12A.5

LONG-TERM VARIATIONS IN INTENSITY AND LOCATION OF THE AFRICAN EASTERLY JET

Amin K. Dezfuli* and Sharon E. Nicholson
Florida State University, Tallahassee, Florida

1. INTRODUCTION

Many studies have been devoted to achieve a better understanding of the African Easterly Jet (AEJ) which is among the most important features affecting the equatorial and tropical Africa climate (e.g. Fontaine et al., 1995). The AEJ found between 600-700 hPa exists due to positive meridional temperature gradient between the warm Sahara Desert to the north and the cool Gulf of Guinea to the south. The axis of this jet appears above the strongest surface temperature gradient (Burpee, 1972) and its intensity varies from 10 m s^{-1} in wet years to 12 m s^{-1} in dry years (Grist et al. 2002). However, its location varies remarkably and is of critical importance in rainfall variability over northern Sahel (Nicholson and Grist, 2001).

It has been suggested that the strength and location of the AEJ is dictated not only by the temperature gradient, which produces a vertical shear, but also by the low level westerlies, upon which the shear is imposed (Nicholson and Grist, 2001). Moreover, the surface wetness gradient can also enhance the temperature gradient (Cook, 1999). It has been noted (e.g., Fontaine et al., 1995; Grist et al., 2002; Nicholson and Grist, 2001) that in wet (dry) years the AEJ tends to be weaker (stronger) and more poleward (equatorward). Lare and Nicholson (1994) suggested some physical mechanism to explain this contrast.

This study aims to (1) provide more insight into the maximum intensity and the corresponding latitude of the AEJ for August, and (2) find the correlation between intensity and latitude. Our study considers the interannual variability of the AEJ; we will examine a longer time period on a broader area than the previous studies (e.g. Newell and Kidson, 1984; Nicholson and Grist, 2001).

2. DATA AND METHODOLOGY

The NCEP Reanalysis Derived data provided by the NOAA/OAR/ESRL PSD, Boulder, Colorado, USA is used for this study. The analyses are carried out for the time period of 1948 to 2003 over a region extending latitudinally from Equator to 20N and longitudinally from 20W to 30E. The AEJ exists in this region located in the North Tropical Africa.

Choosing pressure level of 600 hPa, the maximum intensity of AEJ and its corresponding latitude is provided for August, the month of the maximum intensity. The interannual variability of the intensity and the latitude of the maximum jet are then investigated. Moreover, the linear regression is used to evaluate the correlation between these two variables. The influence of the low level westerlies, NAO and Atlantic Nino on the AEJ are also examined statistically.

3. RESULTS

3.1 Intensity and location of AEJ

The horizental pattern of the AEJ at 600 hPa is assessed over the period of 1948 to 2003. The results reveal a double-core structure in the AEJ which is more clearly recognizable in some years (1949, 1950, 1951, 1953, 1958, 1975, 1980, 1985, 1988, 1995, 1999 and 2003). This suggests the AEJ to be split up into two components: the western component between 20W-5E and the eastern component between 5E-30E (Figure 1).

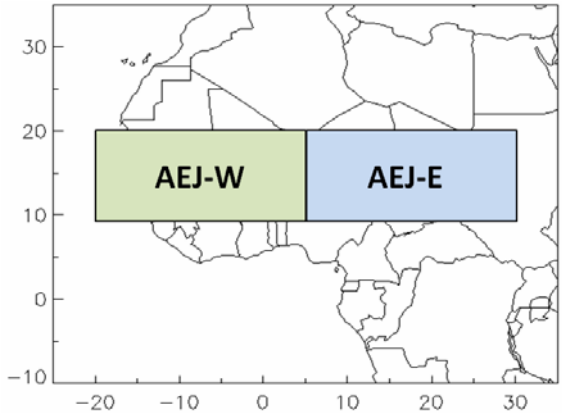

Figure 1. Location of western (AEJ-W) and eastern (AEJ-E) components of the AEJ.

Hereafter, we refer to these components as AEJ-W and AEJ-E, respectively. The maximum intenisty of

---

* *Corresponding author address:* Amin K. Dezfuli, Department of Meteorology, Florida State University, Tallahassee, FL, 32306; e-mail: *adezfuli@met.fsu.edu*.

the AEJ-W and AEJ-E and the corresponding latitudes are obtained for the month of August. The results are shown in Figure 2 and a summary of the statistics of intensity and latitude time series is presented in Table 1. The intensity of AEJ-W ranges from 10.9 m s^{-1} to 16.8 m s^{-1} with an average and standard deviation of 13.5 and 1.4 m s^{-1}, respectively. Its location varies from 12.5N to 17.5N with an average and a standard deviation of 15.6 and 1.6 degrees. The minimum, maximum and average intensity of AEJ-E are found to be 9, 16.3 and 12.7 m s^{-1}, respectively. The variability of its location is bounded between 10N to 20N with an average of 12.9N.

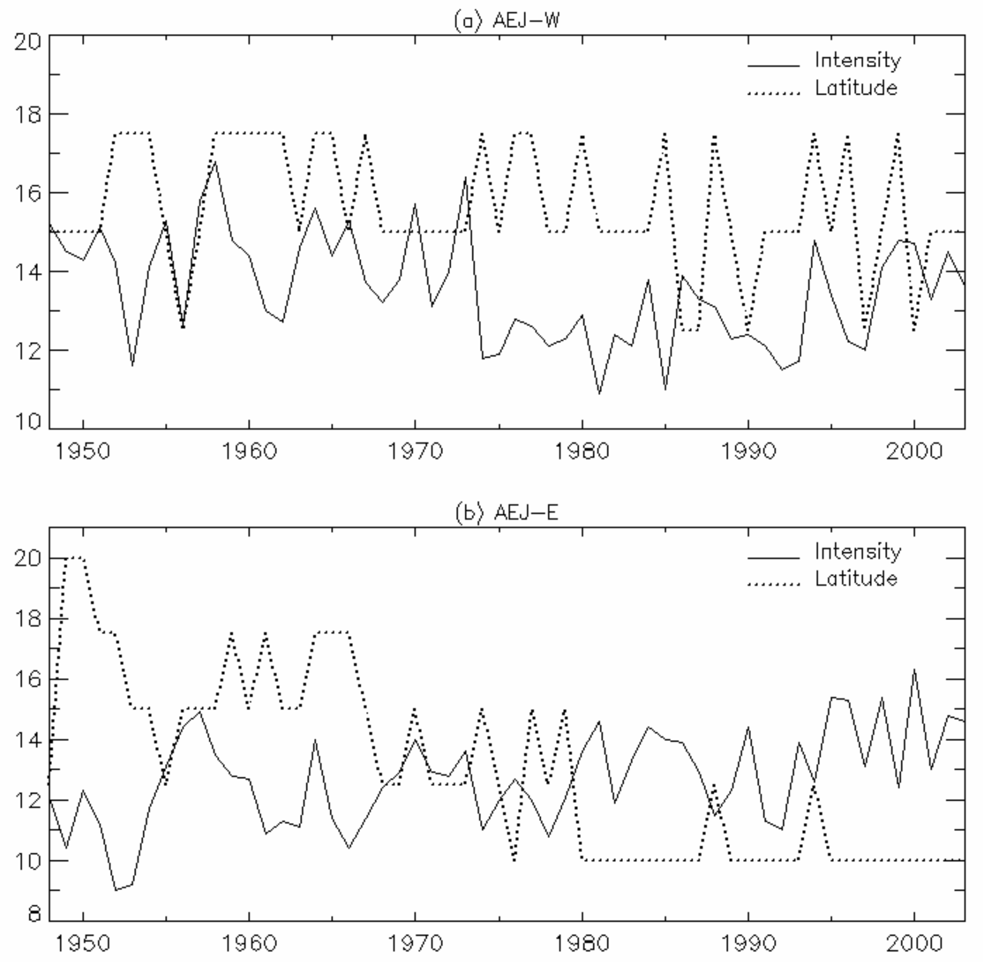

Figure 2. Maximum intensity (solid line) and latitude (dotted line) of (a) AEJ-W and (b) AEJ-E over 1948-2003.

Table 1. Summary of statistics of AEJ-W, AEJ-E and LLW

	AEJ-W (20W-5E)		AEJ-E (5E-30E)		LLW: 15W-15E	
	Intensity (m/s)	Latitude (^{o}N)	Intensity (m/s)	Latitude (^{o}N)	Intensity (m/s)	Latitude (^{o}N)
Avg.	13.5	15.6	12.7	12.9	8	7.3
Max.	16.8	17.5	16.3	20	16.8	10
Min.	10.9	12.5	9	10	2	2.5
SD.	1.4	1.6	1.6	3.0	4.1	2.1

Figure 2a shows the time series of maximum intensity (solid line) and latitude (dotted line) of the AEJ-W. An abrupt decrease in mean intensity is apparent in early 1970's which is coincident with the onset of the long dry period in Sahel. This implies that the Sahelian dry (wet) years are associated with weaker (stronger) AEJ-W. However, the latitudinal change of maximum jet remains relatively stationary. The correlation coefficient between intensity and latitude of the AEJ-W is nearly zero.

As depicted in Figure 2b, the intensity (solid line) and latitude (dotted line) of the AEJ-E is similarly investigated. The mean intensity of the jet demonstrates an increasing trend starting in the late 1960's simultaneous with the Sahelian dry period. Unlike AEJ-W, the mean latitude of AEJ-E is not stationary. It exhibits a decreasing trend which starts at the same time as intensity increase. The intensity and latitude show a high negative correlation (R= -0.52, significant at 0.1% level).

The decrease in mean intensity of AEJ-W is slightly larger in magnitude than the increase in AEJ-E. These two jets also respond differently to the moisture where in wet years AEJ-W is stronger and in dry years the AEJ-E. However, in dry years this contrast is less pronounced.

3.2 AEJ and Low Level Westerly jet

The intensity and location of the westerly jet at 850 hPa between 15W-15E are obtained from NCEP reanalysis data. The summary of its statistics is given in Table 1. The relationship between Low Level Westerly (LLW) jet and AEJ components is examined. The results suggest a positive correlation between intensity of AEJ-W and LLW (R= 0.46, significant at 0.1% level) and their corresponding latitudes (R= 0.44, significant at 0.1% level) as shown in Figure 3a and 3b, respectively. Figure 3c suggests also a high positive correlation between the location of AEJ-E and LLW (R=0.61, significant at 0.1% level). Moreover, the intensity and latitude of LLW in August are strongly, positively correlated with a correlation coefficient of 0.63.

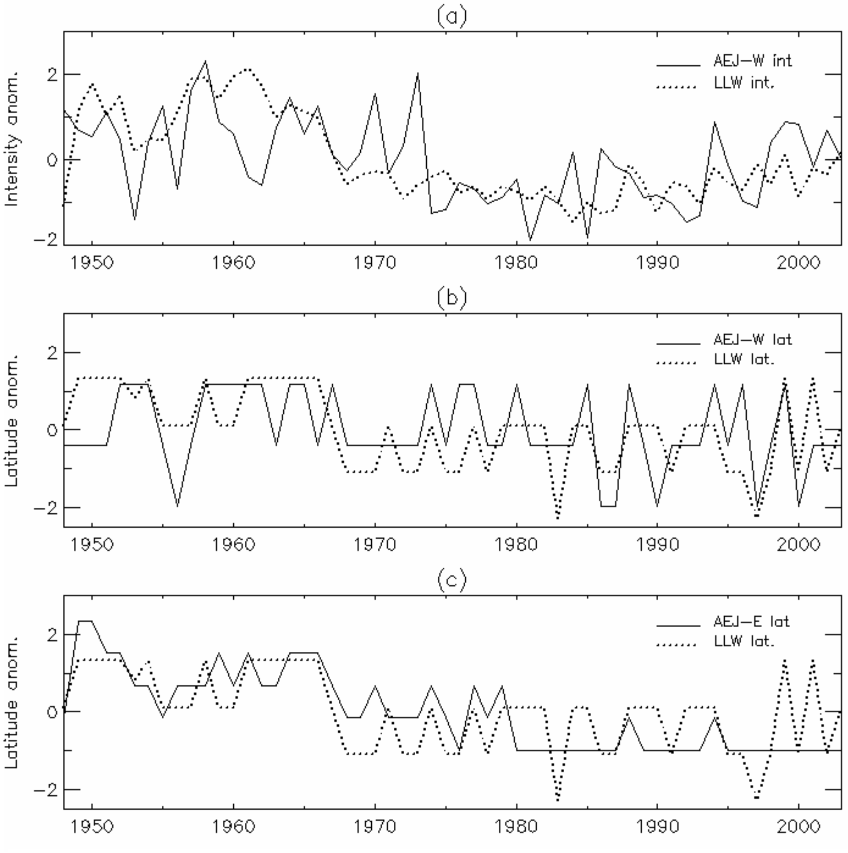

Figure 3. Relationship between (a) intensity of AEJ-W and LLW, (b) location of AEJ-W and LLW and (c) location of AEJ-E and LLW.

3.3 AEJ and Atlantic Ocean

Although the AEJ is mainly driven by surface temperature gradient, its intensity and location may be influenced by the North Atlantic variability. To evaluate this hypothesis the relationship of AEJ to seasonal North Atlantic Oscillation (NAO) index and Atlantic Nino is examined. The NAO represents the meridional oscillation of sea level pressure over the North Atlantic Ocean. The Atlantic Nino shows the Sea Surface Temperature Anomaly (SSTA) averaged over the region bounded between 25W-5E and 2S-6N. We use the mean SSTA of March-April to represent the Atlantic Nino. As shown in Figure 4a and 4b, the intensity of AEJ-W is positively lag-correlated with the April-June NAO (R=0.38, significant at 1% level), while negatively correlated with July-August NAO (R=-0.42, significant at 1% level). However, the intensity of AEJ-E and the latitude time series of both components appear to be poorly correlated with NAO. The SSTA over Atlantic Nino region is lag correlated with the intensity and latitude of the two jets. Depicted in Figure 4c, the results suggest a relatively significant lag-correlation only between March-April SSTA in Atlantic Nino region and intensity of AEJ-E (R=0.31, significant at 5% level).

4. SUMMARY AND CONCLUSIONS

We found a zonal double-core structure in the AEJ at 600 hPa that allows us to split up the jet into two components: AEJ-W and AEJ-E. The mean intensity of AEJ-W (AEJ-E) demonstrates an abrupt decrease (increase) in early 1970's (late 1960's) which is coincident with the onset of the long Sahelian dry period. The wet period before that threshold is associated with stronger AEJ-W than AEJ-E. Although the opposite case occurs in the dry period, the contrast between intensity of the two components in this case is less noticeable.

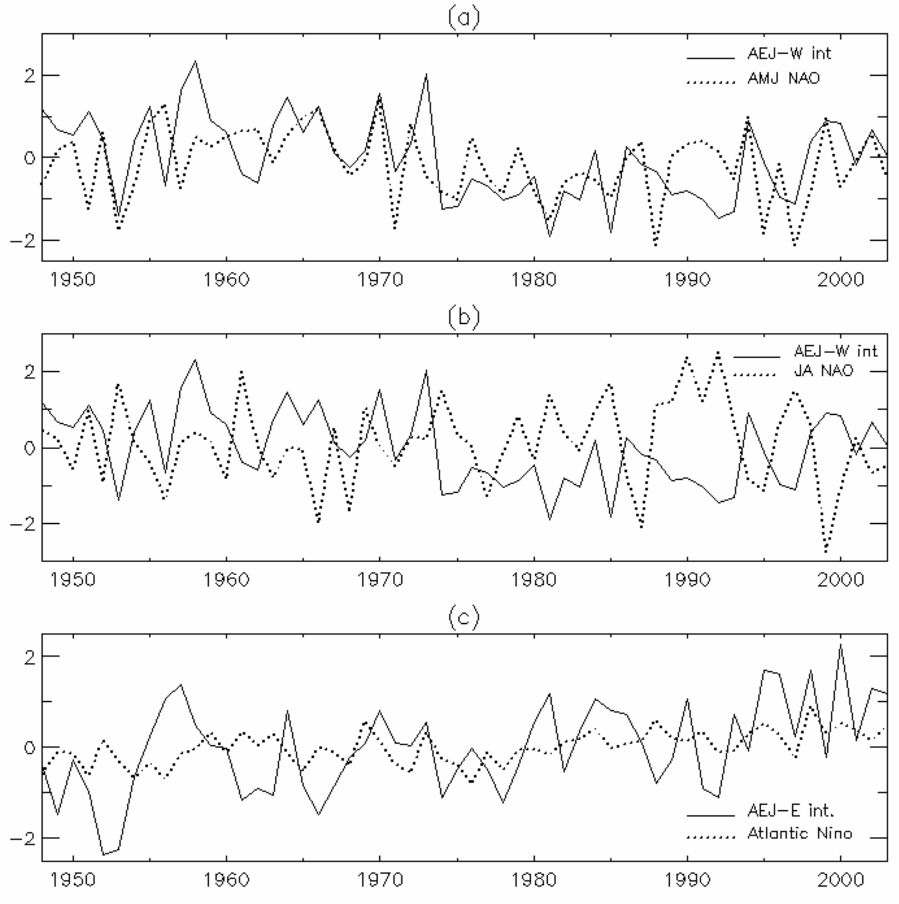

Figure 4. Relationship between (a) April-June NAO and intensity of AEJ-W, (b) July-August NAO and intensity of AEJ-W and (c) Atlantic Nino and intensity of AEJ-E.

The moisture-intensity relationship we found for AEJ-E is more consistent with the previous studies (e.g., Fontaine et al., 1995; Grist et al., 2002; Nicholson and Grist, 2001). However, the AEJ-W shows the opposite behavior. This could be resulted from the extended region and also the interannual analysis approach we have used, which enables us to capture the contrast between west and east of the AEJ. The differences between AEJ-W and AEJ-E justify the necessity of introducing the two individual compomenets. This difference is also evident in the relationship between intensity and latitude of the jets. The intensity and latitude of the AEJ-E are found to be highly negatively correlated, while they do not show any correlation for the AEJ-W.

The intensity of the AEJ-W and LLW (at 850 hPa and between 15W-15E) and their corresponding latitudes are positively correlated. There is also a high positive correlation between location of LLW and AEJ-E. Moreover, jets were found to be somehow influenced by the NAO and Atlantic Nino; however, the relationships are less significant than with local phenomena.

Further studies are needed to provide more dynamical and physical insights into the double-core structure of the AEJ.

REFERENCES

Burpee RW. 1972. The origin and structure of easterly waves in the lower troposphere. *Journal of Atmospheric Science.* **29:** 77–90.

Cook KH. 1999: Generation of the African easterly jet and its role in determining West African precipitation. *Journal of Climate*. **12:** 1165–1184.

Fontaine B, Janicot S, Moron V. 1995. Rainfall anomaly patterns and wind field signals over West Africa in August (1958–1989*). Journal of Climate* **8:** 1503–1510.

Grist JP, Nicholson SE, Barcilon AI. 2002. Easterly waves over Africa. Part II: Observed and modeled contrasts between wet and dry years. *Monthly Weather Review.* **130:** 212–225.

Lare AR, Nicholson SE. 1994. Contrasting Conditions of Surface Water Balance in Wet Years and Dry Years as a Possible Land Surface-Atmosphere Feedback Mechanism in the West African Sahel. *Journal of Climate*. **7:** 653-668

Newell RE, Kidson JW. 1984. African mean wind changes between sahelian wet and dry periods. *Journal of Climatology.* **4:** 27-33.

Nicholson SE, Grist JP. 2001. A conceptual model for understanding rainfall variability in the West African Sahel on interannual and interdecadal timescales. *International Journal of Climatology.* **21:** 1733–1757