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Possible impact of urbanization on the thermal climate of some large cities in México

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RESUMEN

La urbanización ha sido la tendencia demográfica dominante en México durante la segunda mitad del siglo XX. En el año 2000 había 69 ciudades con más de 100,000 habitantes, nueve de las cuales tenían más de un millón, para dar un total de 53.4 millones. Este trabajo trata de examinar los cambios de temperatura ocurridos al final del siglo XX utilizando series de tiempo de las medias de temperatura mensual para una docena de estaciones disponibles. Se seleccionaron series de temperatura mínima después de una prueba para homogeneidad ya que está bien establecido que el calentamiento urbano es un fenómeno principalmente nocturno. Se aplicó un análisis de tendencias a las series de temperatura mínima y se obtuvo el coeficiente de regresión lineal. Al aplicar pruebas de significación se observó que la mayoría de las tendencias positivas fueron significativas (> 90 %). Aunque la variabilidad en las tendencias de temperatura entre las ciudad fue grande (de 0.02 °C/década a 0.74 °C/década), el incremento de la temperatura promedio en las ciudades grandes ($\geq 10^6$ habitantes) fue considerablemente mayor (0.57 °C/década) que en los centros urbanos correspondientes de tamaño medio, en los que el incremento en la temperatura promedio fue de 0.37 °C/ década. Estos incrementos de la temperatura expresan no solamente el efecto de la urbanización, si no que también se deben al cambio climático global (del orden de 0.07 °C/década) y a la variación natural. En conclusión, se puede decir que el incremento de la urbanización en México ha originado una tendencia positiva de las temperaturas urbanas, lo que tiene implicaciones para la salud y el bienestar humanos.

ABSTRACT

Urbanization has been the dominant demographic trend during the second half of the 20th century in México. In 2000 there were 69 cities with more than 100,000 inhabitants of which 9 of them exceeded one million population, totalizing 53.4 million. Using time series of mean monthly temperature for about a dozen available stations, this paper sets out to examine temperature changes occurring during the late 20th century. Since it is well established that urban warming is mainly a nocturnal phenomenon minimum temperature series were

selected after a test for homogeneity. Trend analysis was applied to the minimum temperature series and a linear regression coefficient was obtained. Tests of significance were performed. Most of the positive trends proved to be significant (>90%). Although temperature trend variability amongst the individual cities was large (from 0.02°C/decade to 0.74 °C/decade) average temperature increase in large ($\geq 10^6$ inhabitants) cities was (0.57 °C/decade) considerably higher than that corresponding to medium size urban centers where on the average temperature increase was 0.37 °C/decade. These temperature increases express not only the urbanization effect but also that due to global climate change (of the order of 0.07 °C/decade) and natural variability. In concluding it may be said that increasing urbanization in México has originated a positive trend in urban temperatures which has implications
for human comfort and health.

Key words: Heat island, urban warming, México.

1. Introduction

During the second half of the 20th Century, migration from rural centers to medium/large cities took place in México. In recent decades a program by the government (The One Hundred Cities' Program) was initiated in order to decentralize activities in the areas of industry, manufacture and federal administration. The result of these policies has been that the few large cities (>2 million) (e.g. México City, Monterrey, Guadalajara) have reduced their growth while intermediate or medium size cities (population between 100,000 to 1,000,000) have been growing at a faster rate (Fig. 1). In 2000 the country counted 69 cities with more than 100,000 inhabitants, of which nine cities (larger than one million) showed metropolitan characteristics and housed 53.4 million (CONAPO, 2000). The impact of the process of urbanization on the climate of cities is well documented in the literature. As cities grow in extension the urban/rural thermal contrast increases (Oke, 1973). The characteristic warmth of towns is the so called "heat island" (Chandler, 1976; Landsberg, 1981; Oke, 1982). This phenomenon attains it maximum intensity at about daybreak. The objective of this note is to stress the changes in air temperature and their trend coincidental with the observed increase in urbanization.

2. Data and method

Mean minimum annual temperature series of 14 stations were used for the available period 1950-1990. Minimum temperatures were selected since they occur at the time maximum urban/rural contrasts are observed in the city. Trend analysis was applied to detect the effects of urbanization, as well as those due to natural variability and global climate change. The magnitude of the trend varies according to the period available, but in general it is more marked in the last decades of the 20th century. Trend of temperature series was positive for the selected cities.

3. Results

For convenience, the magnitude of the temperature trend was expressed in °C/decade. Table 1 shows population, temperature trend, and level of statistical significance in cities grouped according to population size: a) large cities over one million and b) medium size cities ranging from 125,000 to 700,000.

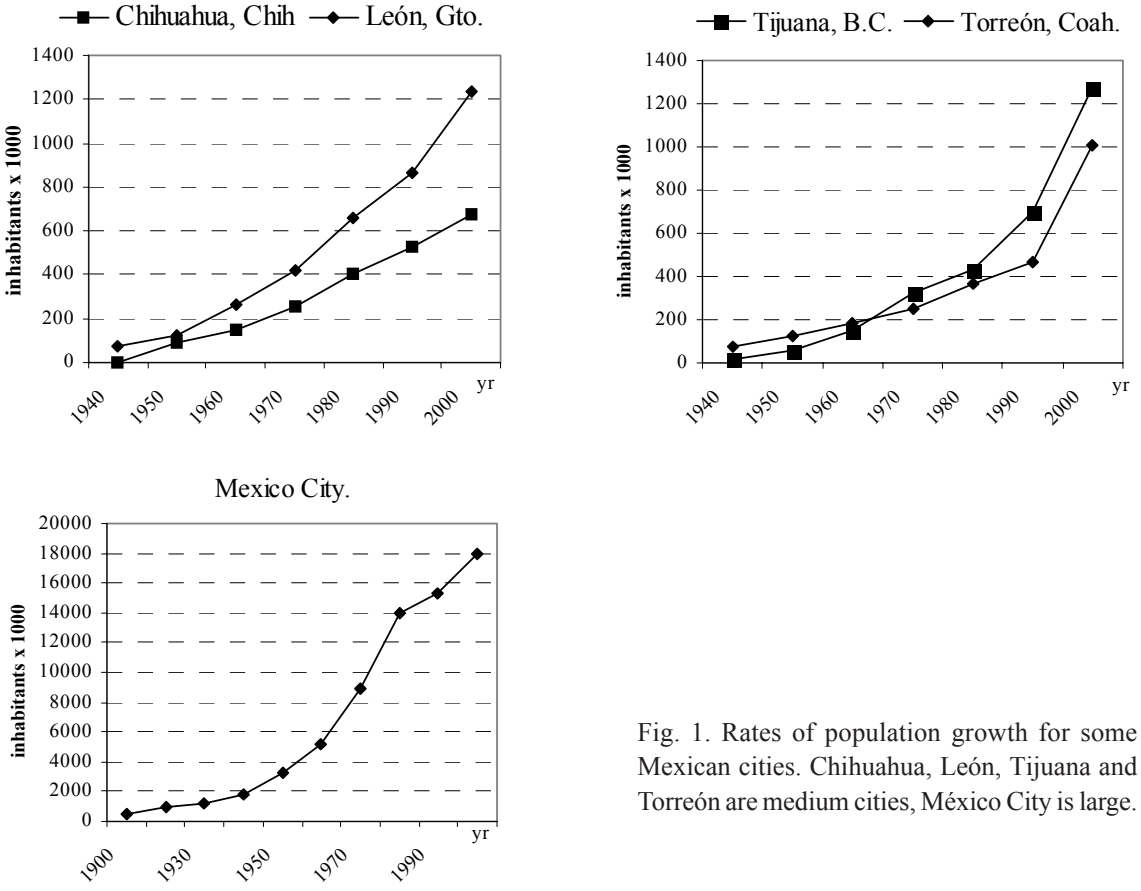

Fig. 1. Rates of population growth for some Mexican cities. Chihuahua, León, Tijuana and Torreón are medium cities, México City is large.

While variability is large among the seven selected cities, the average temperature trend was 0.57°C/decade for the large metropolis (> one million) and somewhat smaller (0.37°C/decade) for medium size cities. These values are clearly larger than the one attributed to the mean global greenhouse effect (0.07°C/decade) for the tropics. (WMO, 2001). One reason is that mean minimum annual temperatures have been used in this analysis to estimate the trend, instead of the hundreds of mean annual temperature series used to estimate temperature variability at the global scale. Another point to consider is that climate variability at the local scale may be affected, as this paper attempts to show, by local/regional factors. While separation of urban effects in the urban temperature series from those due to natural variability and global temperature change is still a problem to be solved, it is likely that the so called heat island effect is, as stated by Oke (1993) "among the largest climate change directly attributed to human activities". Finally, the above results suggest that the accelerated urbanization process in recent decades may have substantially contributed to the warming of the urban air observed in large cities in México, affecting the comfort and health of the population.

Table 1. Statistics of trend of minimum temperature, significance level and population of large and medium cities of México.

Population $> 10^6$	Trend °C/decade	Available period	Population 2000 x 1000	% Significance
Tacubaya (D. F.)	0.62	1920-1995	17.942	99.95
Guadalajara	0.74	1920-1997	3.677	99.95
Monterrey	0.27	1960-1986	3.243	<75
Puebla	0.02	1976-1995	2.220	<75
Tijuana	0.59	1949-1984	1.274	99.5
León	0.59	1959-1998	1.235	99
Torreón	1.2	1952-1998	1.000	99.9
Average	**0.57**			
Population 10^6 - 10^4				
Cd. Obregón	0.85	1961-1998	251	>95
Cuernavaca	0.18	1956-1994	705	75
Chihuahua	0.37	1950-1997	677	95
Tampico	0.34	1961-1997	664	90
Zacatecas	0.30	1961-1997	232	90
Guanajuato	0.19	1969-1997	748	<75
Mexicali	0.40	1951-1980	549	75
Average	**0.37**			

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References

Chandler, T. J., 1976. Urban Climatology and its relevance to urban design. WMO Tech Note No. 149, WMO, Geneva.

CONAPO, 2001. Consejo Nacional de Población. Secretaría de Gobernación. México.

Landsberg, H.E., 1981. *The Urban Climate*. Academic Press. New York.

Oke, T. R., 1982. The energetic basis of the urban heat island. *Quart. J. Royal Meteorol. Soc*. **108**, 1-24.

Oke, T. R., 1973. City size and urban heat island. *Atmos. Environ*. **7**, 769-779.

Oke, T. R., 1993. Global change and urban climates. Proceed. 13th Int. Congress Biometeorology. Sept. 12-18. Calgary, 123-134, Canada.

WMO 2001. Statement on the status of the global climate in 2001. WMO-No. 940; p. 5.