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# A comparative study of differences in the averages of temperatures and rainfall over the Indian stations during the periods 1931-60 and 1961-90

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**सार** — भारत के प्रमुख भागों के 166 स्टेशनों के 1931 से 1960 और 1961 से 1990 तक की अवधियों में धरातल के ताप एवं वर्षा के औसत में पाई गई विभिन्नताओं का अध्ययन किया गया है । एक प्रतिशत तक विभिन्नता के महत्व की जांच के लिए स्टूडेंट 'टी' परीक्षण का प्रयोग किया गया है । उत्तर भारत के स्थानों में वायु ताप में कमी का मूल कारण वहाँ पर निम्नतम ताप में उल्लेखनीय कमी तथा दक्षिण भारत के स्थानों में वायु ताप में वृद्धि का मूल कारण वहाँ पर उच्चतम ताप में उल्लेखनीय वृद्धि पाया गया है । वर्षा में किसी उल्लेखनीय परिवर्तन का पता नहीं चला है । तथापि पहाड़ी स्थानों में वर्षा में कमी और शहरों/औद्योगिक नगरों में वर्षा में वृद्धि हुई है ।

**ABSTRACT.** The differences in the averages of surface temperature and rainfall during the periods 1931-60 and 1961-90 are studied for 166 individual stations covering major parts of India. To test the significance of the difference, student's 't' test has been applied. The fall in air temperatures in the north Indian stations is mainly due to the significant fall in minimum temperatures and rise in air temperatures in the south Indian stations is due to the significant rise in maximum temperatures. No significant change is observed in rainfall. However, over hill stations the rainfall has decreased and over urban/industrialised cities the rainfall has increased.

**Key words** — Global warming, Climate change, Seasonal and annual temperature differences.

## 1. Introduction

The Global warming and its impact on climate change has attracted the attention of several scientists round the globe and as a result several studies have been made in this direction. Pramanik and Jagannathan (1954) studied the annual mean maximum and minimum temperature data of 30 meteorological stations over India and Pakistan with 60 to 75 years of data and concluded that there is no general tendency of systematic increase or decrease in temperatures over these stations. Recently, Hingane *et al.* (1985), Srivastava *et al.* (1992), Rupakumar *et al.* (1988, 1994) have studied the trends in long period temperature data of India. Their studies have brought out that there is a small but definite warming trend (0.2 to 0.6 °C) during the recent 100 years.

In this paper the authors have made an attempt to study the differences in the averages of temperatures and rainfall over the country during the periods 1931-60 and 1961-90. The changes in seasonal and annual temperature and rainfall are analysed using the data of 166 stations that are distributed throughout the country and the results are discussed.

## 2. Data

Meteorological data pertaining to the Indian region are archived at the National Data Center (NDC) of the India Meteorological Department at Pune. The data collected from various meteorological centres are cleaned, electronically processed and archived at NDC. Thus, for the present study the stations whose temperature and rainfall data are available from 1931 to 1990 have been selected and these locations are shown in Fig. 1.

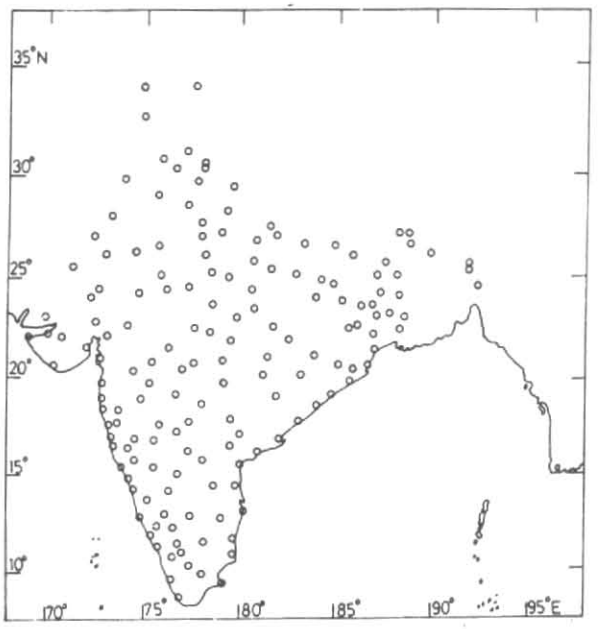



**Fig. 1.** Network of stations selected for the study

## 3. Analysis and discussion

### 3.1. *Temperature*

The mean series for maximum and minimum temperature for the annual as well as seasonal periods *i.e.*, pre-monsoon (March-May), monsoon (June - September), post-monsoon (October - November) and winter (December - February), are computed separately for 1931-60 and 1961-90 and their differences are worked out. To test the significance of the differences in the two series student's 't' test has been applied and stations which have differences significant at 1% level are only presented. This has been done to present only the noticeable differences.

The differences in seasonal and annual temperatures for the 166 stations are plotted and analysed. They are presented in Figs. 2 (a-k). The shaded regions indicate that temperatures have fallen during the period 1961-90 compared to 1931-60 and vice-versa for the unshaded regions.

*Annual mean temperature* — The maximum temperatures have risen all over the country except over parts of north Orissa, northeast Madhya Pradesh (M.P.), Bihar and parts of northwest Rajasthan, Punjab, Haryana, west Uttar Pradesh (U.P.) and parts of east U.P. (Fig. 2a).

The minimum temperatures have risen over the peninsula, Saurashtra & Kutch, Punjab, parts of Rajasthan and M.P. There is a fall in temperatures in remaining parts of the country (Fig. 2b).

*Summer season* — The maximum temperatures have risen over the peninsula, Gujarat, Saurashtra & Kutch, parts of Rajasthan, southeast Madhya Pradesh, parts of Bihar plains, north Assam and hills of west U.P. Over the rest of the country the temperatures have fallen (Fig. 2c).

The minimum temperatures have fallen over Punjab, Haryana, Himachal Pradesh, Uttar Pradesh, east Rajasthan, parts of Gujarat region, Saurashtra & Kutch, parts of Madhya Pradesh, Bihar, West Bengal, Orissa, parts of north Andhra Pradesh, parts of Tamil Nadu, Kerala, parts of interior Karnataka, along the west coast, Madhya Maharashtra and parts of Marathwada. There is rise in temperatures in the remaining parts of the country (Fig. 2d).

*Monsoon season* — The maximum temperatures have shown a rise all over the country except over parts of east M.P., Bihar plateau and a tongue extending from north west Rajasthan to east U.P. through Punjab, Haryana and Himachal Pradesh (Fig. 2e).

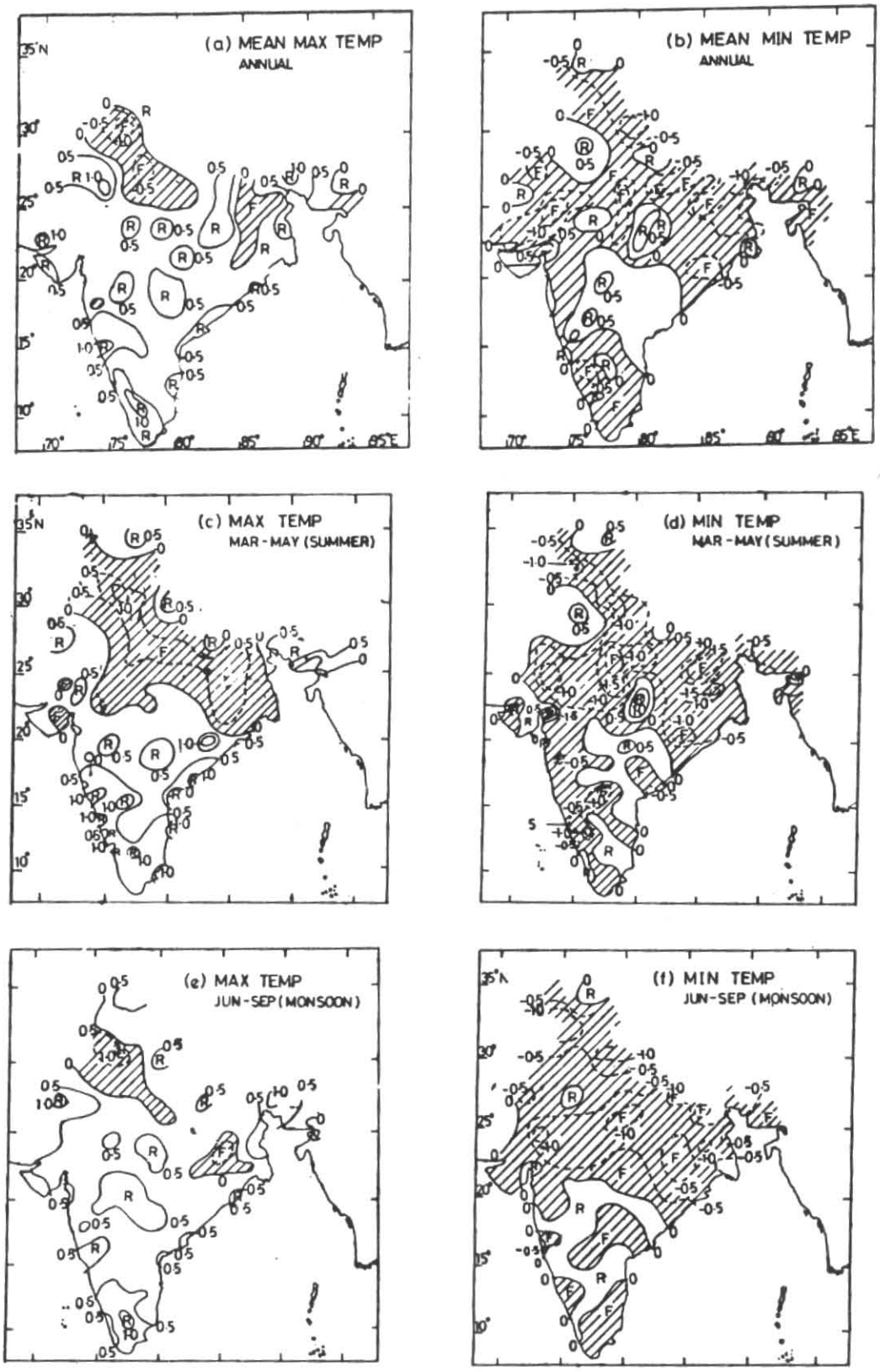
The minimum temperatures during this season have fallen all over the country except over parts of Gujarat, Madhya Maharashtra, Marathwada, North Coastal Andhra Pradesh, South Orissa, Rayalaseema and interior Karnataka (Fig. 2f).

The increase in the maximum temperatures and decrease in minimum temperatures have lead to an increase in the diurnal variation of temperatures. This can be attributed to the decrease in cloud cover.

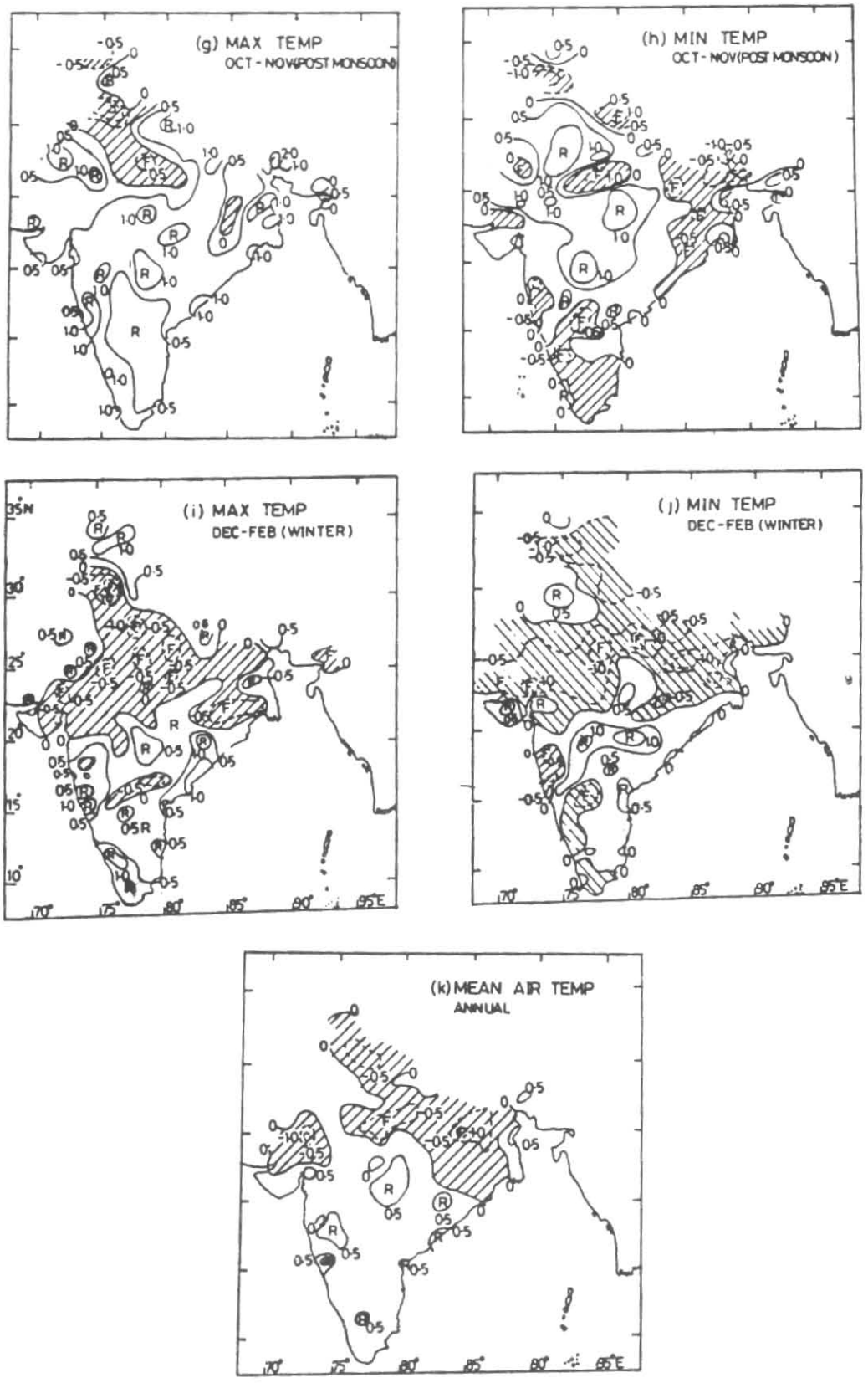
*Post-monsoon season* — The maximum temperatures have risen all over the country except over parts of Bihar, north western parts of Rajasthan, Punjab, Haryana and parts of Uttar Pradesh (Fig. 2g).

The minimum temperatures have fallen over Tamil Nadu, Kerala, parts of interior Karnataka, South Konkan & Goa coasts, parts of south Madhya Maharashtra, parts of south Rajasthan, Saurashtra & Kutch, northwest M.P., southern parts of U.P., Punjab, hills of west Uttar Pradesh, North coastal Andhra Pradesh, Orissa and Bihar. Elsewhere there is a rise in temperatures (Fig. 2h).

*Winter season* — The maximum temperatures have fallen north of 20°N except over parts of Saurashtra




**Figs. 2(a-f).** Differences in mean series for 1931-60 and 1961-90 for maximum and minimum temperatures for the annual as well as seasonal periods (summer and monsoon). Shades regions indicate fall in temperatures during 1961-1990.




**Figs. 2(g-k).** Differences in mean series for 1931-60 and 1961-90 for maximum and minimum temperatures for the annual as well as seasonal periods (post-monsoon and winter). Shades regions indicate fall in temperatures during 1961-1990.

& Kutch and west Rajasthan. They have mainly risen over the peninsula (south of 20°N) except for isolated pockets over Telangana and north interior Karnataka (Fig. 2i).

The minimum temperatures have risen over parts of west Rajasthan, Gujarat, Saurashtra & Kutch, parts of east Madhya Pradesh, Marathwada, parts of interior Maharashtra, interior Orissa, Telangana, Rayalaseema and parts of Tamil Nadu. In the remaining parts of the country the temperatures have fallen (Fig. 2j).

*Annual mean temperatures* — The temperatures have risen over the peninsula (south of 20°N), west M.P., parts of east M.P., Gujarat, Saurashtra & Kutch and parts of Rajasthan. A fall in temperatures is registered in the other parts of the country (Fig. 2k).

*Temperature changes over individual stations* — A study of the variations in temperatures significant at 1% level as per student's 't' test for individual stations are examined and presented below.

(*i*) The mean air temperatures have fallen during 1961-90 in Lucknow, Gwalior, Jhansi, Abu, Gaya, Hassan, Port Blair, Fathepur, Purnea, Dehri, Pune, Raichur, Dehradun and Darbhanga. This is mainly due to the fall in minimum temperature and the contribution form the maximum temperature is negligible.

(*ii*) The annual and seasonal mean minimum temperatures have fallen during 1961-90 in Roorkee, Sabur, Ahmedabad, Hoshangabad, Jamnagar, Chandbali, Simla, Motihari, Kota and Jammu.

(*iii*) Ambala, Silchar, Ludhiana recorded a significant fall during 1961-90 in seasonal and annual mean maximum temperatures but no change is observed in minimum temperatures.

(*iv*) Dhubri, Gorakhpur, Balasore, Machilipatnam, Bellary, Sagar, Krishnanagar, Kalingapatnam, Cuddalore, Mukteshwar, Puri, Tiruvanantha-puram exhibited a rise in the maximum temperatures and a fall in minimum temperatures during 1961-90 but no change in the air temperature is observed.

(*v*) Many stations in Rajasthan, Gujarat, Madhya Pradesh, plains of Uttar Pradesh, Bihar and Orissa have shown significant rise during 1961-90 in seasonal/annual maximum temperatures but the rise is not reflected in air temperatures.

(*vi*) The mean air temperatures have shown a significant rise over most parts of peninsula during 1961-90 and the contribution is due to the significant rise in maximum temperatures. No change is seen in minimum temperatures.

(*vii*) Baroda, Jabalpur, Ongole, Bangalore, Bijapur and Belgaum have shown significant rise during 1961-90 in respect of maximum as well as minimum temperatures.

### 3.2. *Rainfall*

During the last 100 years considerable amount of work has been done by several workers on the variability of seasonal and annual rainfall over India (*e.g.*, Paramanik and Jagannathan 1953, Koteswaram and Alvi (1969, 1970), Mooley and Parthasarathy 1984, Pant and Hingane 1988, Parthasarathy *et al.* 1993). In the present study the stations whose rainfall data are fully available throughout the year (for the period 1931-90) are considered and the series are subjected to student's 't' test. The variations are not significant at 1% level for seasonal and annual rainfall. However, some hill stations, *viz.*, Simla, Mukteshwar, Pachmari, Mahabaleshwar, Mercara, Kodaikanal, Ootacamund, Abu, Darjeeling, Dalhousie, Aijal, Dharmasala reported a decrease in the rainfall during 1961-90. This result lends support that deforestation could have contributed towards the lowering of the rainfall.

The development of urbanisation and industrialisation will have an effect on the local climate (Atkinson 1971, Huff and Changnon 1973, Khemani *et al.* 1973) which generally indicates that the industrial cities get more precipitation. Some of the urban and industrial stations like Mumbai, Chennai, New Delhi, Calcutta, Surat, Hyderabad, Bangalore and Dhanbad recorded an increase in rainfall during 1961-90.

## 4. Conclusions

(*i*) The stationwise study shows a decrease in air temperatures in many of the north Indian stations. This is mainly due to the fall in minimum temperatures.

(*ii*) The increase in air temperatures in the south Indian stations is mainly due to the rise in maximum temperatures. A few stations however recorded rise in both maximum and minimum temperatures.

(*iii*) There is no significant variation in rainfall during the period under study. However, the hill stations have recorded comparatively less rainfall during 1961-90. Similarly, increase in rainfall during the same period is also observed for some of the major cities.

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