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Climate changes and trends over India

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सार – भारत में एक शताब्दी से अधिक समय के उपलब्ध संयंत्रों से प्राप्त प्रेक्षणों के आधार पर यह प्रयास किया गया है कि वर्षा, भूसतही ताप, वायुमण्डलीय दाब और कुल ओजोन के विशेष सन्दर्भ में क्या भारत में जलवायु परिवर्तन या प्रवृत्ति का कोई स्पष्ट प्रमाण है ? इस अध्ययन से यह निष्कर्ष निकला है कि यद्यपि इन वायुमण्डलीय चरों में वर्ष प्रतिवर्ष या दृच्छिक उतार-चढाव होते हैं और वर्षा एवं भूसतही ताप के सन्दर्भ में कहीं-कहीं कालावधिक वृद्धि या ह्रास होते हैं किन्तु भारत में क्रमबद्ध जलवायु परिवर्तन अथवा प्रवृत्ति प्रतीत नहीं होते हैं। भारत के ऊपर ओजोन की कमी का भी कोई प्रमाण नहीं है।

ABSTRACT. Based on the instrumental observations of over a century available in India, attempt is made to study if there is a clear-cut evidence of any climate change or trend over India with particular reference to rainfall, surface temperature, atmospheric pressure and total ozone. The study concludes that while there are year to year random fluctuations in these atmospheric variables and there are certain epochal increases and decreases in respect of rainfall and surface temperature, there appears to be no systematic climate change or trend over India. There is also no evidence of ozone depletion over India.

Key words — Random fluctuation, Epochal increase, Total ozone, Pressure, Temperature, Rainfall.

1. Introduction

In India, climatic data based on instrumental observations are available from 1870 onwards for about 120 years. By using these data, the problem of climate changes and trends in India has been studied by several investigators and the reviews on the subject are available in the literature (Sarker and Thapliyal 1988). Here an attempt has been made to summarise the evidence and identify signals, if any, which indicate climate change over the Indian region. The problem has been discussed with particular reference to the Indian rainfall, temperature, pressure and ozone data.

2. Rainfall

Among various climatic parameters, rainfall is of greatest concern to the population of India. The inter-annual variability of the yearly and monsoon rainfall has considerable impact on national activities like, agriculture, water management and energy generation.

Towards the end of the nineteenth century, scientists from the India Meteorological Department started analysing the available annual rainfall data over India and studied year to year variability in the rainfall. Blanford (1886) was the first meteorologist to make extensive studies of Indian rainfall. The analysis of 19 years (1867-1885) annual rainfall data for India as a whole did not reveal any systematic trend. Perhaps this was too short a period for such a study.

Sarker and Thapliyal (1988) and Thapliyal (1990) studied the long period (1875-1989) annual rainfall of India using the data of large number of raingauges (about 2500) well distributed over the country. The analysis of the data did not reveal any significant trend. The rainfall anomalies as percentage of the yearly normal (based on 1901-1950 data) are shown in Fig. 1. As seen in the figure, the annual rainfall of India exhibits considerable year to year variation, but does not show any increasing or decreasing trend throughout the period. For the 70-year period (1901-1970) the average rainfall and its standard deviation (σ) are 1148 mm and 108 mm respectively.

Five-year running means, have also been plotted in Fig. 1. Two dotted lines in the figure indicate the upper and lower limits of $\pm\sigma$. It is seen from the figure that during the 115 years (1875-1989), the 5-year running means have fluctuated from the normal rainfall within *plus* and *minus* one standard deviation.

NOTE — A detailed paper on the subject was presented by the authors at the 'Asian Workshop on the International Geosphere Biosphere Programme' (New Delhi, February 1991) and it may appear in the proceedings of the Workshop, if and when published. This abridged version is published here after following the procedure prescribed for reviewing scientific contributions in *Mausam*.

— Editor

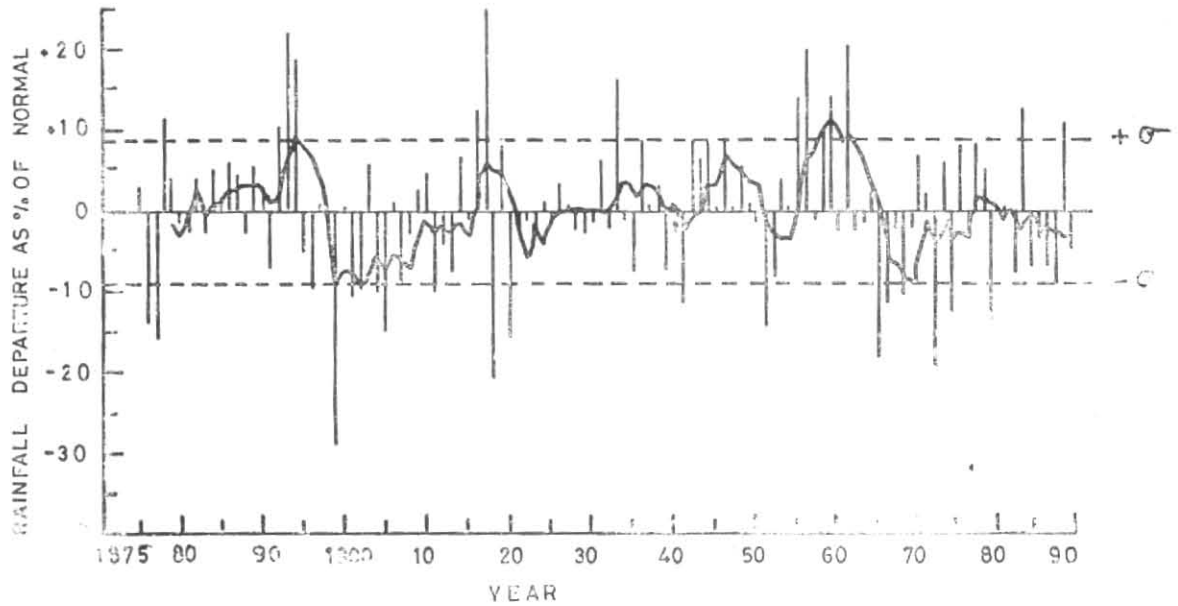

Fig. 1. Annual rainfall of India (Thick curve 5-year running mean)

For determining the decadal trend, running means of annual rainfall have been studied by different investigators (Pramanik and Jagannathan 1953, Thapliyal 1990). No significant decreasing or increasing trend has been found throughout the period of 115 years (1875-1989). However, as would be seen from Fig. 2, linearly increasing trends are found during 3 epochs (1876-1894, 1906-1964 and 1973 onwards) while linearly decreasing trends are noticed during the two epochs (1895-1905 and 1965-1972). This suggests that the rainfall of India exhibits fluctuating epochal decreasing and increasing trends during recent 115 years. This transition from one state of above normal to another state of below normal rainfall is an interesting result in keeping with Lorenz (1963) who attributed such aperiodic random behaviour to deterministic chaos. The system chooses one state (according to the initial conditions) from a variety of simultaneously available states known as attractors. The initial conditions are decided by events like enhanced/weak land sea temperature contrasts, advective/convective processes, etc.

It would, therefore, appear that the long period annual rainfall data exhibits year to year fluctuations but does not indicate any long term climate change and trend. Similar results have been reported earlier also (Rao 1936, Agarwala 1952, Pramanik and Jagannathan 1955, Rao and Jagannathan 1963, Koteswaram and Alvi 1969, 1970; Raghavendra 1974, 1980; Dhar *et al.* 1982, Sarker and Thapliyal 1988, Thapliyal 1990) when the rainfall of different stations and regions of India were analysed.

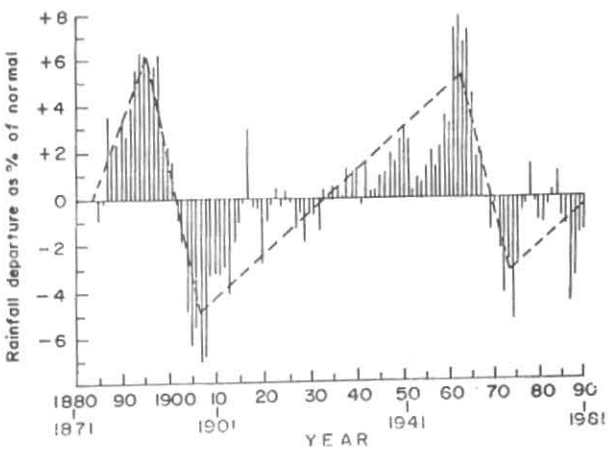

Fig. 2. Annual rainfall of India (10-year running mean)

Figs. 3 and 4 for monsoon rainfall over India show similar patterns as the annual rainfall. This is understandable as the bulk of the Indian rainfall is from the summer monsoon.

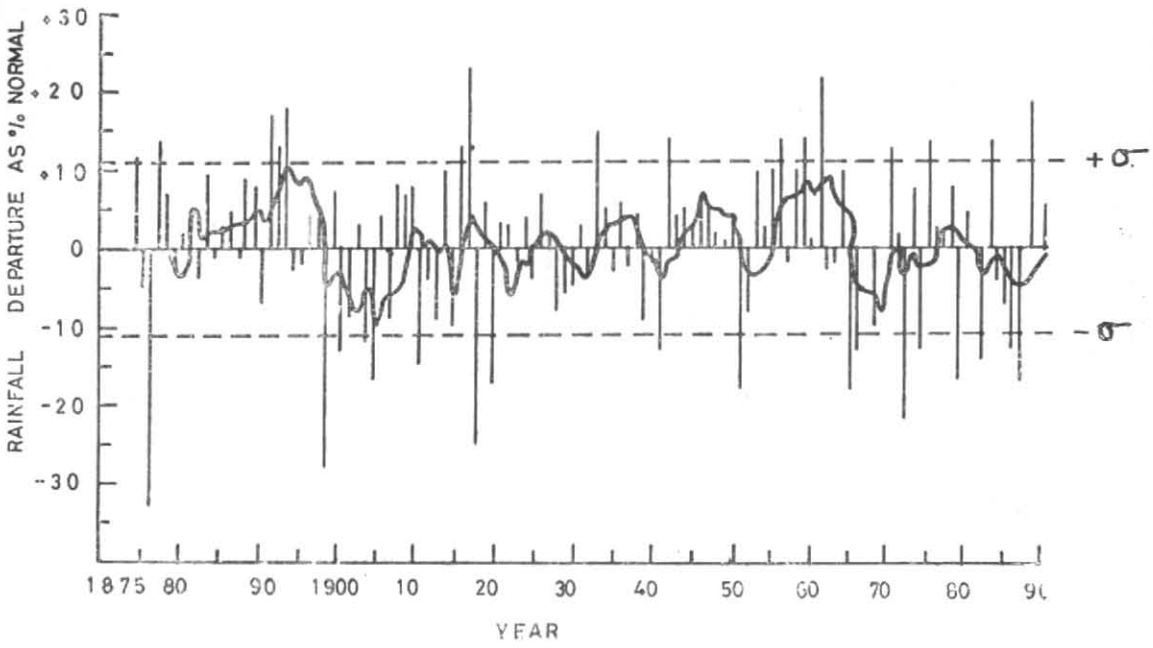

Fig. 3. Monsoon rainfall of India (Thick curve 5-year running mean)

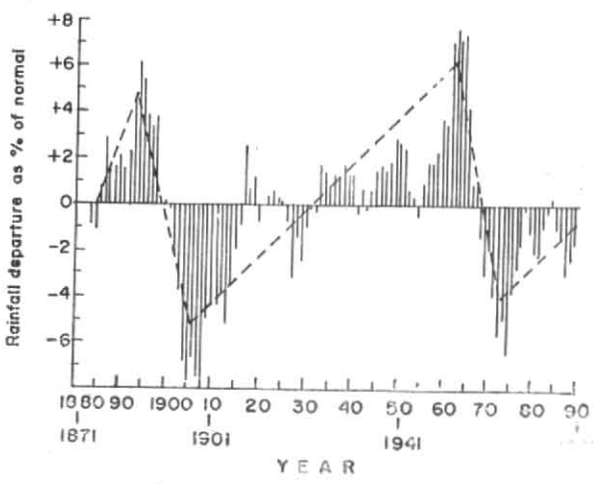

Fig. 4. Monsoon rainfall of India (10-year running mean)

3. Temperature

For a tropical country like India, the temperature of the air near the surface of the ground is another important climatic parameter. Realising the importance of the long term climate change in the surface temperature of India, scientists from the India Meteorologieal Department started analysing the land surface temperature data of India as early as the middle of this century. The annual maximum and minimum temperatures of 20 meteorological observatories situated in India and neighbourhood were studied by Pramanik and Jagannathan (1954). The study revealed that there is no general tendency of systematic increase or decrease of temperature over these stations. Jagannathan (1963) and Jagannathan and Parthasarathy (1972) have analysed the trends in the characteristics of seasonal variation of temperature in the arid and semi-arid regions of the globe which included 8 Indian stations with about 55 to 100 years data. No systematic increase or decrease were observed by them in the mean annual temperature of Indian stations. Recently, Hingane *et al.* (1985), Sarker and Thapliyal (1988) and Thapliyal (1990) have studied the trends in long period temperature data from about 70 stations well distributed over India. The temperature anomalies for the entire period shown in Fig. 5 indicate a slight warming trend of the order of 0.4°C during the last 89 years. In the figure, the trend is depicted by a dotted line. The 5-year running means shown in the figure by a continuous curve also confirm the slightly warming trend since 1901, though well within one standard deviation. While certain regions of the country such as the west coast, interior peninsula, north central India and northeast India have shown warming, other regions have either shown slight cooling or no noticeable trends at all.

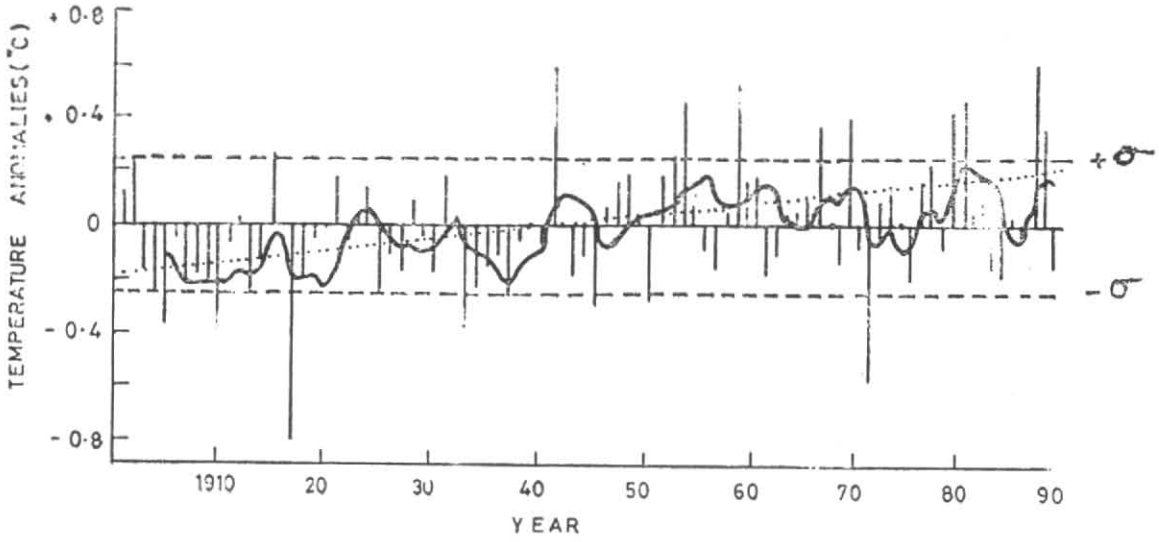

Fig. 5. Annual temperature of India (Thick curve 5-year running mean)

For determining the decadal trend in temperature, Thapliyal (1990) studied the 10-year running means of Indian surface temperatures for 89 years (1901-1989) which are plotted in Fig. 6. It is seen from the figure that on decadal basis, temperature variation also exhibits epochal trends as in case of rainfall although it does not seem possible to delineate a relationship between temperature and rainfall variations.

An interesting feature is that the Indian mean annual temperature does not show the post-1940 cooling observed in the Northern Hemisphere data. Though it is difficult to interpret the above results in terms of cause and effect, one cannot but note a significant increase in the consumption of fossil-fuel, deforestation and land use in India, during the period.

Despite the importance of monitoring a wide range of climatic variables, surface temperature trends — especially land-surface trends — are frequently cited as the potential indicator of climate change. One yet unresolved problem is the warming bias caused by urban heat island effects as there are fewer observing stations in sparsely populated or rural areas.

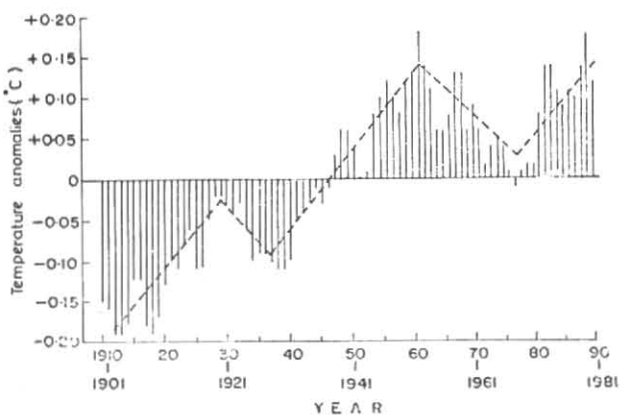

Fig. 6. Annual temperature of India (10-yr running mean)

4. Atmospheric pressure

Detailed analysis of long period (80 to 100 years) pressure of India (Pramanik and Jagannathan 1955, Sarker and Thapliyal 1988) has not revealed any systematic increasing or decreasing trend of the surface atmospheric pressure over the country, though considerable year to year fluctuations have been noted.

5. Total ozone

In India, total ozone is being measured since 1928, when the first Dobson Ozone Spectrophotometer measurements were carried out at Kodaikanal. By using Indian data, Ramanathan (1963) studied the total ozone amounts observed at Mount Abu/Ahmedabad (25° N-22° N) and Kodaikanal (10°N) and noted a biennial variation in ozone amount during the period 1954 to 1962.

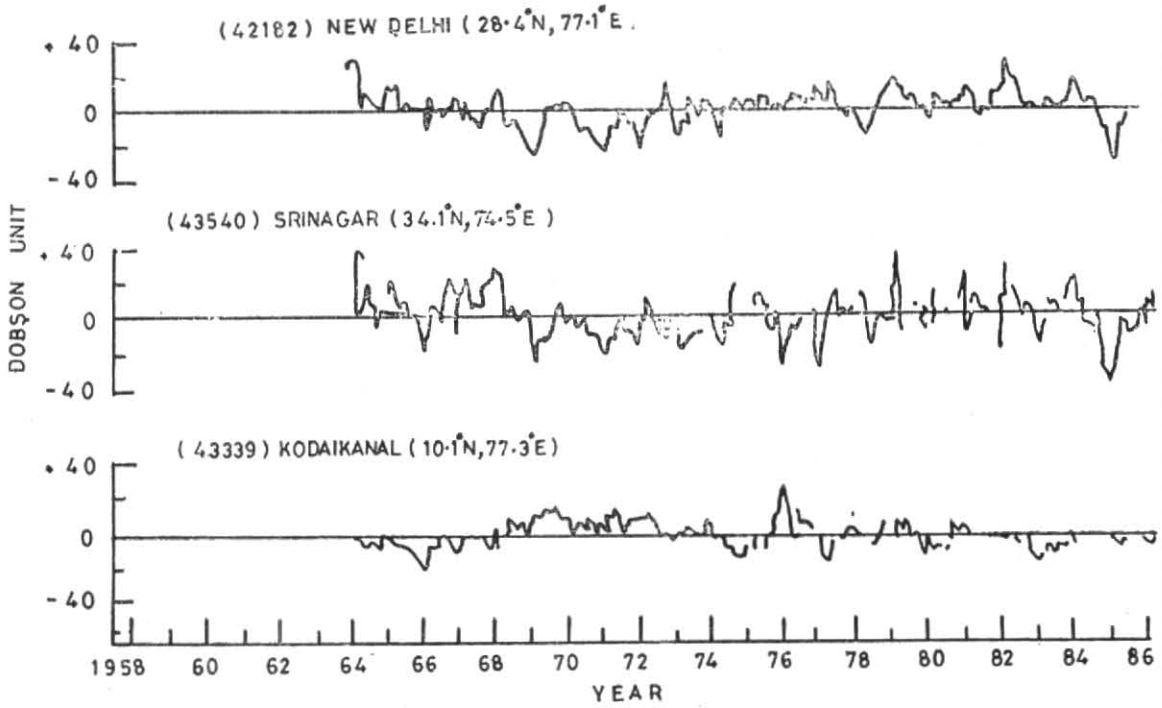

Fig. 7. Ozone distribution over India

For studying the inter-annual and long term variability of ozone over India, a number of investigators (Tiwari 1973, Tiwari and Sreedharan 1973, Thapliyal 1990) analysed ozone measurements over India. The ozone distribution over 3 representative stations of India are shown in Fig. 7 for the period (1958-86). It may be seen from the figure that ozone measurements exhibit year to year variability but do not show any systematic decreasing or increasing trend over India.

6. Conclusions

During the period of about 120 years from 1870 for which instrumental records are available, the important climatic parameters over India show considerable year to year random fluctuations. Except for temperature which has shown slight warming within the limits of one standard deviation over a century, rainfall and pressure do not indicate any systematic decreasing or increasing trend throughout the period. However, fluctuating epochal decreasing or increasing trends have been noted in the surface temperature and rainfall patterns of India.

Analysis of total ozone data does not show any significant evidence towards depletion of ozone over India.

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