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Effect of ENSO on the mid–summer drought in Veracruz State, Mexico

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RESUMEN

En el presente trabajo se muestra el efecto de El Niño/Oscilación del Sur (ENSO) sobre la sequía intraestival o canícula en el estado de Veracruz. Para realizar lo anterior se comparó la precipitación promedio mensual de los años de Niño con los de no Niño, de 51 estaciones climatológicas. El período de registro de cada estación varió entre 25 y 75 años. Los resultados muestran que durante los eventos de El Niño disminuye o desaparece la sequía intraestival, para casi todo el estado de Veracruz. Esto ocurre durante los meses de julio y agosto, con excepción de la región alta del centro del Estado, que incluye Xalapa, Naolinco y Orizaba, donde se incrementa la sequía. Finalmente, se aplicó la prueba de comparación de varianzas de Fisher para saber si la variación de la precipitación durante el evento El Niño era aleatoria o se debía al efecto de El Niño. El análisis estadístico indica que la variación de la precipitación en el estado de Veracruz fue significativa, para algunas regiones, entre .1% y 5%.

ABSTRACT

This paper shows the effect of El Niño/Southern Oscillation(ENSO) on the mid–summer drought at Veracruz state. To analyze this effect we compared the average monthly precipitation of the years with El Niño and that for not El Niño years of 51 climatological stations. The period of record for each station varied from 25 to 75 years. The results show that during the event El Niño the mid–summer drought is diminished or disappeared in almost all the Veracruz state. This occurs during the months of July and August. However, on the highlands of central Veracruz the intensity of mid–summer drought is incremented. Finally we applied the variance comparison test of Fisher to know if the variation of the precipitation in July and August was random or originated from El Niño. The statistical analysis shows that the variation of the precipitation in some regions of Veracruz states is significant from .1% to 5%.

1. Introduction

According to Mosiño and García (1974) and Reyna (1990) the mid–summer drought is a short rain deficient period which occurs in the middle of the rainy season. This drought covers a large extension of the country and its intensity varies through the Mexican Republic. Geographically it covers the half eastern and southern parts of the country, from the parallel 14°30'N to the

border with the United States. This drought causes very high losses on both agriculture and cattle raising of Mexico (Reyna and Pérez, 1978; Reyna and Rebollo, 1985).

The El Niño/Southern Oscillation (ENSO) phenomenon is an anomalous warming of the eastern equatorial Pacific that takes place at irregular intervals of 2–7 years and lasts for 1–2 years (De la Lanza and Galindo, 1989). This event has been named El Niño because it often occurs around December 24th (Galindo, 1987).

Recent researches have been focused towards the likely effects that El Niño causes to the climatic variations in a global–scale, among these researches it is mentioned the following:

Galindo (1987) associates this oceanic–atmospheric interaction phenomenon with strong perturbations in the rainfall regime in the tropics. These effects are, in some agricultural areas, either strong droughts strong floods in arid areas.

Ropelewski and Halpert (1986) and Rogers (1988) consider that El Niño induces changes in the extratropical atmospheric circulation during the winter, generating anomalous weather situations.

Mosiño and Morales (1988) found, when they analysed the precipitation record at Tacubaya, Mexico, D. F., for the period 1921-83, that in the presence of moderate El Niño the rainfall was incremented, together with the number of tropical disturbances in the southeastern Pacific. The strong El Niño events show a different tendency; scarcity of rainfall at Tacubaya and a decrease in the number of oceanic tropical perturbations.

According to Schneider and Schonwiese (1989) the ENSO is a coupled oceanic/atmospheric phenomenon, it is one of the most prominent signals of short–term internal climate variability.

Cavazos and Hastenrath (1990) correlated the Southern Oscillation Index (SOI) versus the winter rainfalls of the Mexican Republic and found an increment in the precipitation of northern Mexico, for the central Pacific coast and over the Peninsula of Yucatan when El Niño occurred or SOI was in a negative phase. In the positive phase of SOI (not–El Niño years) the precipitation is incremented in central Mexico and the Tehuantepec Isthmus. This last zone is lashed by the Gulf of Mexico northers.

Gay and Conde (1990) related El Niño phenomenon for the period 1982-83 with an increment in the global radiation averages at the National University of Mexico.

Pereyra *et al.* (1991) published a preliminary study where they encountered a relation, statistically significant, between an increment of annual precipitation at Xalapa, Veracruz and El Niño event when this occurred with a strong intensity, and a diminution (of 14.4%), not significant, when El Niño is very strong.

Pereyra *et al.* (1992), found a correlation between El Niño events and the yield of temporal beans in the Veracruz state, Mexico, during the period 1980-88.

Tejeda *et al.* (1992), using graphic analysis found that the average temperature and the annual precipitation at Xalapa, Veracruz, show a diminution in the former and an increment in the latter during the years of a moderate El Niño, respectively. In presence of strong El Niño event occurred the opposite, though.

This study shows that during El Niño event the mid–summer drought is diminished strongly or disappears, throughout the Veracruz state. This occurs during the months of July and August. It was also fund that in the highlands of central Veracruz the intensity of mid–summer drought is incremented during El Niño years.

2. Methodology

To effect this study we obtained records of precipitation for 51 climatic stations, located in all the Veracruz state (Fig. 1). The period of register of the stations varied from 25 to 75 years. The average monthly precipitation of El Niño years and not–El Niño ones for each station was compared in graphics (Figs. 2-5).

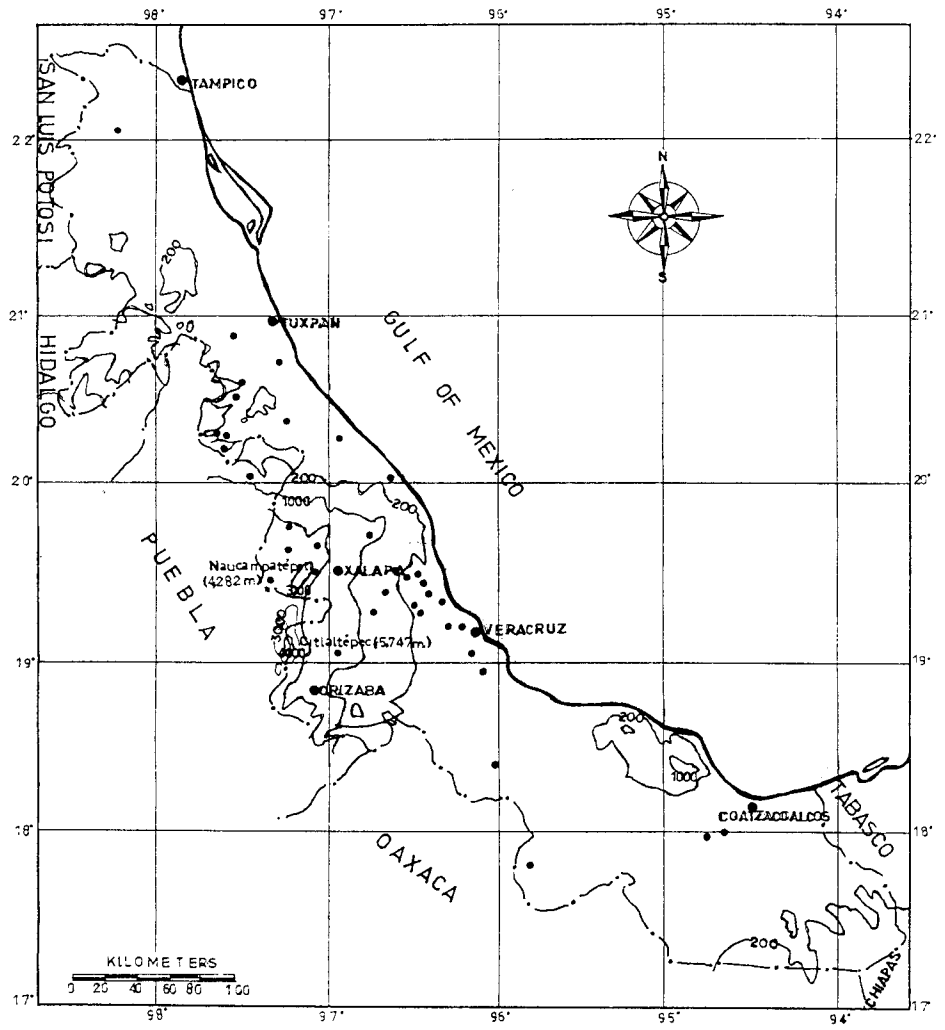

Fig. 1. Location of the area of study.

Later on we compared the precipitation for July and August with the five months moving average, of the pressure anomalies of the Southern Oscillation Index, normalized to its maximum values (Figs. 6-9).

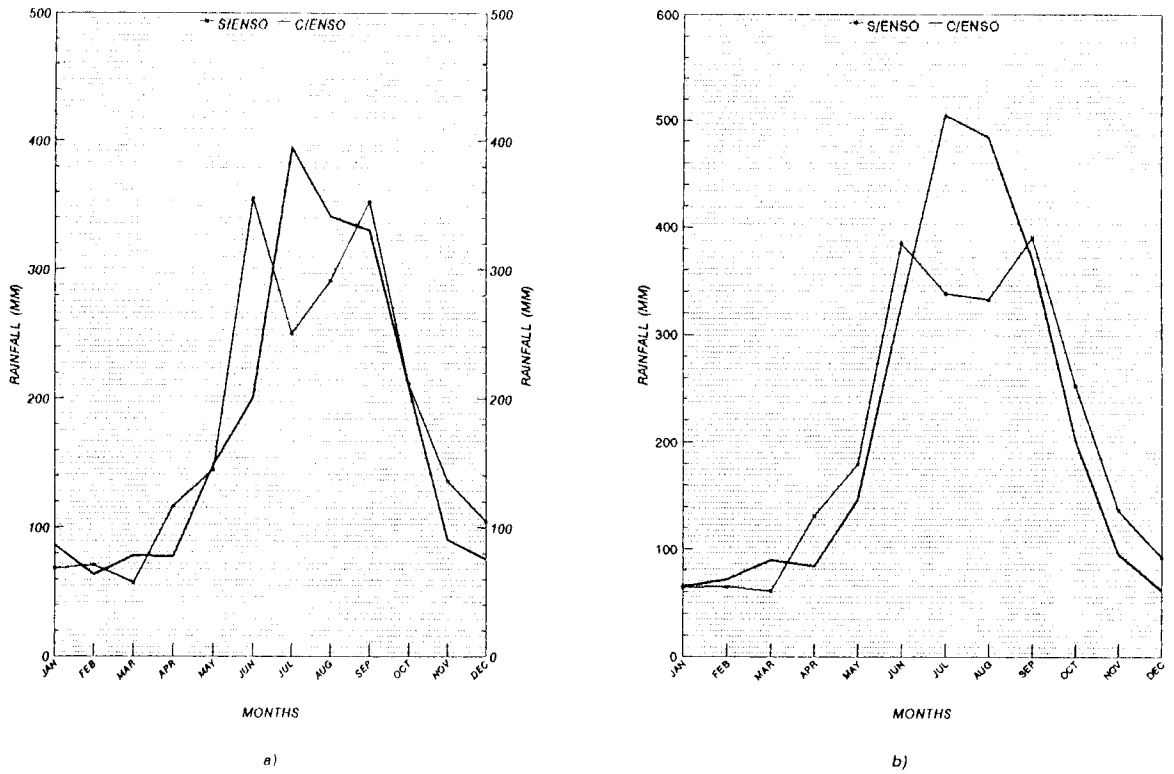

Fig. 2. Monthly average precipitation of a) Santa Ana, Ver. and b) Coyutla, Ver., during the years with El Niño (C/ENSO) and not El Niño(S/ENSO), period 1961-1989.

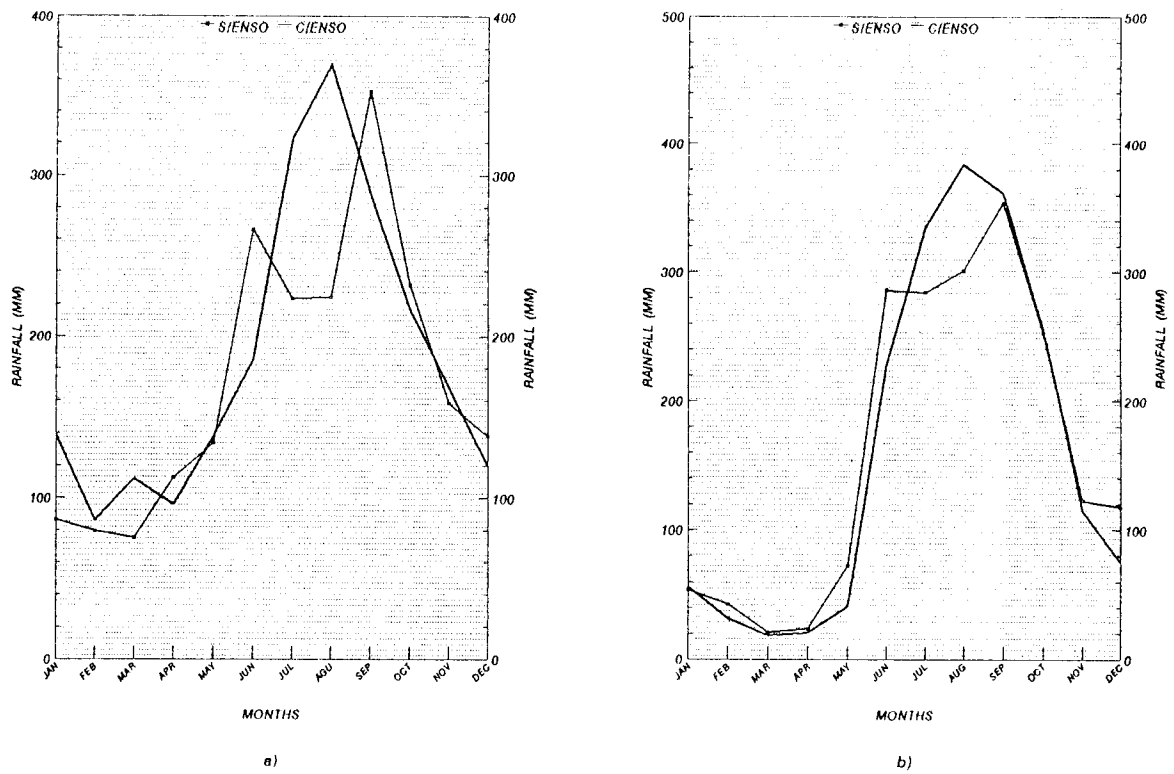

Fig. 3. Monthly average precipitation of a) Ayotoxco, Pue. and b) Jáltipan, Ver., during the years with El Niño(C/ENSO), and not El Niño(S/ENSO), period 1961-1992.

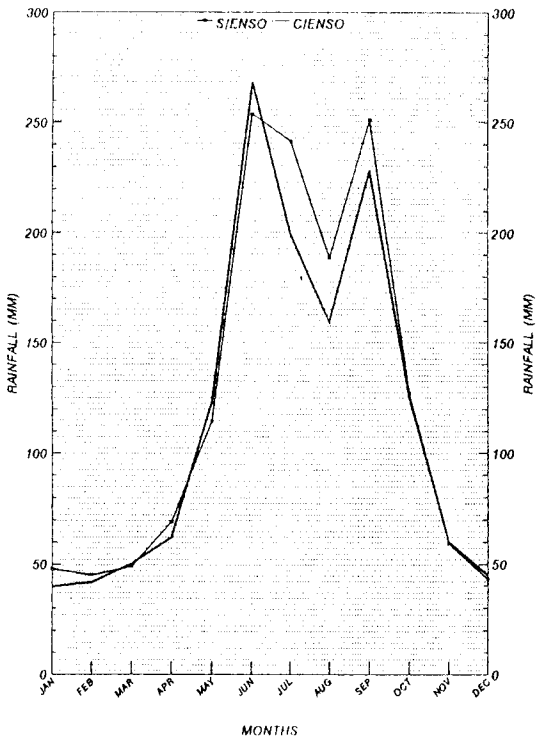

Fig. 4. Monthly average precipitation of Xalapa, Ver., during the years with El Niño(C/ENSO) and not El Niño(S/ENSO), period 1920-1992.

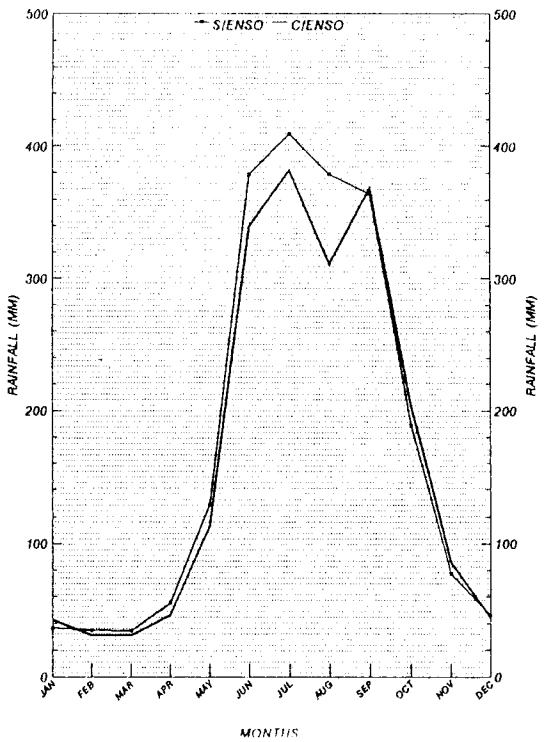

Fig. 5. Monthly average precipitation of Orizaba, Ver., during the years with El Niño(C/ENSO) and not El Niño(S/ENSO), period 1930-1992.

To give a statistical support to the observed (precipitation anomalies) in the Figures 2 to 9, we applied the Fisher's variance comparison test, to the monthly precipitation for July and August of El Niño and not–El Niño years. Before applying the variance comparison test we verified the normality of the samples, using the χ^2 test (Snedecor and Cochran, 1979; Kennedy and Neville, 1982):

The Fisher's variance comparison test is the following:

$$F = S_1^2/S_2^2 \tag{1}$$

where, S_1^2 is the variance of sample 1, S_2^2 is the variance of sample 2 (for $S_1 > S_2$). If the value estimated with equation (1) is larger than the value in tables, for an assigned significant level, the null hypothesis is rejected.

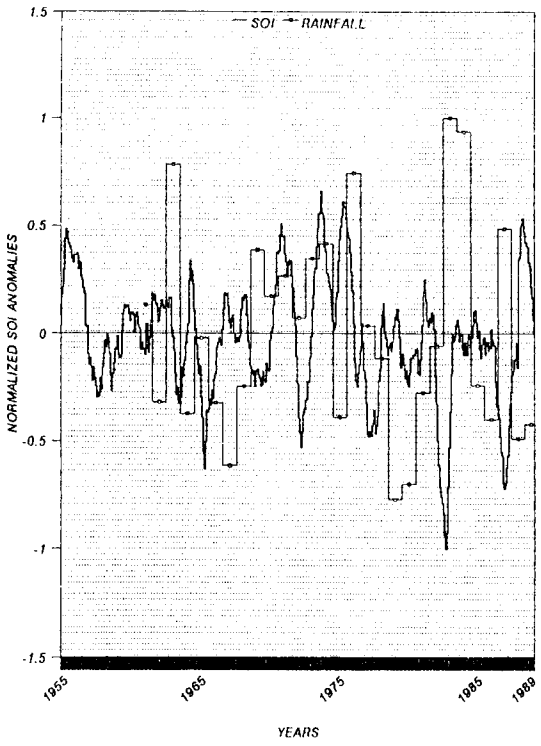

Fig. 6. Comparison of the Southern Oscillation Index anomalies with the rainfall of July in Coyutla, Ver.

3. Results

When the statistical analysis of the samples is done, we found that the rainfall in maritime regions of Veracruz state is incremented when El Niño event occurs, this increment being significant at 0.1% to 5% levels. This effect occurs during the months of July and August.

This increment in the precipitation causes a strong diminution or disappearance of the mid–summer drought in the maritime part of Veracruz state (Figs. 2-3). Whereas on the highlands of central Veracruz the intensity of mid–summer drought is incremented during July and August (Figs. 4-5). This increment in the mid-summer drought varied from 98% at Xalapa to 940% at Orizaba.

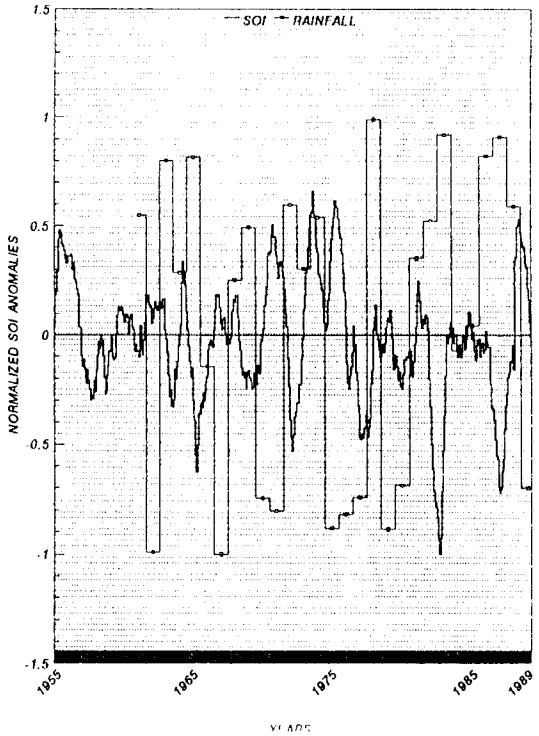

Fig. 7. Comparison of the Southern Oscillation Index anomalies with the rainfall of July in Jáltipan, Ver.

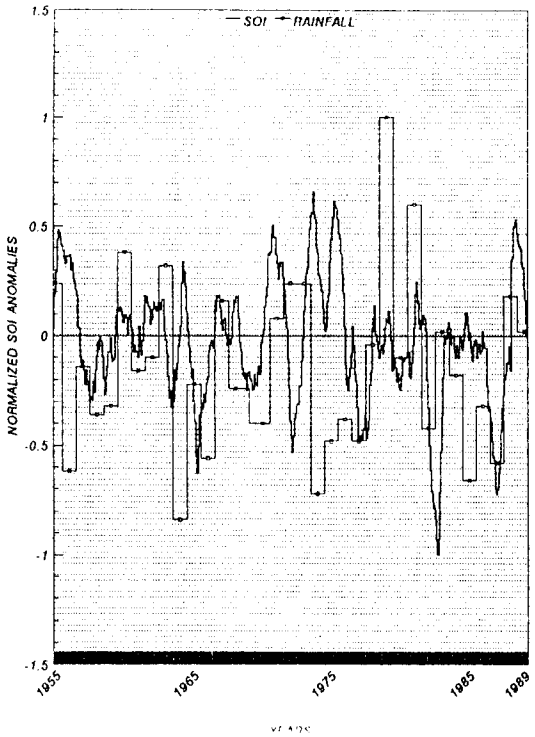

Fig. 8. Comparison of the Southern Oscillation Index anomalies with the rainfall of August in Xalapa, Ver.

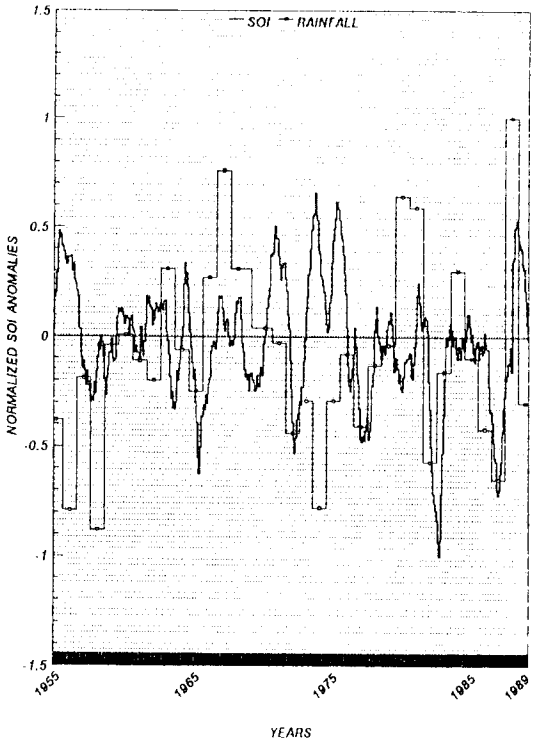

Fig. 9. Comparison of the Southern Oscillation Index anomalies with the rainfall of August in Orizaba, Ver.

4. Conclusions

The influence of El Niño/Southern Oscillation phenomenon on the Veracruz state rainfall during the months of July and August was significant from some regions at 0.1% to 5% levels (Figs. 2-5). This effect is also observed in Figures 6-9, mainly when El Niño events are very strong (1982-83, 1987).

The intensity of the mid–summer drought is diminished or disappeared in the maritime parts of Veracruz state when El Niño event occurs.

The intensity of the mid–summer drought is incremented strongly in Orizaba (940%) and Xalapa (98%) when El Niño occurs.

Knowing that during the years of El Niño event the precipitation of Veracruz state is incremented in the maritime parts and diminished in the highlands central of Veracruz, will permit to take precautions to prevent losses in agriculture and cattle raising of Veracruz state, Mexico.

Acknowledgements

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