SUMMER MEAN FIELDS OVER TROPICAL AFRICA, INDIAN AND ATLANTIC OCEANS DURING EL NINO AND LA NINA YEARS

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ABSTRACT

El- Nino and La- Nina conditions have been reported during the years of 1997 and 1998 respectively. Different meteorological fields of NCEP/NCAR data have been investigated during summers of 96, 97, 98, and 1999 in a trial to explain the mechanism through which El Nino and La Nina conditions may affect the climate of Africa. Negative anomalies of precipitation rate dominate over tropical Africa and SE Asia during the summer of 1997, while positive anomalies dominate during 98 and 1999. In the lower troposphere both the SE trades of the southern hemispheres and the southwest monsoons over both Indian and Atlantic Oceans have been observed stronger and occupy a larger areas during summers of 98, 1999 than those observed during 1997. In the upper troposphere the subtropical westerly jet stream of the southern hemisphere has been found to extend more zonally during 1997 than that during 1996,to become weaker during summers of 98 and 1999. The tropical Easterly Jet (TEJ) has been observed stronger during 98 and 1999 than that observed during summer of 1997. The results revealed that intensification of TEJ is usually associated with stronger monsoons over Indian Ocean and eastern tropical Africa during La-Nina years which may lead to above normal rainfall. Also, during 1998 the strongest easterlies in the upper troposphere can be noticed to extend from over the west Pacific Ocean to Atlantic Ocean. So, the more zonal extend of the TEJ may enhance the monsoon circulation over western tropical Africa which may lead to a rainy summer during La Nina condition. Investigations of the meteorological fields show many other significant differences between the summer seasons of 96, 97, 98, and 1999.

INTRODUCTION

El Nino / Southern Oscillation (ENSO) is the most important coupled Ocean-atmosphere phenomenon to cause global climate variability on interannual time scales, El-Nino can be regarded as the oceanic component of the phenomenon. It has been pointed out that El-Nino event is generally the invasion of warm water from the western equatorial Pacific into the central and/or eastern equatorial Pacific Ocean, in conjunction with a cessation of upwelling of cold water along the equator (Rasmusson and Carpenter, 1982). La Nina or anti-El-Nino event can be referred to as the appearance of colder than average sea surface temperatures SST in the central or eastern equatorial Pacific region. A strong signal of climate variability in the Tropics is derived from El-Nino, which is a relaxation of trade winds in the central and western Pacific leading to a lowered thermocline in the eastern Pacific and an elevated thermocline in the western Pacific (Cane 1983, Rasmusson and Carpenter 1983). Many studies have shown that El-Nino /Southern Oscillation ENSO have a significant influence on climate in many parts of the globe (Shukla and Paolino1983, Ropelewski and Helpert 1987, Schonher and Nicholson 1989, Ropelewski et al 1992, Price et al 1998, Diaz and Markgraf 2000, Kevin and Caron 2000, Zengrui et al 2007, Hafez and El Rafy2007). Although many statistical connections between El Nino/Southern Oscillation ENSO events and precipitation anomalies around the world have been found, it is still not clearly understood how changes in the sea surface temperatures SST in the Pacific Ocean affect weather patterns at great distances from the Pacific.

This work includes farther studies to rely better understanding of atmospheric variations in the tropical region, notably over Africa. This is of great importance to Egypt since these climatic variabilities are the controlling factors causing variation of Nile flood. The aim of the present work is to explain the mechanism through which El Nino and La Nina conditions may affect the climate of Africa and nearby oceans.

DATA AND METHODOLOGY

The NCEP/NCAR Reanalysis data of composite sea surface temperature, surface precipitation rate and vector wind at different levels from July to September were obtained from Climate diagnostics center (NOAA, boulder, Colorado) through the Web Site: //www.cdc.noaa.gov/composites. Each field have been investigated through the years 96, 97, 98, and 1999 in order to explain (compare) the distribution of each meteorological (climatological) elements during normal, El-Nino and La Nina conditions. These data sets have been analyzed using mean and /or anomalies methodologies.

ANALYSIS AND DISCUSSION

Dramatic changes in sea surface temperature SST in Equatorial Pacific Ocean as well as in Equatorial and Tropical Atlantic and Indian Oceans have been observed during the years of study. For sake of simplicity variability of SSTs over each ocean will be discussed separately. Fig.(1) shows composite anomalies of sea surface temperature SST over Pacific Ocean. During summer season of 1996 , as shown in Fig.(1 a), negative anomaly (cold water)can be observed in the east, while positive anomaly dominates in the western part of the ocean. This SST pattern can be considered as a normal condition. A wide tongue of high positive SST anomalies (warm water) can be observed to extend zonally from the south American coast westward to the date line during 1997 , which can be considered as typical El Nino condition (Fig.1 b). During the summer of 1998 the warm water (+ve anomaly) has been detected in the east only, with cold water (-ve anomaly) along the Equator in the central part of the Pacific Ocean, which may represent the initiation of La Nina condition. Cold water (+ve anomaly) has been observed in the hall Equatorial Pacific during 1999, which can be considered as a typical La Nina condition. Over the Atlantic, warm pool (+ve anomaly) can be noticed in the central part along the Equator during 96, with nearly normal conditions along the coasts of West Africa and South America. During the summer of 1997, below normal SSTs (cold water) can be observed in the Equatorial Atlantic as a hall, which indicates Atlantic La Nina. Above normal SSTs (+Ve anomalies) can be observed in the Equatorial and Tropical Atlantic during the years 1998 and 99, which indicate El Nino conditions (Atlantic Nino). Thus, one can notice that the Pacific El Nino of 1997 is associated with Atlantic La Nina while the Pacific La Nina of 1998 and 1999 are associated with Atlantic El Nino.

Composite anomalies of surface precipitation rate for the four seasons of study have been presented in Fig.(2). During 1996 +ve anomalies of precipitation rate (above normal) dominate over eastern Indian and western Pacific Oceans, with nearly normal conditions over Africa and Atlantic Ocean. Below normal rainfall (-ve anomalies) can be observed over SE Asia and along the coast of S America during 1997, while +ve anomalies can be noticed over the western Indian Ocean. During 98 and 1999, above normal precipitation rate (+ve anomalies) dominate over SE Asia, equatorial Indian Ocean and western and central Africa. Comparison between Fig.s (1 & 2) indicates that above normal values (+ve anomalies) in both SSTs and precipitation rates over eastern Indian and western Pacific Oceans are concurrent during 1996 and 1998, while –ve anomalies in both patterns are concurrent during 1997. Thus, one may suggest that rainfall over SE Asia is in good association with warmer SSTs.

Fig.s (3 & 4) show composite mean surface and 850 mb vector wind for the summer seasons of 96, 97, 98 and 1999. The following common significant features can be noticed. The wind circulation over tropical Africa is such that the southwesterly flow (S.W.monsoon) meets the northeasterly flow to form the Inter Tropical Convergence Zone ITCZ (El Rafy and El Shahawy 1996). Over West Africa southwesterlies originate over the Atlantic Ocean as the southeastern trades of the southern hemisphere, while the southwesterlies of eastern Tropical Africa and Indian monsoon originate over the Southern Indian Ocean as the southeastern trades of the southern hemisphere also. The monsoonal southwesterlies of East Africa do not penetrate very far into the continent; this might be due to the blocking effect of the Ethiopian highlands. Easterlies can be observed south of the equator over Africa, to originate as southesterlies from over the southern Indian Ocean. Also, southerlies can be noticed along the west coast of Africa south of the equator to originate from over the southern Atlantic Ocean. Those easterlies and southerlies seem to be the origin of southwesterlies over the central part of tropical Africa. This points to the important role that the trades of the southern hemisphere, from over both Atlantic and Oceans, play in climate variability over Africa. Over the northern Indian Ocean, axis of strong SW monsoon can be observed over the Arabian Sea during 1996, to become stronger and shifted eastward during 1997, notably at 850 mb level. Axis of strong westerlies had been shifted westward and became stronger during 1998. The SE trades of the southern hemisphere over both Indian and Atlantic Oceans have been observed stronger and occupy larger areas during summers of 98 and 1999 than those observed during summer of 1997.

Composite mean vector winds at 700 and 500 mb levels have been presented in Figs (5). At 700 mb level, easterlies are stronger and cover a larger area over the Atlantic and western tropical Africa. This may draw the attention to recognize the upper limit of the monsoon in 850-700 mb layer over West Africa. Westerlies still can be observed over the African horn and Indian Ocean. Those westerlies and the SE trades of the southern hemisphere can be observed stronger during 98 and 1999 than those during 1997 over the Indian Ocean. Therefore, one may notice that the monsoon circulation over the Indian Ocean is stronger and deeper during La Nina condition than that during El Nino. At 500 mb level(not shown), easterlies dominate over the Indian Ocean, with weak westerlies still can be detected along the equator. This may indicate that the upper limit of the westerlies (SW monsoon) is in 700-500 mb layer over eastern tropical Africa and Indian Ocean.

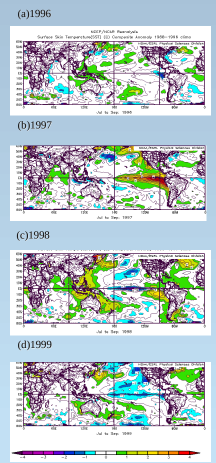

Fig.(1):Composite anomaly of sea surface temperature SST for July to September for the years (a)1996,(b)1997,©1998 and(d)1999

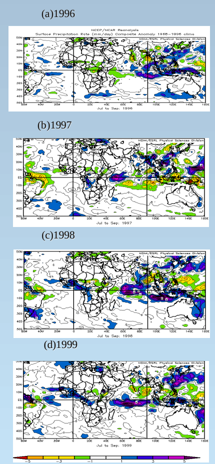

Fig.(2):Composite anomaly of surface precipitation rate (mm/day) for July to September for the years (a) 1996, (b) 1997, (c) 1998 and(d)1999

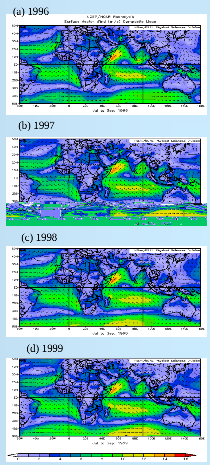

Fig. (3): Composite mean surface wind vector from July to September for the years (a)1996,(b)1997,(c)1998 and (d)1999

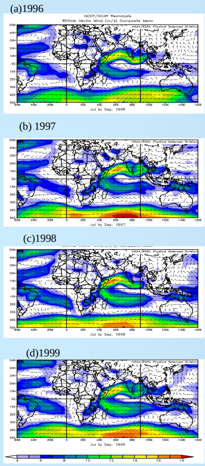

Fig.(4): Composite mean 850 mb wind vector from July to September for the years (a)1996,(b)1997,(c)1998 and (d)1999

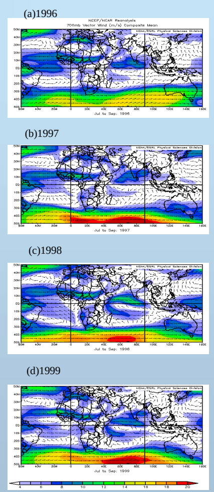

Fig. (5): Composite mean 700 mb wind vector from July to September for the years (a)1996,(b)1997,(c)1998 and (d)1999

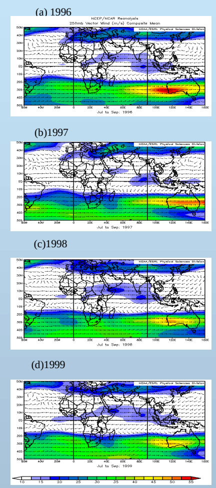

Fig. (6): Composite mean 250 mb wind vector from July to September for the years (a)1996,(b)1997,(c)1998 and (d)1999

Figs(6) show composite mean vector wind at 250 mb levels. The following significant features can be noticed. The flow fields are characterized by easterly winds within the tropics and westerly flow to the north and south. Strongest easterlies cover a wide latitude band over the Indian Ocean, width of the easterly flow decreases westward. Strongest easterlies can be observed to extend from over SE Asia westward to eastern tropical Africa during 1996. During 1997, easterlies weakened, shifted eastward and had less zonal extend. During summers of 98 and 1999, easterlies became stronger than those during 96 and 1997 to extend more zonally from over western Pacific Ocean westward to eastern tropical Atlantic. The subtropical westerly jet stream of the southern hemisphere can be observed over the southern Indian Ocean and Australia during 1996 along latitude 30 S. During 1997 the subtropical westerly jet had been found to extend more zonally and shifted eastward, to become weaker during summers of 98 and 1999.

Composite mean vector wind at 150 and 100 mb levels have been presented in Figs. (7 & 8). The major similar features again include a belt of easterly flow nearly within the tropics and westerly flow to the north and south. Axis of maximum easterlies (Tropical Easterly Jet TEJ) is located along latitude 10 Nat 150 mb level, while at 100 mb level the axis is located along latitude 18 N. Strength and zonal extension of the tropical easterly jet TEJ are quite variable through the years of study. The strength of the TEJ can be noticed to become weaker during 1997 than that during 1996, to become much stronger during 98 and 1999. The zonal extension of the TEJ during 1997 is less than that during 1996, to become much greater during 98 and 1999. The core of the jet during 1997 appeared to be shifted mor eastward than those observed during 96, 98 and 1999. Axis of strongest easterlies can be noticed to extend from over western Pacific Ocean, through Indian Ocean and tropical Africa westward to the eastern part of the Atlantic Ocean.

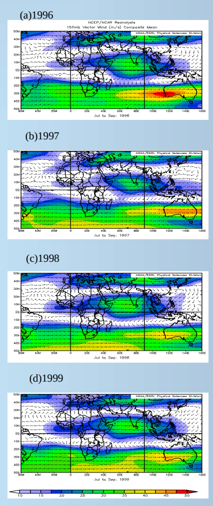

Fig.(7):Composite mean 150 mb vector wind from July to September for the years (a)1996,(b)1997,(c)1998 and (d)1999

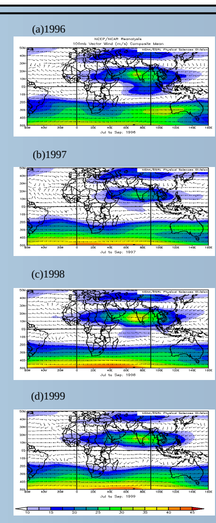

Fig.(8): Composite mean 100 mb vector wind from July to September for the years (a)1996,(b)1997,(c)1998 and (d)1999

RESULTS AND CONCLUSION

The 1997/98 El Nino event has been hailed as the El Nino of the 20th century. El-Nino conditions begin to appear on February and continue to December 1997, while La Nina showed itself firstly in May 1998 and continued to the end of the year. Different meteorological fields have been investigated during summer seasons of 96, 97, 98 and 1999 in a trial to explain the mechanism through which El Nino conditions may affect the climate of Africa. This is of great importance to Egypt since these climatic variabilities are the controlling factors causing variation of Nile flood. Below normal rainfall dominates over tropical Africa and SE Asia during summer of El Nino year 1997, while above normal rainfall dominates during La Nina years 98 and 1999. The SE trades of the southern hemisphere and the SW monsoon over both Indian and Atlantic Oceans have been observed stronger and occupy larger areas during summers of 98 and 1999 (La Nina) years than those observed during 1997 (El Nino). The Tropical Easterly Jet TEJ has been observed stronger during 98 and 1999 than that observed during summer of 1997. Also, during 98 and 1999 the TEJ had been noticed to extend more zonally than that during1997. Therefore, the most possible mechanism through which El Nino and La Nina conditions may affect the climate of Africa and nearby oceans is as follows: during La Nina, fluctuations of Pacific SSTs may enhance upper easterlies via thermal wind at the entrance of the TEJ which may lead to stronger and more zonal extend of the jet westward. Over Indian Ocean and eastern tropical Africa, stronger TEJ may lead to stronger and deeper monsoon. The more zonal extend may lead to westward shift for the exit of the TEJ to lay over western tropical Africa, which in turn may affect the lower tropospheric circulation over western tropical Africa and eastern tropical Atlantic.

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