ANALYSIS OF SURFACE AIR TEMPERATURE RECORDED IN LAHORE AND MIANWALI OVER THE PAST THREE DECADES

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ABSTRACT

Surface air temperatures recorded over the past three decades at the weather stations located in Lahore (an industrialized and densely populated city) and Mianwali (a small and sparsely populated city) were analyzed in order to study their climatic trend. Lahore, where meteorological data are recorded at two weather stations (city station and airport station) indicates a cooling trend, of about 0.5℃ per record period of 1953—1992, for the airport station (31°31′N, 74°24′E) and a slight warming trend, of about 0.2℃, for the city station (31°33′N, 74°20′E) for the record period of 1950—1992. The Mianwali weather station (32°33′N, 71°31′E) also shows a slight cooling trend, of about 0.4℃ per record period of 1959—1992. The climatic variability at these stations was studied by computing seasonal and annual temperature anomalies. The results are explained in terms of the local environmental conditions.

Key words: surface air temperature, climatic change, temperature trend

I. INTRODUCTION

Surface air temperature is the principal climatic element influencing significantly the man and his environment. This is perhaps the reason that much attention has been focused on its measurement and its record taken over long period of time is now available for analysis.

Several studies of surface air temperatures recorded in the past century have been reported for the whole globe and also for the Northern Hemisphere. A recent review of these studies by Hingane et al. (1985) has indicated warming of the Northern Hemisphere between 1880 and 1940 and cooling between 1940 and 1950. A reversal of post-1940 cooling during 1960s has been suggested by some researchers (see, e.g., Lamb et al. 1975). A general warming during the past century has been reported by Hansen et al. (1981) for the southern latitudes although according to Klein (1982), the conclusion is uncertain because of sparse data. It is noted by Watts (1982) and Jones et al. (1982) that the surface air temperature studies are more or less inhomogeneous in space and time. It is reported that several geographical regions such as the oceans, the Asian highlands and the central Arctic are missing in these studies.

It is found as a result of an extensive literature survey by the authors that almost no study has been ever made on climatic change or even climatic variability in Pakistan, although several meteorological stations located in Pakistan have been maintaining weather data for the last several decades. Study of variation of surface air temperature recorded at the weather stations located in the Punjab Province of Pakistan was undertaken and preliminary results of the two cities Lahore (an industrial and densely populated city) and Mianwali (a non-industrial and thinly

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populated city) are reported in this paper.

II. GEOGRAPHICAL LOCATIONS OF STATIONS

Presently about 270 weather stations are collecting meteorological data in Pakistan. Some of the stations, namely, Karachi Maripur, Nawabshah, Muzaffargarh, Sargodha, Chaklala–Rawalpindi, Kakul, Nathiagali, Chillas and Skardu cities, were established in 1950—1958, and the rest, namely, Badin, Khanpur, Bahawalnagar, Harnai, Leiah, Bannu, Mianwali, Kohat, Mardan and Saidu Sharif during 1958—1962 and Turbat, Dadu, Khuzdar, Khairpur, Jacobabad, Sibi and Bahawalpur were established during 1963—1980. Although some meteorological stations, e.g., Karachi, Lahore and other stations started operating several years before, the meteorological data recorded at these stations prior to 1950 were not available for analysis. *Geographical locations and environmental conditions of the stations of study are described be*low.

Lahore is the capital of the Punjab Province of Pakistan and is situated on the left bank of the Ravi River. It is the second thickly populated city in Pakistan having a population of about 4 million. It is famous for beautiful gardens and historical places. It is an industrial city producing rayon, fertilizers, glass, ghee, paper, board, match, chemicals and pharmaceuticals, and iron and steel. The city is also famous for leather tanneries. Heavy traffic plies on the city roads throughout the day. There are two weather stations, one in the city center (Lahore PBO) and the other on the airport (Lahore AP). The city is situated in the steppe hot climatic region with record extreme highest and lowest temperatures of 50.0℃ and −4.0℃ respectively. Lahore PBO weather station (31°33′N, 74°20′E) is located in thickly populated part of the city. The Lahore AP weather station (31°31′N, 74°24′E) is located in the thinly populated part of the city.

Mianwali station (32°33′N, 71°31′E) is situated in the sandy, semi–arid desert area near the left bank of the Indus River. It is also characterized as an extreme climate region, i.e. hot in summer and cold in winter with record extreme highest and lowest temperatures of 50.0℃ and −3.0℃ respectively.

III. DATA AND ANALYSIS

A record of surface air temperatures was obtained from Meteorological Services of Pakistan for the Lahore and Mianwali weather stations. Analysis of the data obtained from meteorological stations for a period of 1950 to 1992 for Lahore and 1959 to 1992 for Mianwali was carried out.

Monthly mean temperatures were calculated from the mean values of the daily maximum and minimum temperatures recorded at the stations mentioned in this study. Mean annual and mean seasonal temperatures were also calculated for all the stations. The seasons were taken from December to February as winter, March to May as pre–monsoon, June to September as monsoon and October to November as post–monsoon. In the analysis, the number of years included in the winter season becomes one year less than the remaining seasons because December of each year is included in the following year for obtaining the mean seasonal temperature for winter. The mean seasonal and annual temperatures for the years of study were utilized to obtain temperature anomalies by subtracting the arithmetic mean of a series from the corresponding yearly values.

The long term variation in surface air temperatures was investigated by plotting the

temperature anomalies against time, the anomalies are denoted by ANOM in the plots. A rather smoother curve was plotted by computing the 9–point moving average of the anomalies. These anomalies are denoted by 9–point in the plots. A linear regression curve was fitted to all the temperature anomalies; these anomalies are denoted by YEST in the plots. The temperature trends as predicted by the linear curve are given as temperature changes in degrees Celsius (℃) for the entire period of record for each station.

IV. RESULTS AND DISCUSSIONS

Temperature anomalies for Lahore city, Lahore airport and Mianwali are shown in Figs.1, 2 and 3 respectively.

Figure 1a shows that lower winter temperatures were observed during 1952 to 1957, 1959 to 1964 and 1966 to 1974 and higher from 1974 to 1990 with a few exceptions in both cases. As the rate of rise in temperature is more significant than the fall in temperature, an overall warming trend of about 1.2℃ is obvious.

Temperature anomalies for the pre–monsoon months have been plotted in Fig.1b. Here the anomalies show almost a consistent fall in temperature for the years 1954 to 1965 with a few exceptions. In the years from 1966 to 1975, there is a consistent rise in pre–monsoon temperature. From 1973 to 1982 temperature again falls almost with the same rate as for the period from 1954 to 1965. If the entire pre–monsoon period is considered seasonal estimated temperature shows modest fall of the order of 0.4℃ for the period of record under analysis.

During the monsoon period (Fig.1c), the temperature anomalies show a fall for the entire period of record; the seasonal estimated temperature is found to fall by about 0.4℃. This fall occurred exactly at the same rate as the pre–monsoon period. It is interesting to note that in the post–monsoon period, the anomalies show an almost consistent rise of temperature by about 1.0℃ for the entire period of record under analysis except for the years from 1974 to 1981 when the temperature remained almost consistent (Fig.1d).

Figure 1e shows the plot of annual temperature anomalies for Lahore PBO against the years of record. As rise of temperature during winter and post–monsoon periods is more significant than the fall of temperature during pre–monsoon and monsoon periods, the annual anomalies show a modest rise (0.2℃) of temperature in the Lahore city for the entire record period from 1950 to 1992.

In contrast to Lahore city, Lahore airport station shows an insignificant rise (0.1℃) in temperature for winter (Fig.2a), a bigger fall for the pre–monsoon (Fig.2b) and monsoon (Fig.2c) periods. Here, the pre–monsoon and monsoon anomalies show a fall of 1.3℃ and 0.6℃ for the record period respectively. However, the winter and post–monsoon periods show a modest temperature rise of about 0.1℃ and 0.2℃ for the record period respectively.

The temperature anomalies during the monsoon months show a small fall in temperature for some years from the beginning of the period of study, followed by a faster fall of temperature after 1970. The variation of temperature during the pre–monsoon months is about twice the variation during monsoon months (Figs.2b and 2c). However, during the winter and post–monsoon months of the entire period of study, temperature is not found to vary significantly (Figs.2a and 2d). The significant fall of temperature during pre–monsoon and monsoon months has resulted in overall cooling trend at Lahore airport by about 0.5℃ for the entire period of record, i.e. 1953 to 1992 (Fig.2e).

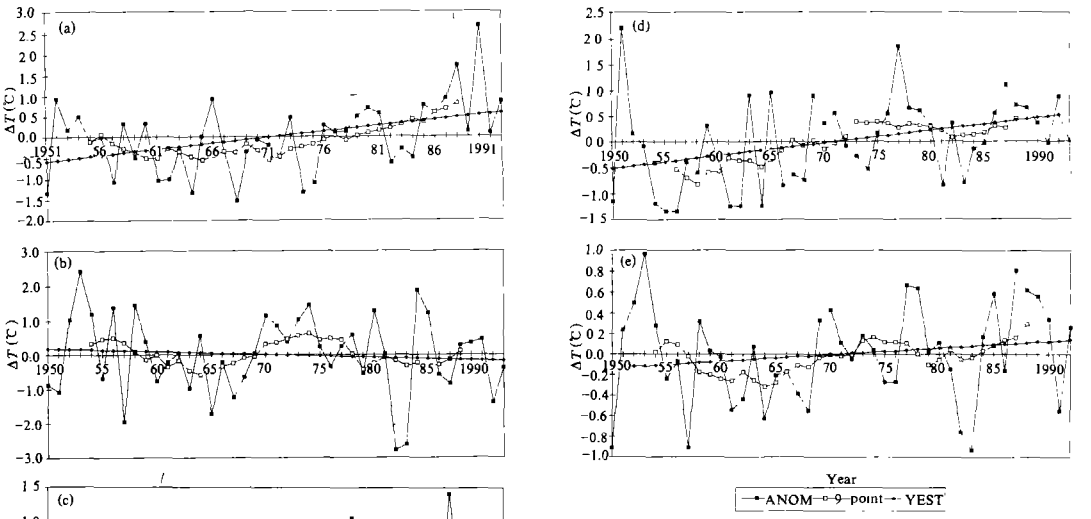

Fig. 1. Temperature anomalies for Lahore PBO from 1950 to 1992. (a) Winter (1951—1992); (b) pre-monsoon; (c) monsoon; (d) post-monsoon; (e) annual.

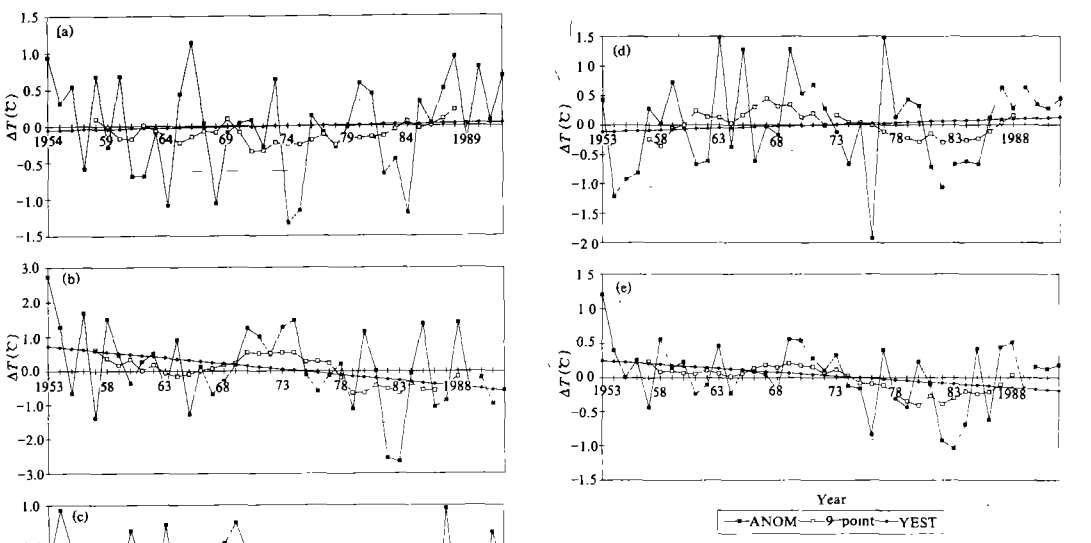

Fig. 2. Temperature anomalies for Lahore airport from 1953 to 1992. (a) Winter (1954—1992); (b) pre-monsoon; (c) monsoon; (d) post-monsoon; (e) annual.

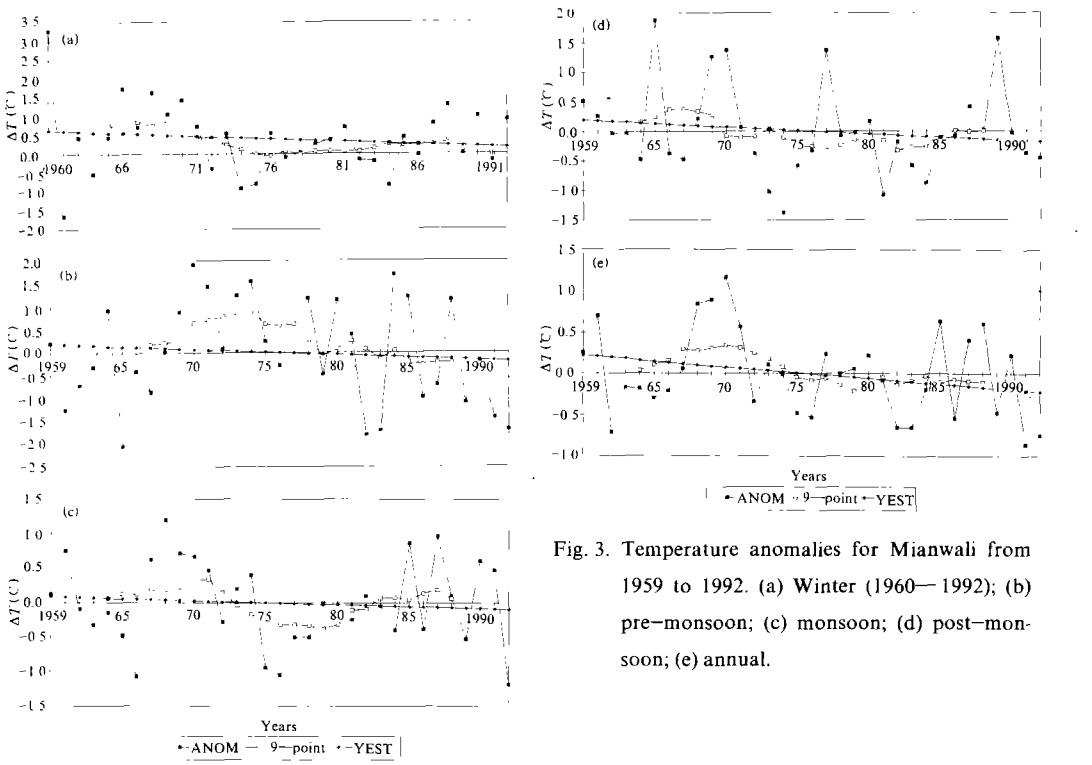

Fig. 3. Temperature anomalies for Mianwali from 1959 to 1992. (a) Winter (1960—1992); (b) pre-monsoon; (c) monsoon; (d) post-monsoon; (e) annual.

The Mianwali surface air temperature data, recorded during 1959 to 1992, show respectively the same temperature fall of about 0.4℃ for the winter and post-monsoon months (Figs.3a and 3d). The Mianwali temperature is, however, found to fall during the pre-monsoon months by about 0.4℃ (Fig.3b) for the period of record. There is an insignificant fall (0.2℃) in Mianwali temperature during the monsoon months (Fig.3c).

The annual anomalies plotted in Fig.3e for Mianwali station for the period of record from 1959 to 1992 show a fall in temperature by about 0.4°C. A closer look on these temperature data, Figs.3a and 3d show that the winters of the years from 1966 to 1971, the pre-monsoon months of the years from 1968 to 1975, monsoon months of the years from 1966 to 1971 and the post-monsoon months of the years from 1965 to 1970 were hotter than the other seasons of the record period. A summary of all the results of stations under analysis is given in Table 1 along with their locations and heights above mean sea level.

V. CONCLUSIONS

Analyses of surface air temperatures recorded at Lahore PBO (1950—1992) and airport (1953—1992) and at Mianwali (1959—1992) have shown a modest warming trend by about 0.2℃ for the Lahore city localities, a cooling trend by about 0.5℃ for the Lahore airport localities and a cooling trend for Mianwali by about 0.4°C. Although the Lahore city and airport weather stations are situated very close to each other geographically, the opposite temperature trends found for the stations are not very significant for estimating climate trend. However in the Lahore city, where Lahore PBO is situated, the area is thickly populated and has busy

Table 1. Climatic Variability at Lahore and Mianwali over the Past Three Decades

Station	Elevation	Winter	Pre-monsoon	Monsoon	Post-monsoon	Annual
Lahore PBO (1950—1992)	215 m	−0.6 to +0.6 (1.2℃) warming	+0.2 to −0.2 (0.4℃) cooling	+0.2 to −0.2 (0.4℃) cooling	−0.5 to +0.5 (1.0℃) warming	−0.1 to +0.1 (0.2℃) warming
Lahore airport (1953—1992)	216 m	−0.1 to +0.0 (0.1℃) warming	+0.7 to −0.6 (1.3℃) cooling	+0.3 to −0.3 (0.6℃) cooling	−0.1 to +0.1 (0.2℃) warming	+0.3 to −0.2 (0.5℃) cooling
Mianwali (1959—1992)	212 m	+0.6 to +0.2 (0.4℃) cooling	+0.2 to −0.2 (0.4℃) cooling	+0.1 to −0.1 (0.2℃) cooling	+0.2 to −0.2 (0.4℃) cooling	+0.2 to −0.2 (0.4℃) cooling

roads full of traffic all the day long in contrast to the airport localities. The former area therefore exhibits a warming trend possibly because of polluted environment and a little plantation. Mianwali area which is much less populated and polluted than the Lahore city thereby shows a likely warming trend. As the wind speed for most of the Punjab Province stays calm to gentle breeze throughout the year (Shamshad 1988), environmental changes occurring in one area may not have a noticeable effect on the adjoining regions.

The results of the study are being further investigated in terms of other meteorological parameters namely precipitation and environmental effects of pollution.

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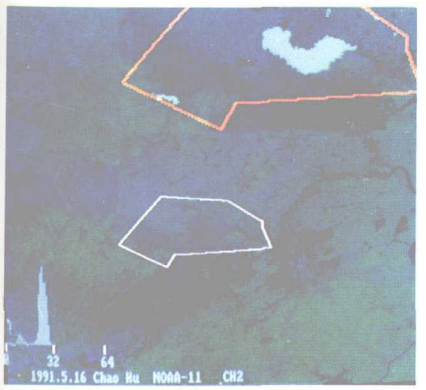

Fig. 1. Cloud—free image from CH2 of NOAA-11 in the Chaohu Lake and its surrounding area on May 16, 1991, with the analysis method shown (see text).

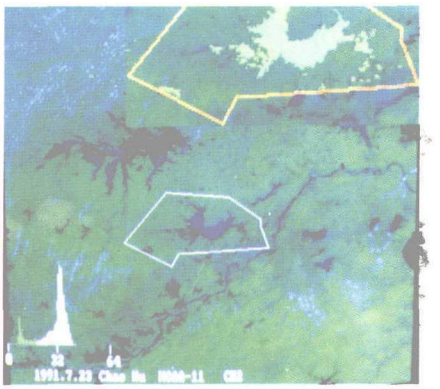

Fig. 2. As in Fig. 1 but for July 23, 1991.

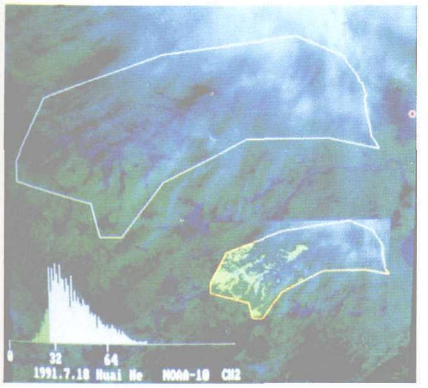

Fig. 3. Image from CH2 of NOAA-10 on July 18, 1991 over the Huaihe River basin. The histogram analysis is done with albedo of CH2.

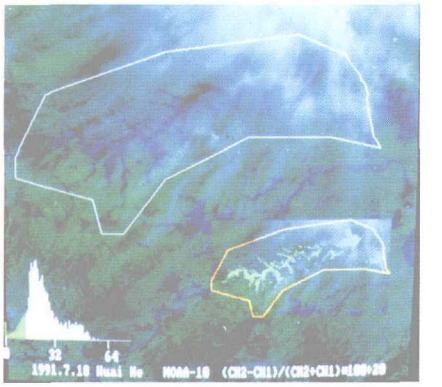

Fig. 4. As in Fig. 3 but with vegetation index for the histogram analysis (see text).

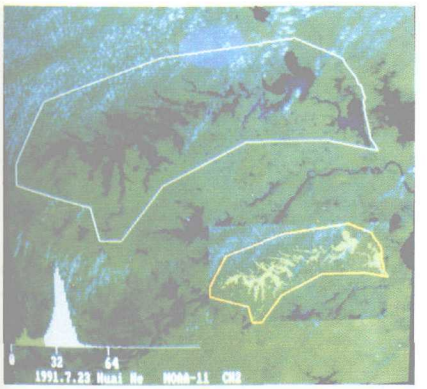

Fig. 5. Satellite image from CH2 of NOAA-11 over the Huaihe River basin on July 23, 1991. The histogram analysis is made with albedo from CH2.

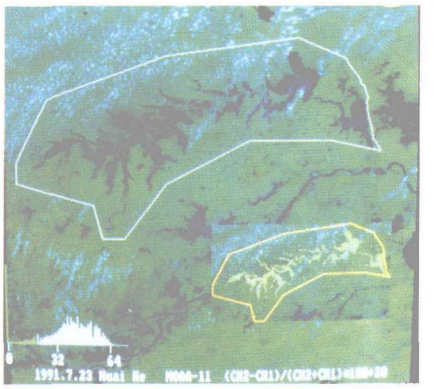

Fig. 6. As in Fig. 5 but the histogram analysis is made with vegetation index.