Atmósfera (1988), **1**, pp. 39-44

Temperature, precipitation variations and local effects Aguascalientes 1921-1985

L. LEMUS and C. GAY

Centro de Ciencias de la Atmósfera, Universidad Nacional Autónoma de México, 04510, México, D.F., MEXICO

(Manuscript received September 10, 1987; in final form January 20, 1988)

RESUMEN

Con el propósito de estudiar variaciones de temperatura y precipitación en el estado de Aguascalientes, México (22°, 2' N Lat., 102° W Long), se analizan los datos de siete estaciones meteorológicas. Los datos colectados corresponden a periodos comprendidos entre 1921 y 1985. Los posibles efectos locales se estudian a través del comportamiento del índice de aridez y la productividad (biomasa). Los resultados muestran un incremento de temperatura para el Estado de 0.4°C. Este incremento coincide con las tendencias generales de calentamiento global reportadas por Jones *et al.* (1986). También hallamos un incremento del índice de aridez y una reducción de la productividad (gr/m^2 año) en el Estado.

ABSTRACT

In order to study the temperature and precipitation variations for the state of Aguascalientes, Mexico (22°, 2' N Lat, 102° W Long), seven meteorological stations data are analyzed. The recorded data are for periods between 1921 to 1985. The possible local effects associated to these variations are studied by the aridity index and productivity (biomass) behavior. The results show an average increase of temperature in the state of $T = 0.4^o$ C. This increase coincides with the general global warming trend reported by Jones *et al.* (1986). We also found an increase in the aridity index and a reduction of the productivity (gr/m^2 year) of the state.

1. Introduction

Recently several authors have studied climatic variations. For example Hansen *et al.* (1981) have projected for the 21st century, under the assumption of different scenarios in which anthropogenic CO_2 emissions play a dominant role, global warmings ranging from 1 to 4°C. They point out that the observed temperature trends indicate that global temperature has risen by 0.2°C between the middle 1960's and 1980 yielding a warming of 0.4°C in the past century, consitent with the greenhouse effect due to the increases of atmospheric CO_2. These results agree with the more recent work of Jones *et al.* (1986) who have taken into account both sea surface temperatures and marine air temperatures for their analysis. They find an increase in global temperature of 0.5°C for the last century. It is interesting to mention that the warming for the 1980's announced by Hansen *et al.* (1981) is found in the data of Jones *et al.* (1986) that show that the warmest 3 years (up to 1984) have all occurred in the 1980's. Wigley and Schlesinger (1985) have studied the effects of the coupling of the ocean and atmosphere, in particular the effective diffusivity of the ocean below the upper mixed layer on the calculated temperature increase due to a doubling of CO_2. They conclude that the observed global warming over the past 100 years is consistent with many calculated CO_2 doubling temperature changes. Adem and Garduño (1984), using a thermodynamic model for climate simulation in which the ocean-atmosphere interaction is taken into account calculate a global increase of 0.6°C for a duplication of CO_2. Among others, the mentioned studies report global temperature variations, however, do these variations hold for a regional scale, and do they have local effects? To study a possible answer to these questions, this paper analyses, for a period between

1921 to 1985, temperature and precipitation variations for a specific geographical region, the state of Aguascalientes, Mexico. For periods between 1968-1985, we also study the possible growth of arid zones and productivity (biomass gr/m^2 year) variations associated to temperature and precipitation behavior.

2. Data and analysis

The location of seven meteorological stations selected for the study are shown in Fig. 1. The selection was made according to the length of the records of temperature and precipitation for the period 1921

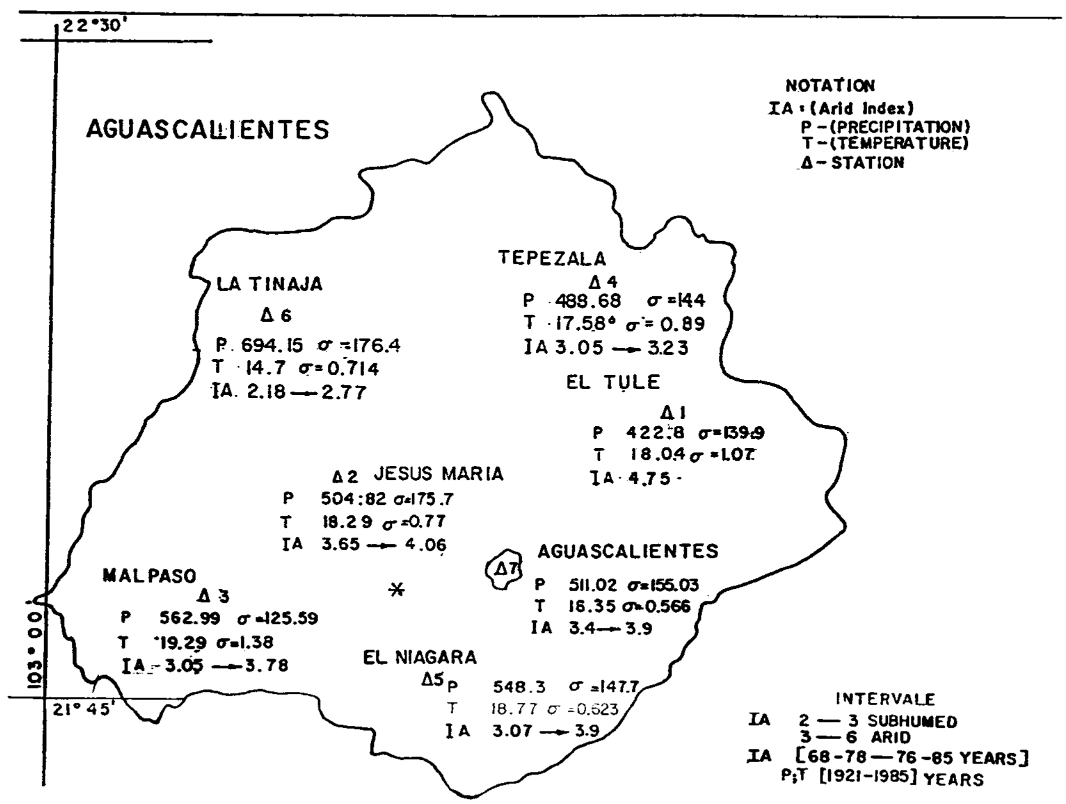

Fig. 1. Location, precipitation P, temperature T and arid index IA for the seven meteorological stations Δ1-Δ7 in the state of Aguascalientes México.

to 1985. The meteorological stations considered are city of Aguascalientes, El Niágara, El Tule, Jesús María, La Tinaja, Malpaso and Tepezala. An important factor taken into account in this selection was that the seven stations are located in different environmental zones; from forest, farming, urban, to arid lands. In Figs. 2 and 3 the temperature and precipitation data for the Aguascalientes station are shown. Average temperatures for different periods between 1948 and 1985 are shown for the seven stations in Fig. 4. Similarly Fig. 5 shows precipitation averages for two differents periods between 1968 and 1985.

For the City of Aguascalientes station, an urban area, a rapid increase in temperature is observed (Fig. 2) since 1980, its annual average for the 1921-1985 period of temperature and precipitation are T = 18.34 ^{o}C with standar deviation $\sigma = 0.57^o$C and $P = 511.02mm$ with $\sigma = 155.03mm$,

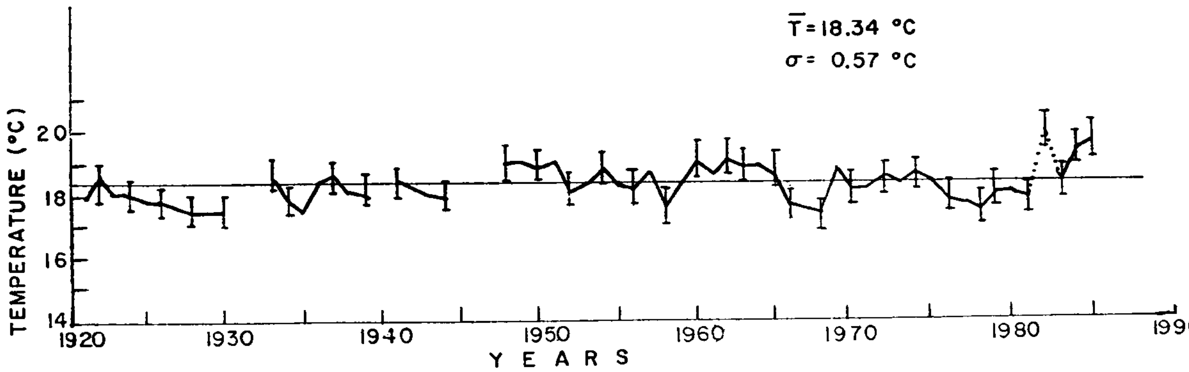

Fig. 2. Temperature for the period 1921-1985 for Aguascalientes station

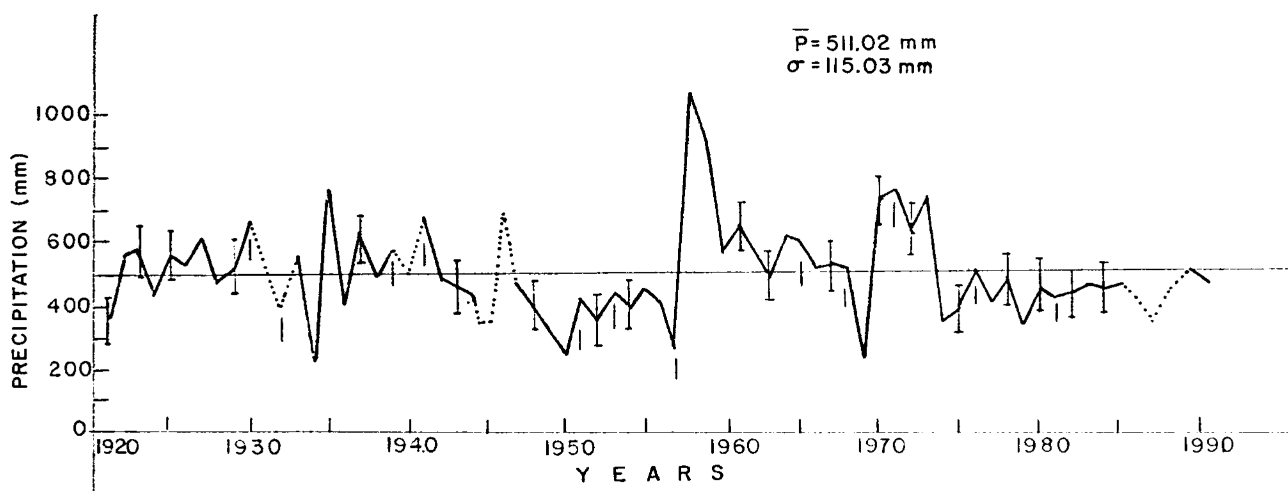

Fig. 3. precipitation (1921-1985) and tendency from 1985 to 1990 for Aguascalientes station.

respectively . In Fig. 1 the annual average of temperature and precipitation for the seven stations are shown. Temperature and precipitation data were analysed for periods 1948-1985 and 1968-1985 (Figs. 4 and 5). An average increase of $T = 0.41^{o}$C with $\sigma = 0.025$, in temperature is observed in the state for the period 1978-1985 with respect to the 1921-1985 average (Fig. 4). The precipitation for

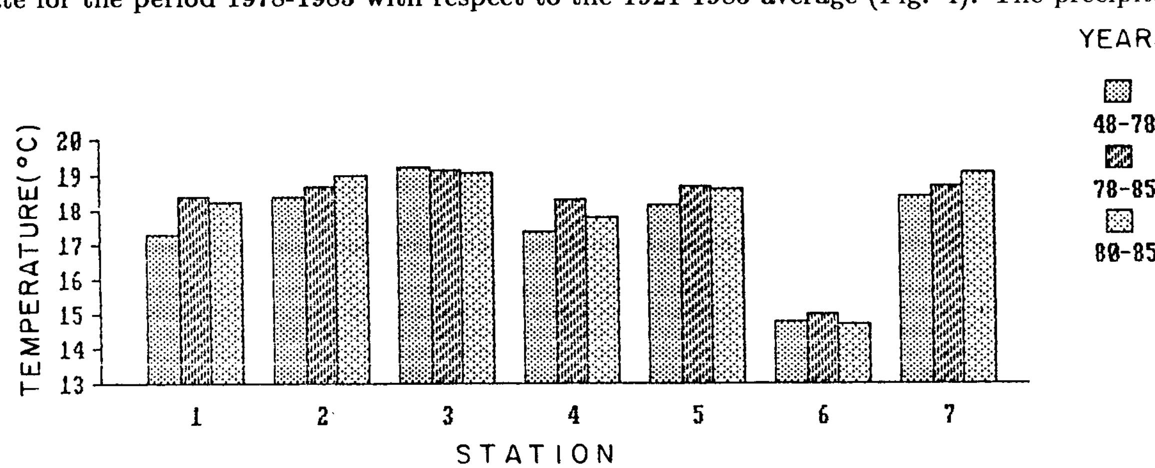

Fig. 4. Average temperatures for seven stations of the state of Aguascalientes, for three periods.

the same period decreased for all the meteorological stations (Fig. 5). With these data and using the thermopluviometric method the aridity indexes IA (the ratio of radiation balance to precipitation) for the stations were calculated and are shown in Fig. 6. The results show an important increase of the IA in all the stations. This represents an increase of the arid region in the state. From the results we observe that the state (with exception of La Tinaja station (with an IA = 2.77)) for this period is classified as arid land, with an IA from 3 to 6.

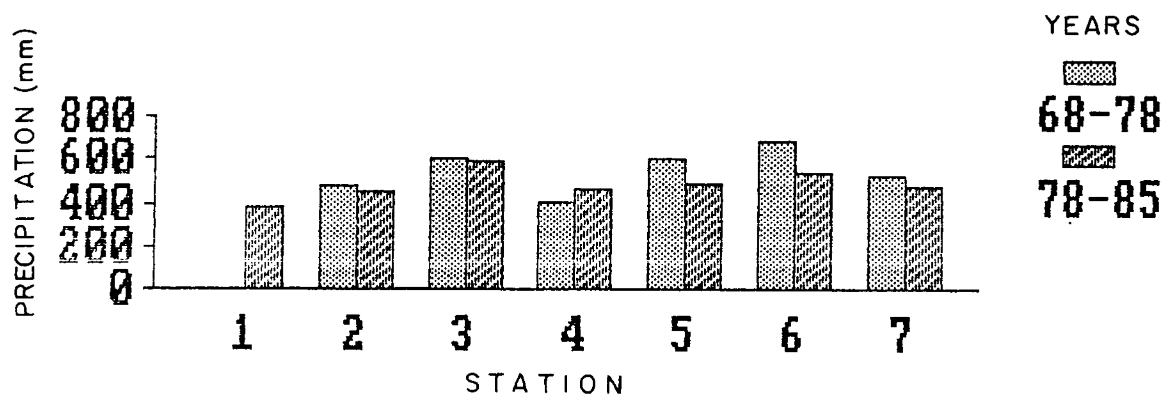

Fig. 5. Average precipitations for seven stations of the state of Aguascalientes, for two periods.

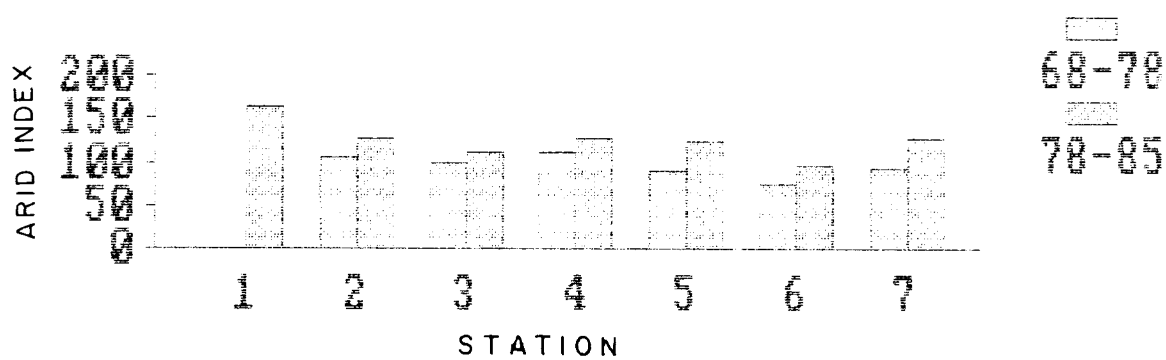

Fig. 6. Average arid index for seven stations of the state of Aguascalientes, for two periods.

In a recent paper based in the aridity index, Ritter *et al.* (1985) propose a method that stablishes a correlation between meteorological data and productivity, in terms of biomass (gr/m^2 year):

$$PN = 2016.0 IA^{-(0.83139)} \tag{1}$$

where PN is the net primary productivity (gr/m^2 year) and IA is the aridity index. The relation was obtained from the analysis of thirteen meteorological stations of Mexico and coincides with Budyko's (Ritter *et al.*, 1985) results.

In this paper, for the seven studied stations, the productivity (gr/m^2 year) is calculated by applying the Ritter and Budyko's method (1985) expresed by eq. 1. The results show (Fig. 7) that the productivity in all the stations has decreased for the period 1978-1985. This agrees with the observational data that report that the forest area of the west of the state, has been decreasing and it is being replaced by "bush". In the northeast, southeast and west, the "bush" area is increasing.

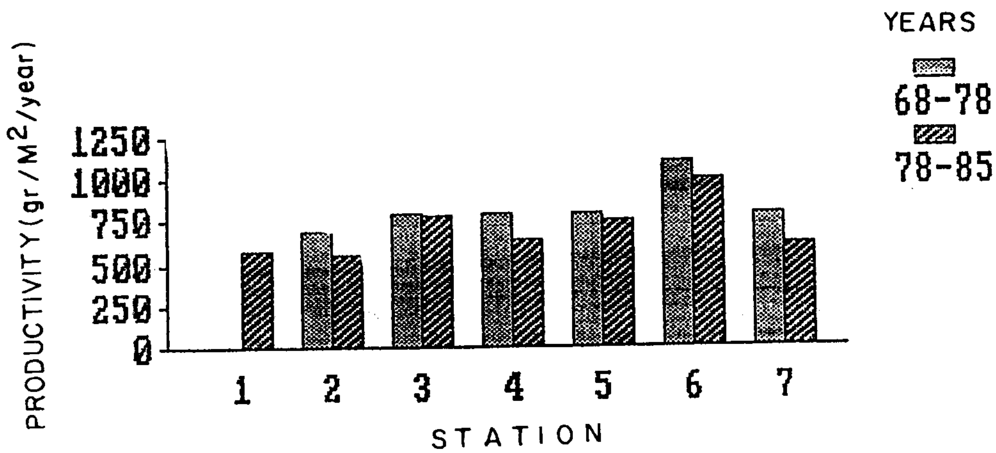

Fig. 7. Average productivity (biomass: gr/m^2 year) for seven stations of the state of Aguascalientes, for two periods.

The Picacho forest has been totally substituted by a "bush" area (Detenal, 1975; Siqueiros and De la Cerda, 1986). In the center of the state the most important changes are due to the growth of the urban and industrial areas.

Going back to Fig. 3, a time series analysis (Otaola and Centeno, 1986) was applied to the precipitation series (1921-1985) of the Aguascalientes station. Using the most significative components, the series was reconstructed and extrapolated to include the period 1985-1990. Taking this as an indication of what might happen to the precipitation in the future, the figure shows that it will be below the average value of $P = 511.01\ mm$ for the 1985-1990 period.

3. Discussion

The results of this work show an average increase in temperature of $T = 0.4^oC$ for the period 1978-1985, in the state of Aguascalientes, Mexico, with respect to the 1921-1985 average. They also show an increase in the aridity index and a reduction of biomass (gr/m^2 year, productivity) in the state. The increase in the state average temperature coincides with the tendency reported by Jones *et al.* (1986) for the period from the middle 70's to 1985. They found from the analysis of hundreds of stations located around the earth that the global temperature increase is of $T = 0.2^oC$ for the given period.

In this case the state of Aguascalientes temperature behavior agrees with the global warming tendency reported by the above authors. The increase of arid zones in the state also agrees with Hansen *et al.*(1981) results. This increase of drought prone zones in the state is closely associated to the decrease of the productivity (biomass: gr/m^2 year) calculated for the same period 1978-1985. If the calculated tendency in precipitation holds for the next four years, the temperature in the state, for the same period could stay above the yearly average as in the past five years. The effect of this temperature increase coupled with human activity can increase severely the arid areas and decrease the productivity (biomass) in the state.

The temperature increase reported here can be related with the global temperature increase that can be associated to variation of the CO_2 concentration, volcanic activity and greenhouse effect

(Hansen *et al.*, 1985; Wigley and Schlesinger, 1985; Adem and Garduño, 1984; Jones *et al.*, 1986). In this case this increase is also closely associated to the growth of urban areas, and deforestation due to human activity.

Acknowledgements

We thank to the Secretaría de Apoyo Académico de la U.A.A. and the Depto. de Biología. Centro Básico, U.A.A. for the facilities provided to us for the realization of this work.

REFERENCES

Adem J. and R. Garduño , 1984. Sensitivity Studies on Climatic Effect of an Increase of Atmospheric CO_2. *Geofís. Inter.*, **23**, 17-35.

DETENAL, 1975. Vegetation Cartography of Aguascalientes, Mexico.

Hansen J., D. Johnson, A. Lacis , S. Lebedeff , P. Lee, D. Ruid and G. Russell, 1981. Climate Impact of Increasing Atmospheric Carbon Dioxide. *Science,* **213,** 957-966.

Jones P. D., T. M. L. Wigley and P. B. Wright, 1986. Global Temperature Variations Between 1861-1984. *Nature,* **322,** 430-435.

Otaola J. and G. Centeno, 1986. Comunicación personal. Instituto de Geofísica, UNAM.

Ritter W. D., M. E. Garay y S. R. Guzmán, 1986. Balances de variación y potenciales de productividad primaria en algunos ecosistemas terrestres de la República Mexicana. *Geofís. Inter.*, **25**, 285-314.

Siqueiros M. y M. De La Cerda, 1986. Comunicación personal. Depto. de Biología. Centro Básico. UAA.

Wigley T. M. L. and M. E. Schlesinger, 1985. Analytical Solution for the Effect of Increasing CO_2 on Global Mean Temperature. *Nature,* **315,** 649-652.