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Temporal Variation of Rainfall and Temperature In the Ganga Basin

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SYNPOSIS

A study of the climatic change in a region is important for agro-economic planning. Three stations, viz. Agra, Delhi and Dehradun, were selected for the study of temporal variations of rainfall and temperature in the upper and middle parts of the Ganga Basin. Long-term data on monsoon rainfall, number of rainy days during monsoon season and the annual maximum temperature at these stations were analyzed. Analysis of the data indicated that the total monsoon rainfall and the number of rainy days during monsoon season are on a decline at these stations and the annual maximum temperature shows increasing trend. This shift was observed to have begun during the latter half of nineteen sixties. These results point towards a possible shift in the climate of the Ganga basin.

1.0 INTRODUCTION

A very large part of India faced a severe drought particularly during the latter half of nineteen seventies and the first half of nineteen eighties. This drought persisted for a period of five to seven years and caused untold economic hardship. It complicated economic planning, because Indian economy is agriculture-based and its time scale is smaller than the period of this drought. This drought period was followed by adequate monsoon rains for a few years. An analysis of data indicated that the rainfall during these monsoon years was not as high as it was prior to the drought period. The monsoon rainfall seems to have been on the decline again in recent years. There is a common feeling that the weather in general is warmer these days than it used to be. A consequence of these climatic changes is reflected in large scale changes that have occurred in agricultural practices, say, in the Agra region. Such changes cannot be fully attributed to advances in agricultural technology alone. These changes are typified by dramatic shifts in crops that are now grown in the Agra region. Previously, sugarcane, peas, gram and wheat were the dominant crops. Now-a-days mustard and wheat are the dominant crops. Virtual disappearance of sugarcane and peas may be ascribed to the lack of soil moisture resulting from reduced monsoon rains.

Rainfall and temperature are common climatic indicators. To quantify climatic change, rainfall and temperature changes are often used as yardsticks, in addition to changes in runoff, lake level and ground water table. Temporal variations of these variables are a measure of the sensitivity of the climate system to external forcing factors such as the changes in carbon dioxide concentration and solar output which, in turn, are affected to a certain extent by man's activities such as large scale deforestation and massive urbanization, etc. Quantifying the climatic response to such external changes is essential for predicting climatic changes in the future. This paper attempts to address some of these issues in the context of possible changes in the climate of the Ganga Basin.

2.0 REVIEW OF LITERATURE

Climate change can be characterized by differences in the mean values of climate statistical of successive climatic periods. Changes in the statistics within a climatic period can be termed climatic variation (Kite, 1989). Most of the climatic records are less than 150 years long. As per Klemes (1974), "there is no way of telling from the commonly available record alone to what extent the apparant changes are due to the sampling errors and to what extent they represent changes in the underlying laws". Jones et al. (1986) studied near-surface temperature for a period of 130 years. Their study revealed marked warming of the globe during nineteen fourties, i.e. the war period, relatively steady conditions to the middle of nineteen seventies and a subsequent rapid warming. The warmest three years have all occurred in nineteen eighties.

Kite (1989) fitted a time series model consisting of trend, periodic, autoregressive and residual components to several climatic series that were 70 years long. This analysis did not reveal any trend, that may indicate climatic change possibly induced by the greenhouse effect. An increase in temperature and a decrease in rainfall lead to a decrease in flows and vice-versa. An evidence of climatic change may be reflected by positive or negative trends in natural time series. The trend component of a time series is generally associated with the changes in the structure of the time series caused by cumulative natural or man-made phenomena.

In this study, rainfall and temperature data at three locations in Ganga Basin were analyzed for detection of possible local climatic changes.

3.0 DATA

The meteorology of the Ganga Basin is almost completely governed by the monsoon phenomenon. The monsoon period in this basin, in general, starts somewhere in the last week of June and it ends before the last week of September. For an investigation of climatic change, the total monsoon rainfall may be adequate. In addition, the total number of rainy days during the monsoon period and the series of maximum temperature during the year were chosen for this study.

The meteorologic data of three stations, namely, Agra, New Delhi and Dehradun (see Fig. 1) were compiled from various sources (IMD 1950-1989, 1969), ICAR (1970). The data on rainfall were compiled for the period from 1901 to 1989 and the data on temperature were compiled for the period from 1950 to 1989. Easy access to these data and the representativeness of the basin by these stations were the primary consideration for their selection in this analysis.

4.0 ANALYSIS OF DATA AND DISCUSSION OF RESULTS

The temporal variations of the total monsoon rain, total number of rainy days during the monsoon season and the maximum annual temperature were plotted. The presence of the trend component, which is generally associated with changes in the structure of time series caused by cumulative natural or man-madephenomena, was empirically identified in these plots. In order to clarify the evidence of a trend component in the time series of each variable the ten-year moving average was also plotted. The ten-year moving average was chosen, because climatic variations such as droughts are considered to have a maximum length of ten years. Frequency analysis of the data was carried out to quantify the changes in the statistics of these time series within the intervening period. Attempts were made to provide physical interpretations to such identified trends.

Temporal variation of the monsoon rainfall revealed that within the time span under study there were three distinct periods during which the total rainfall amount and period showed a continuous decline. The temporal variation of rainfall amount of Agra and the temporal variation of the number of rainy days at New Delhi are shown in Fig. (2) and Fig. (4), respectively, for illustration alongwith the variation of the corresponding 10-year moving average Fig. (3) and Fig. (5). The periods during which rainfall amount showed a declining trend were 1922 to 1932, 1950 to 1960 and 1965 to 1989 for New Delhi, 1923 to 1932, 1954 to 1960 and 1968 to 1989 for Dehradun and 1926 to 1936, 1951 to 1960 and 1965 to 1989 for Agra. Of these the first two segments, showing a declining rainfall at these stations, were of shorter duration and hence they were construed as climatic variation. However, the last segment which started almost simultaneously at all the three stations and is most recent, had a length, that was much larger than the length over which climatic variations are known to occur. The same feature was also revealed by the temporal variation of the total number of rainy days during the monsoon season. The average rate of decrease of the rainfall amount at these stations is given in Table 1.

Temporal variations of the annual maximum temperature were also plotted, which indicated a marked increase in the temperature during recent years. Fig. (6) shows such a plot for Dehradun. It is to be noted that the time period subsequent to 1965, during which the rainfall amount and the number of rainy days had shown a continuous decline and the temperature values had shown the increasing trend, is long enough for getting alarmed for a possible climate change.

A frequency analysis of the rainfall data was carried out to determine the decrease in rainfall magnitudes at given frequency levels. Data for the period 1965-ownwards were separated from the original series for this purpose. Results of this analysis are presented in Table 1, which indicates a decrease in rainfall values corresponding to all frequencies. Fig. (7) depicts this change for Dehradun as an illustration.

One reason for these apparent trends shown by the data can be due to the large scale deforestation activities which started in early sixties for the construction of roads, etc. and due to subsequent large scale urbanization of the başin. However, it is difficult to detect that the changes may be possibly due to the accumulation of carbon dioxide and other greenhoues gases in the atmosphere.

TABLE 1 : CHANGES IN STATISTICS OF THE TIME SERIES

S.No.	Station	Average rate of decrease of monsoon rainfall amount (mm/100 years)	Mean monsoon rainfall (mm)		Rainfall amount (mm)					
			Based on data 1901-1965	Based on data 1901-1989	Data Series 1901-1964 Frequencies			Data Series 1965-1989 Frequencies		
					50%	75%	90%	50%	75%	90%
1.	Agra	120	609	580	591	433	316	531	387	276
2.	New Delhi	145	630	610	612.5	457	397	571	410	285
3.	Dehradun	206	2063	2003	1970	1830	1817	1895	1382	1200

5.0 CONCLUSIONS

Rainfall and temperature data at three stations have been analyzed for detecting the change in the climate of the Ganga Basin. Temporal variations of total monsoon rain and total number of rainy days during monsoon have shown a declining trend and annual maximum temperature an increasing trend. The average total rain during monsoon has decreased by 120 mm to 206 mm during past one hundred years. These results strengthen the contention that climate of the Ganga Basin is undergoing a change.

6.0 REFERENCES

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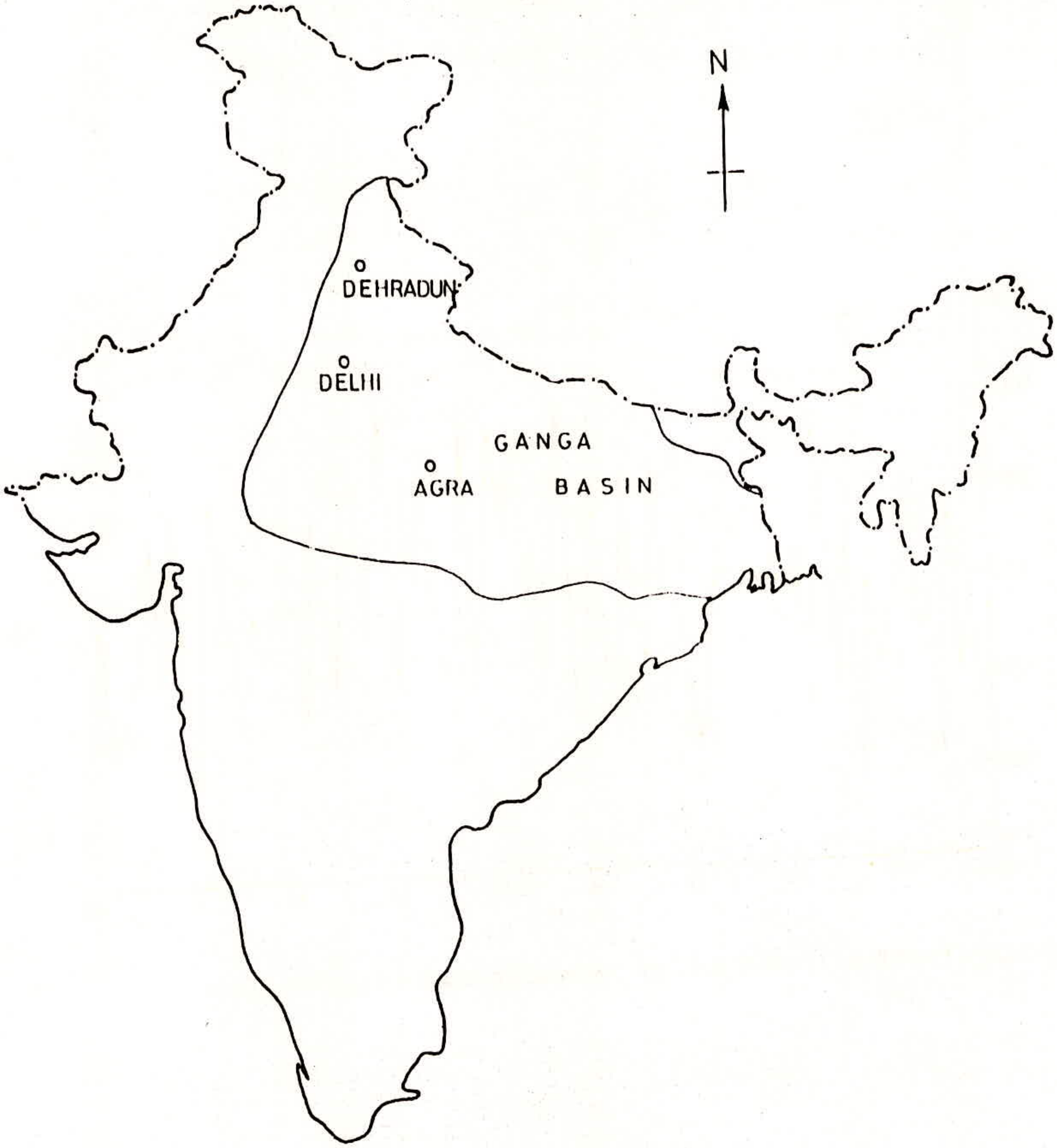

FIG. 1 – MAP OF INDIA SHOWING THE LOCATIONS OF THE STATIONS

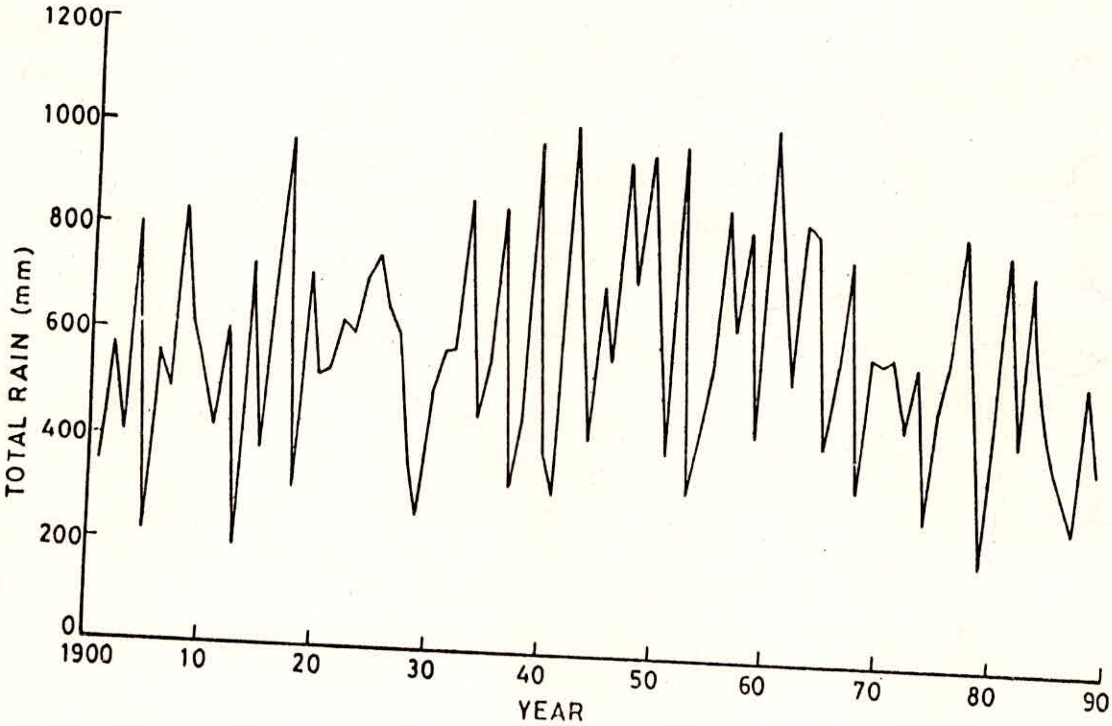

FIG. 2—TEMPORAL VARIATION OF MONSOON RAINFALL AT AGRA

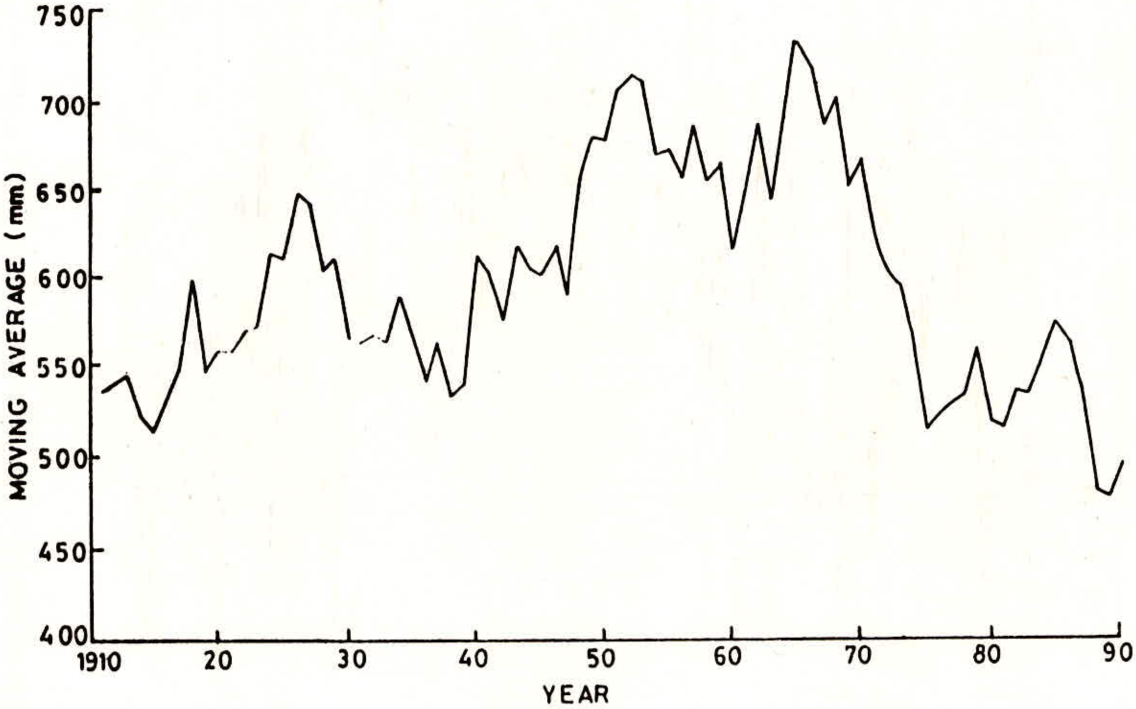

FIG. 3 — 10 YEAR MOVING AVERAGE OF MONSOON RAINFALL AT AGRA

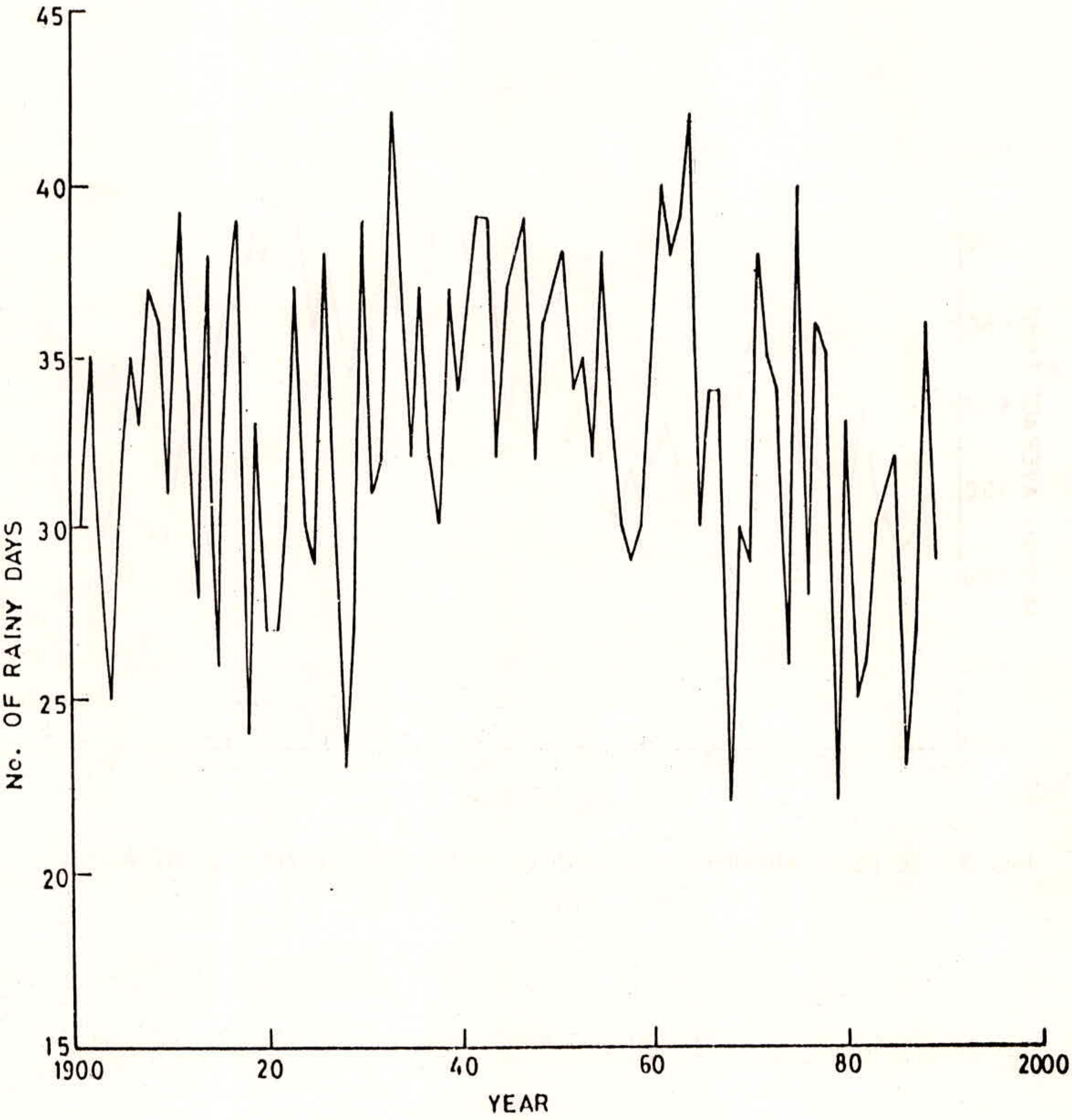

FIG. 4 – TEMPORAL VARIATION OF NUMBER OF RAINY DAYS AT DELHI

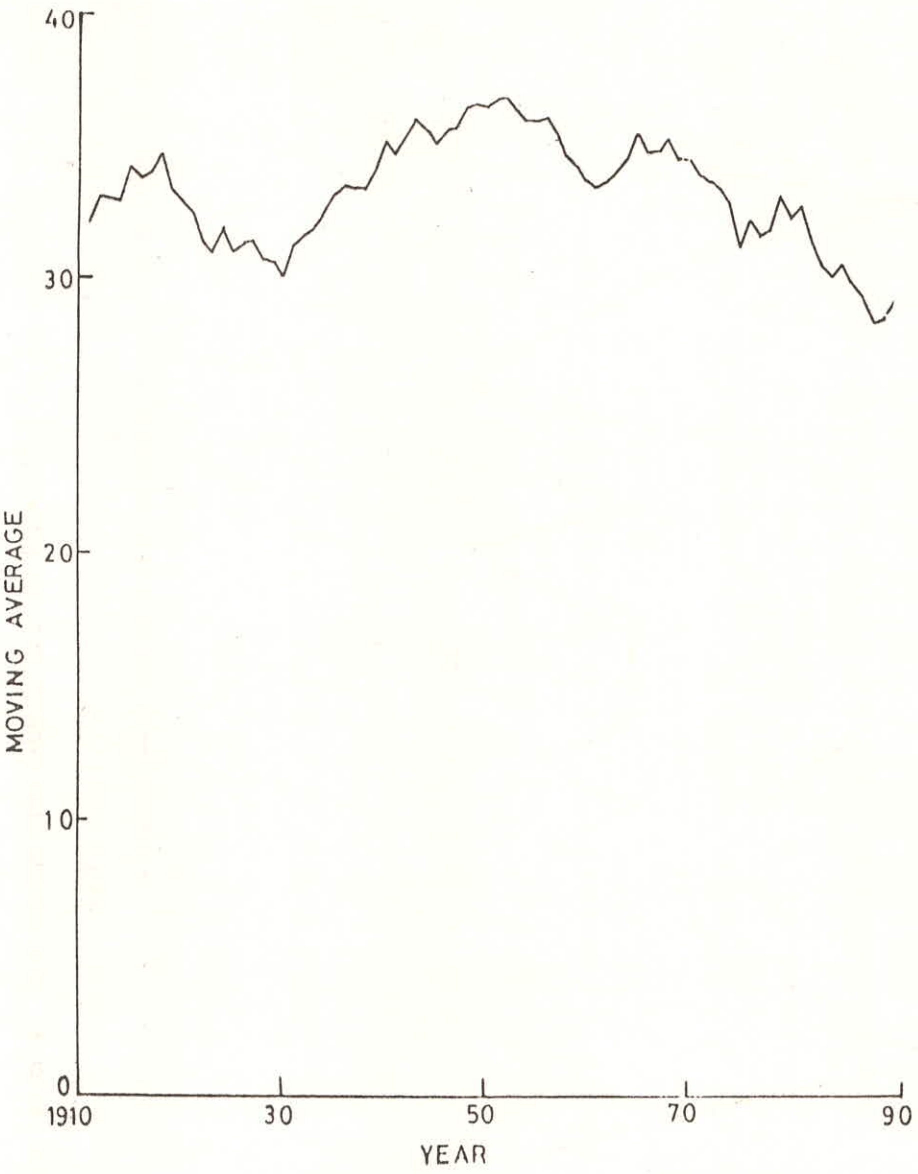

FIG. 5—10 YEAR MOVING AVERAGE OF TOTAL NUMBER OF RAINY DAYS AT DELHI

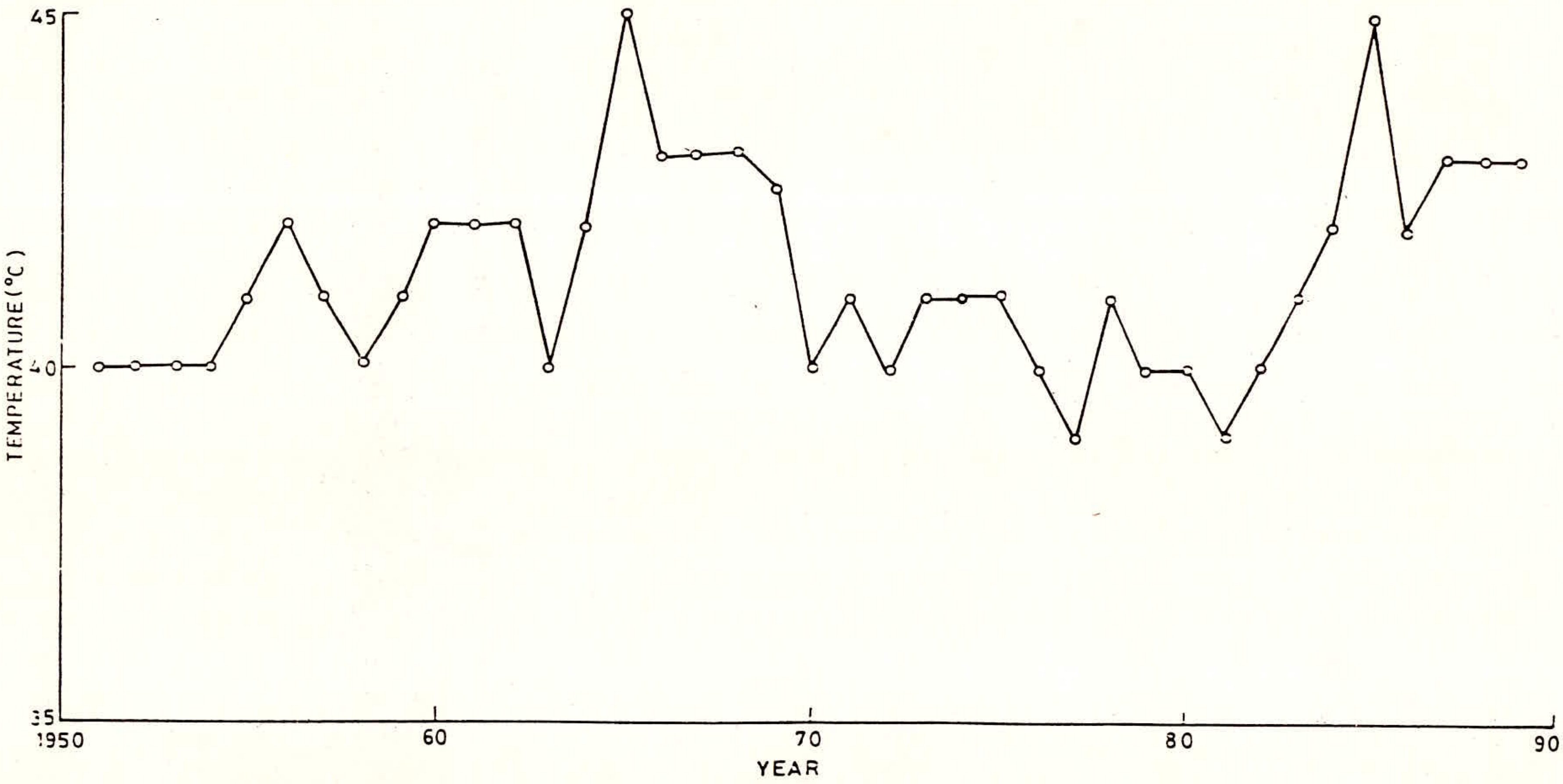

FIG. 6—TEMPORAL VARIATION OF ANNUAL MAXIMUM TEMPERATURE AT DEHRADUN

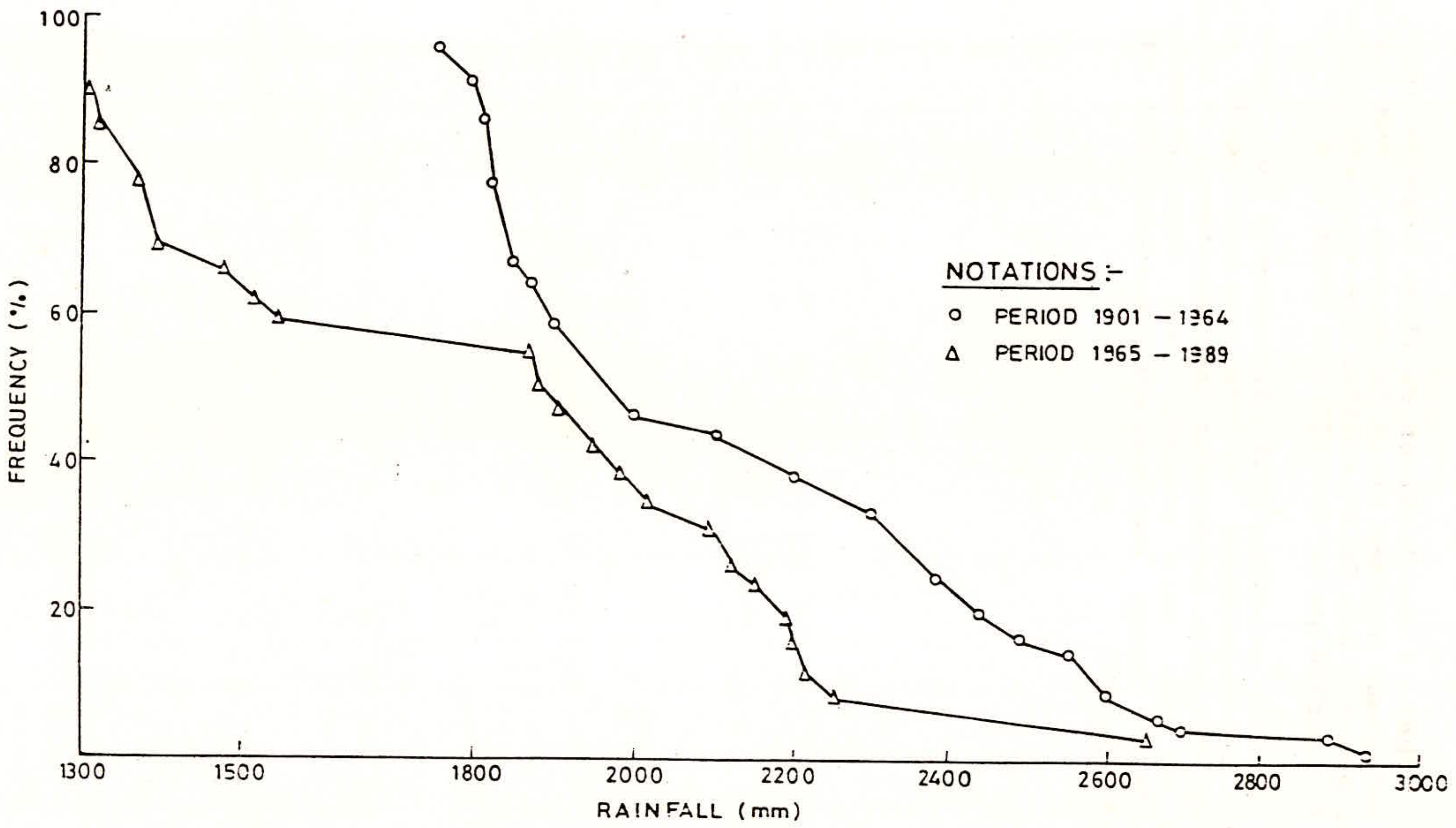

FIG. 7 —FREQUENCY DISTRIBUTIONS OF MONSOON RAINFALL AT DEHRADUN

DISCUSSION

S. M. SETH : What is the location of three observatories at Agra, Delhi and Dehradun? whether it is urban area or was forested area in earlier years ? For Delhi whether there is any difference of behaviour for period prior to 1970 and after 1970 ?

AUTHOR(S) : The stations for measurement or rainfall and temperature as considered in the present study are those monitored by the India Meteorological Department. A change in the behaviours of the rain stations has been detected at all stations. This change has started simultaneously at all the stations around 1965.