-hPa meridional wind averaged in the 65W-60W and 25S-20S area. Gan et al (2004) and Ferreira (2003) identified that during the (active) break periods in the rainy season there is a cyclonic (anticyclonic) anomalous circulation.

The influence of the Bolivian high circulation was analyzed using the 200-hPa zonal wind index. This index is defined as the sum of the zonal wind averaged in the 60W-40W and 22.5S-17.5S area (subtropical jet) and in the 60W-50W and 5S-2.5N (easterlies) area. Gan et al. (2004) and Zhou and Lau (1998) observed that during the break period the Bolivian high is displaced to south.

These five indices and the linear correlation coefficient between the precipitation over the WCB and each index were calculated to the pentads series and month mean series.

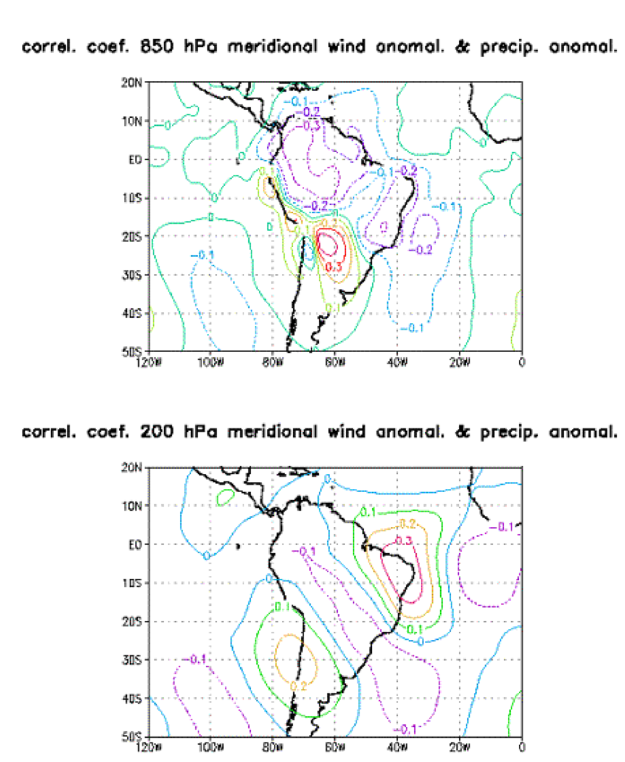

Fig. 1. Correlation coefficient between the precipitation over WCB and the meridional wind.

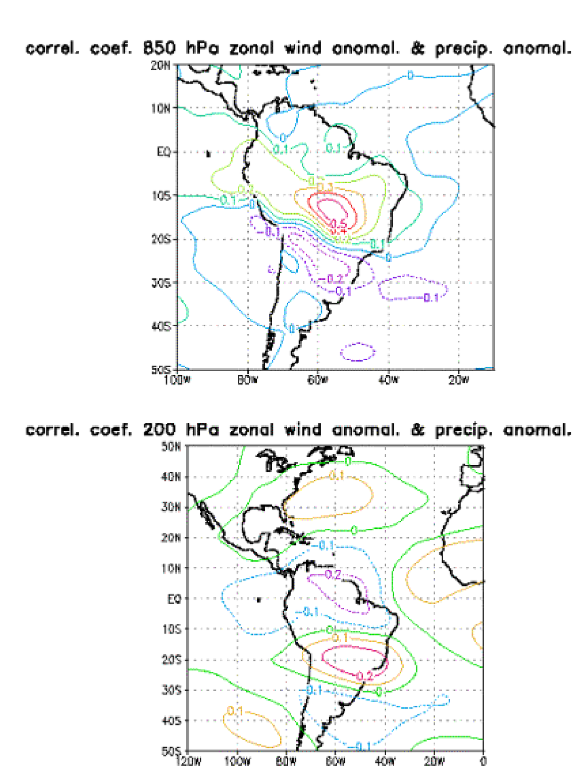

Fig. 2. Correlation coefficient between the precipitation over WCB and the zonal wind

RESULTS

To verify if theses five indices are associated with the precipitation over the WCB we calculated the correlation coefficient with lags from –10 to 10 in the pentadal series. In Fig. 3 we can see that the MWSI, the UVI and the 200-hPa zonal wind index are positively correlated, but the ZWSI and the 850-hPa zonal wind index are negatively correlated. All the correlation coefficients are statistically significant at the 99% confidence level. The maximum values of theses indices are more in the lag=0, except in the 200-hPa zonal wind index that the maximum occurs 4 pentads before. Similar result was observed by Joseph and Sijikumar (2004).

The Figures 4 to 8 show the pentadal series of the five indices for some specific years with respective precipitation series averaged in the 60W-50W and 20S-10S. These series are smoothed with a 3-pentad running mean. We can see that the UVI, the MWSI and the 850-hPa zonal wind represent very well the intraseasonal variability (break and active periods) of the precipitation. While the ZWSI and the 200-hPa zonal wind index do not represent very well this variability.

The onset and demise dates were identified using theses indices which are showed in the Table 1 and 2, respectively. The criterion used for the 850-hPa zonal wind is the same as that of Gan et al. (2004). After the adjustment of the index values in the coordinate, we used the threshold of 4ms^{-1} for the ZWSI and UVI and 8ms^{-1} for 200-hPa zonal wind index to identify the onset and demise dates. For the MWSI we used the criterion the reversal of the signal. A comparative analysis of the onset data of the five indices, we see that the UVI and MWSI have a tendency to delay and the ZWSI the anticipate the rainy season. For the demise date the 200-hPa and MWSI have the tendency to delay the withdrawal of the rainy season. In the same season, normally the difference of the delay index and the early index to the onset date is around a month, except in 1990/1991 season when the difference was more than 3 months. For the demise dates, this difference is not more than 2 months, but normally is a month or less.

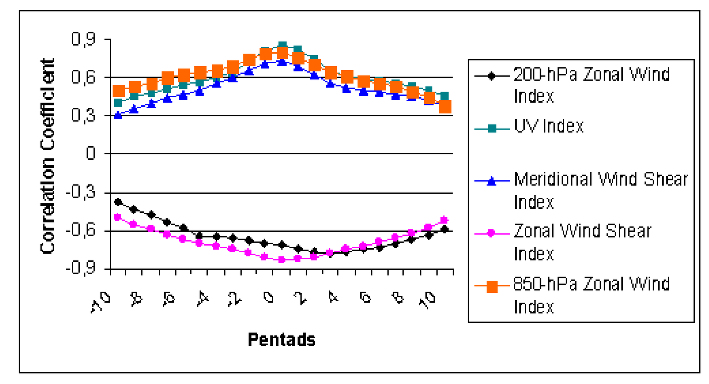

Fig. 3. Correlation coefficient between the precipitation over WCB and the five monsoon indices.

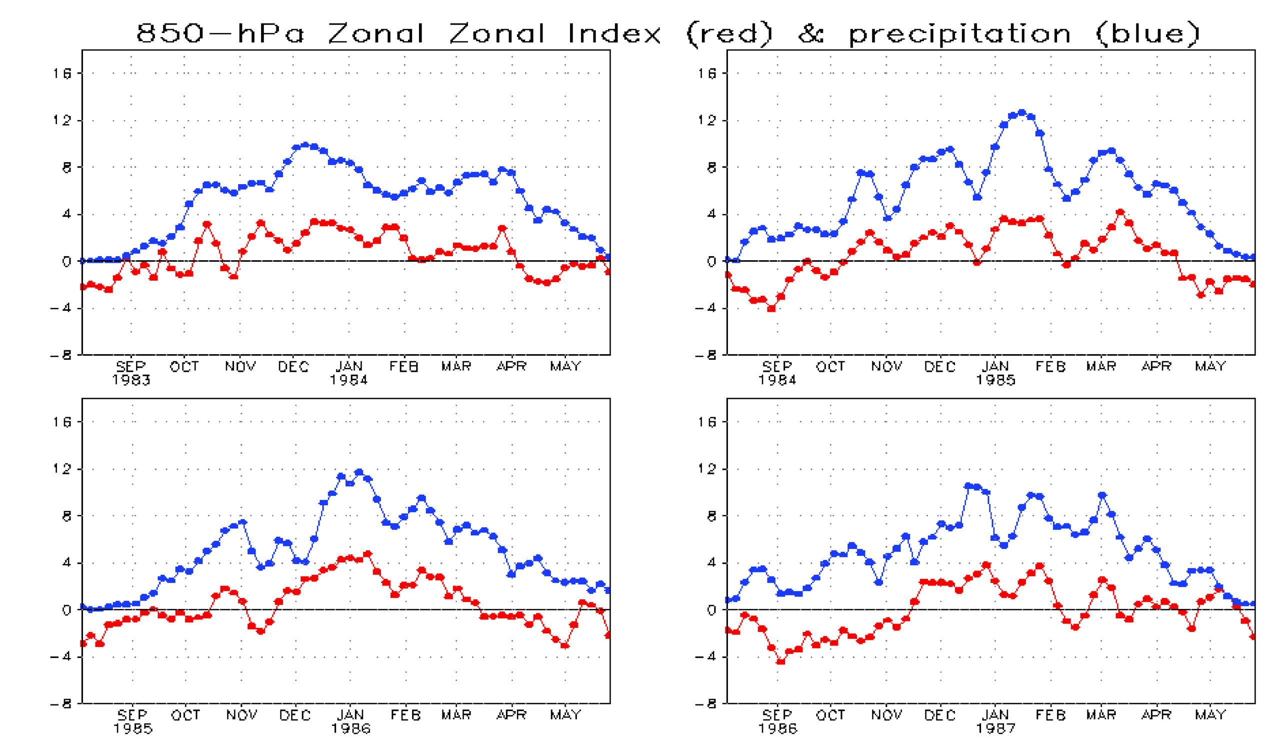

Fig. 4. Pentadal series of the preciptation (blue)over WCB and 850-hPa zonal wind index (read).

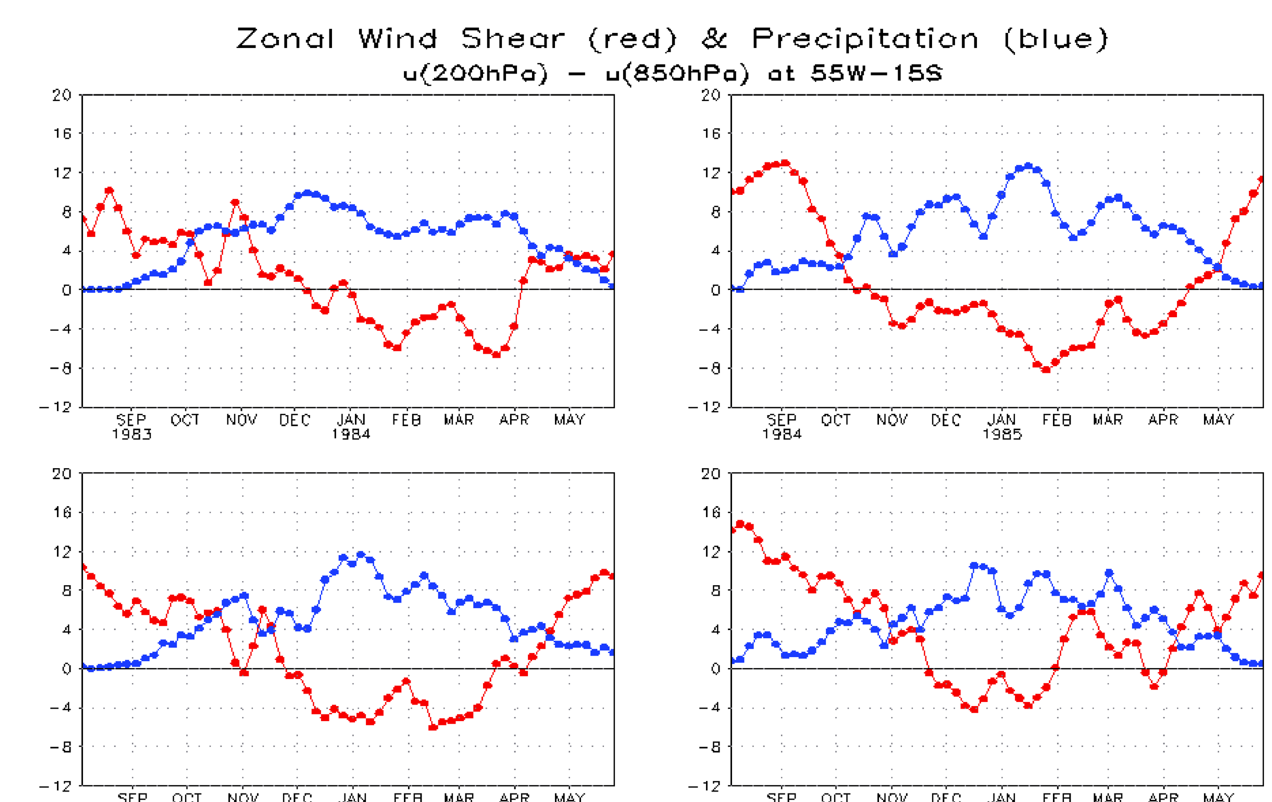

Fig. 5. Pentadal series of the preciptation (blue)over WCB and ZWSI (read).

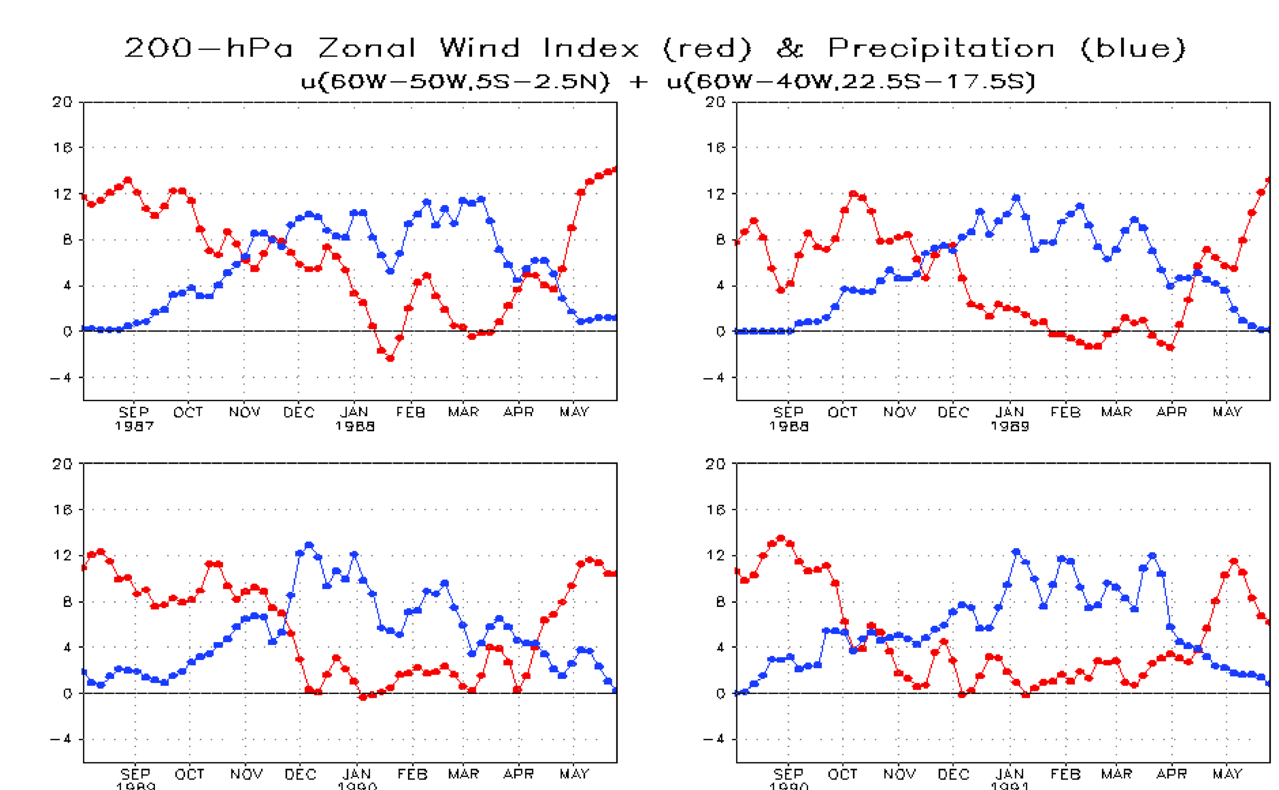

Fig. 6. Pentadal series of the preciptation (blue)over WCB and 200-hPa zonal wind index (read).

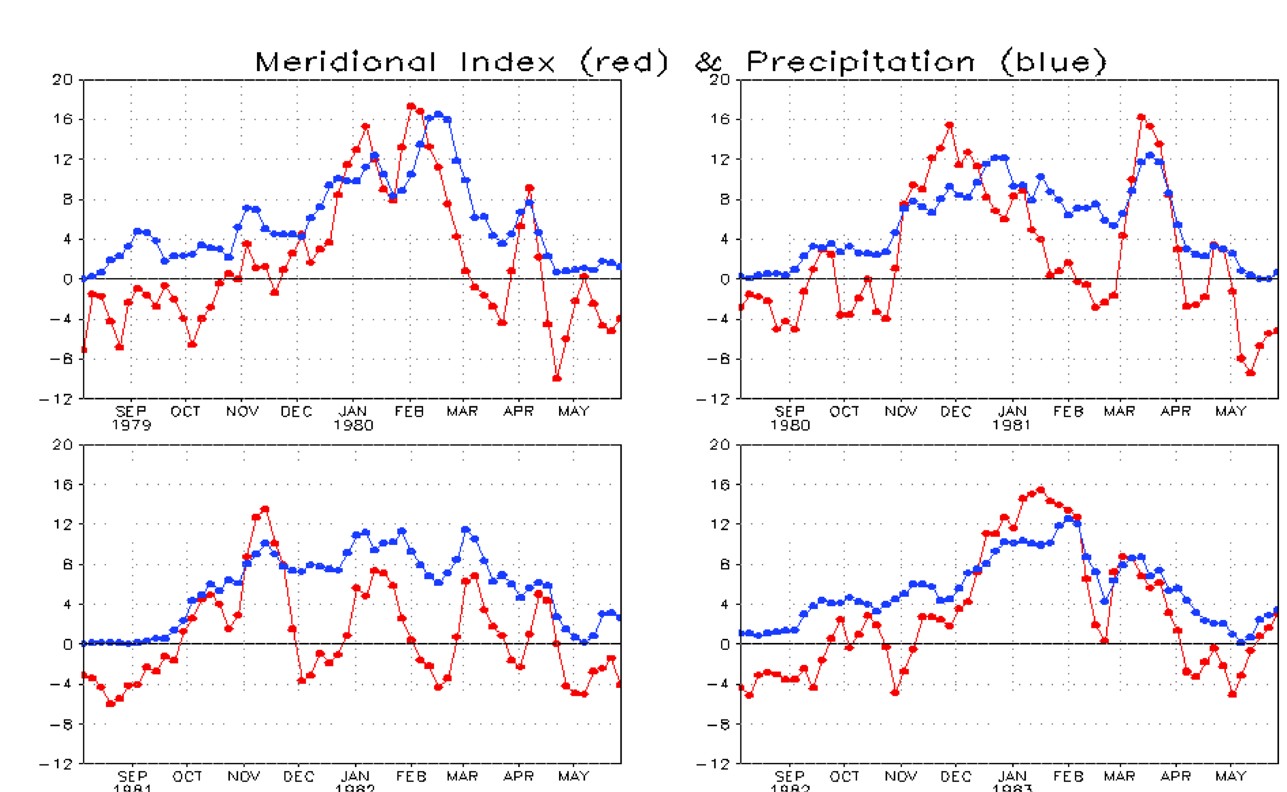

Fig. 7. Pentadal series of the preciptation (blue)over WCB and MWSI (read).

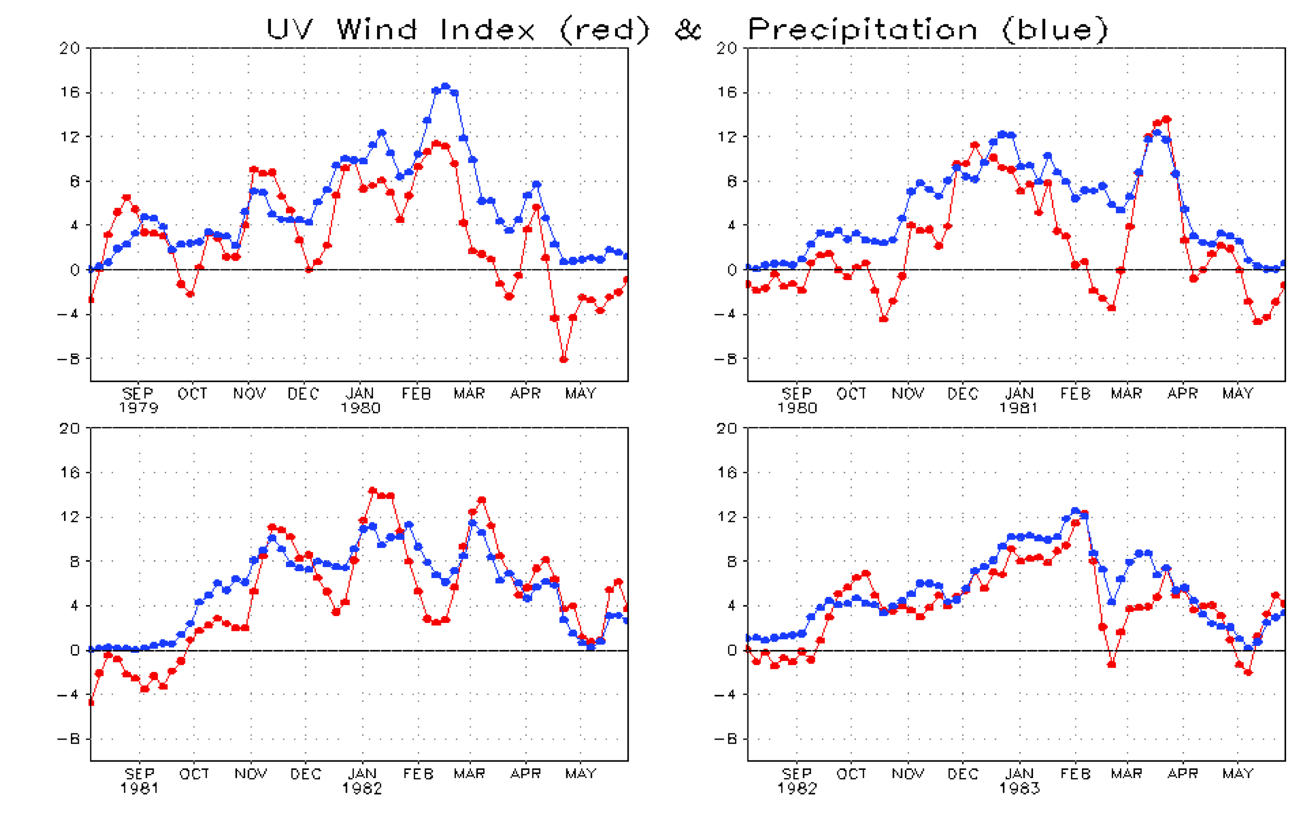

Fig. 8. Pentadal series of the preciptation (blue)over WCB and UVI (read).

Table 1. Onset dates of the rainy season for the five indices

	850-hPa zonal wind	ZWSI	UVI	MWSI	200-hPa zonal wind
79/90	04 Nov	04 Nov	30 Oct	30 Oct	30 Oct
80/81	30 Oct	30 Oct	29 Nov	04 Nov	05 Oct
81/82	05 Oct	15 Sep	09 Nov	05 Oct	30 Oct
82/83	15 Sep	25 Sep	30 Sep	30 Sep	15 Oct
83/84	10 Oct	15 Oct	15 Oct	20 Oct	29 Nov
84/85	15 Oct	10 Oct	20 Oct	19 Nov	10 Oct
85/86	05 Oct	30 Oct	30 Oct	30 Oct	04 Nov
86/87	14 Nov	09 Nov	04 Dec	14 Dec	04 Nov
87/88	25 Oct	15 Oct	30 Oct	09 Nov	20 Oct
88/89	25 Oct	25 Oct	15 Oct	05 Oct	19 Nov
89/90	10 Oct	15 Oct	20 Oct	30 Oct	24 Nov
90/91	30 Sep	15 Oct	04 Dec	03 Jan	10 Oct
91/92	04 Nov	05 Oct	09 Nov	09 Nov	10 Oct
92/93	25 Sep	15 Oct	04 Nov	30 Sep	15 Oct
93/94	15 Oct	25 Sep	29 Nov	29 Nov	15 Oct
94/95	20 Oct	10 Oct	19 Nov	14 Nov	30 Sep
95/96	10 Oct	15 Oct	10 Oct	19 Nov	25 Oct
96/97	10 Oct	10 Oct	19 Nov	05 Oct	10 Oct

Table 2. Demise dates of the rainy season for the five indices

	850-hPa zonal wind	ZWSI	UVI	MWSI	200-hPa zonal wind
79/90	18 Apr	18 Apr	27 Fev	18 Apr	08 May
80/81	08 Apr	08 Apr	19 Mar	08 Apr	13 Apr
81/82	23 Apr	23 Apr	28 Apr	28 Apr	13 Apr
82/83	18 Apr	23 Apr	23 Apr	08 Apr	13 May
83/84	13 Apr	_____	13 Apr	28 Apr	_____
84/85	03 May	15 May	29 Apr	18 Apr	08 May
85/86	03 Apr	28 Apr	29 Mar	_____	03 May
86/87	08 Apr	13 Apr	18 May	02 Jun	28 Apr
87/88	28 Apr	03 May	28 Apr	28 Apr	03 May
88/89	23 Apr	13 May	24 Mar	13 May	18 May
89/90	23 Apr	08 May	18 Apr	18 Apr	03 May
90/91	08 Apr	23 Apr	08 Apr	13 Apr	08 Apr
91/92	28 Apr	13 Apr	03 May	13 May	13 Apr
92/93	13 Apr	18 Apr	13 Apr	08 Apr	28 Apr
93/94	23 Apr	28 Apr	18 Apr	18 Apr	13 May
94/95	23 Apr	23 Apr	18 May	23 May	18 Apr
95/96	23 Apr	28 Apr	23 Apr	23 Apr	03 May
96/97	28 Apr	08 Apr	03 May	03 May	28 Apr

CONCLUSIONS

All five indices have a high correlation with the precipitation over the WCB. The 850-hPa zonal index, the MWSI and the UVI pick up very well the intraseasonal variability. The MWSI show a tendency to delay the onset and the demise of the rainy season.

Once these indices are associated with a wind circulation, a dynamic interpretations of the intrannual and intraseasonal variability of these indices can explain how the regional Hadly cell, the zonal wind shear, the upper level anticyclonic circulation and the low level jet stream contribute to anticipate or delay the onset, or the demise, the break, or active, periods and the intensity of the rainy season.

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