ISSN: 2394-1391

Original Article

Indian Journal of Biology
Volume 7 Number 1 / January-June 2020
DOI: http://dx.doi.org/10.21088/ijb.2394.1391.7120.5

Variations in Temperature and Trends in Tarai Region of Uttrakhand under Changing Climate

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How to cite this article:
Ravi Kiran. Variations in Temperature and Trends in Tarai Region of Uttrakhand under Changing Climate Indian J Biol 2020; 7(1):37–42.

Abstract

The present investigation was carried out using the long term (1981-2015) meteorological data recorded at Agrometeorological Observatory situated at NEB CRC, GBPUA& T, Pantnagar Uttarakhand. The analysis revealed that there is a decreasing trend of maximum temperature at the rate of 0.007°C per year over the years. However minimum temperature shows an increasing trend at the rate of 0.031°C per year. Average temperature range shows an increasing trend at the rate of 0.025°C per year. Maximum temperature anomaly shows a decreasing trend. Minimum temperature anomaly has an increasing trend. Temperature range anomaly showed a decreasing trend. The decadal analysis of temperature shows similar trend. The average monthly maximum temperature found to be at peak in the month of May and lowest in July. The lowest average monthly maximum and minimum temperatures were found in January. Average temperature range was highest in April and lowest in August.

Key words: Maximum; Minimum; Range; Temperature; Trend; Variabilty; Pantnagar; Climate Change; Anomaly.

Introduction

The Indian Himalayan region is one of the most sensitive regions of the country in terms of climate change. Uttarakhand state is highly vulnerable to frequent climatic catastrophic events. It has wide geographical variations. It spreads between 28º43′ to 31º27′ N latitudes and 77º34′ to 81º02′ E longitudes, in the northern part of India with a total geographical area of 5.33 M ha. The 92.57% area is mountainous and 7.43% is occupied by plains.

Since last few decades abrupt changes in temperature has been noticed by researchers. IPCC has stated that the climate change is mainly attributed to anthropogenic activities. Current global mean warming is 0.65 to 1.06°C above preindustrial time over the period of 1880-2012. Climatic extremes and abrupt weather phenomena are becoming an unexpected crisis in human life and human activity, now a days (Jewson and Caballero, 2003; Meze-Hausken et al., 2009).

The trend analysis of temperature recorded for several years provides information about temperature variability. A deep understanding of the influence of changing climate on agricultural production is must to cope up with changes in temperature. Keeping in view the above facts an analysis was made on long term data of temperature recorded at GBPUA and T, Pantnagar.

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Data and Methodology

The present analysis was made using the temperature data from 1981 to 2015 recorded at NEBCRC, GBPUA&T, Pantnagar which is situated in Udham Singh Nagar district (290 N Latitude, 79°

E Longitude and 243.8 m abobe mean sea level). This area lies in Tarai belt of India, located in the foothills of Himalaya with annual rainfall of about 1400 mm. The monthly meteorological data of maximum (Tmax, °C) and minimum (Tmin, °C) temperature were collected from the Agrometeorological Observatory situated at Normen E. Borlague Crop Research Centre situated at Pantnagar and verified for errors. Temperature range was calculated by subtracting T max from Tmin on annual basis.

Further the data were processed at decadal and annual scales and various statistical analyses were made to draw any final conclusion. The magnitude of the trends of increase and decreasing were derived and tested by the Mann-Kendall (Mann, 1945) test and slope of regression line using the least square method. Its range, mean, coefficient of variation (CV) were calculated. Trends and variations were determined by the relationship between the two variables, temperature and time. The magnitudes of the trends of increasing or decreasing temperatures were derived and slope of the regression line using the least square method.

Results and Discussion

Variations in Maximum and Minimum Temperature: The results of the analysis on long period average of maximum temperature on annual basis is presented in Fig. 1. It show that maximum temperature decreases at the rate of 0.007°C per year. The results of the analysis of minimum temperature on annual basis, presented in Fig. 2. It depicts that minimum temperature increases at the rate of 0.031°C per year. The average temperature range on annual basis depicts positive trend at the rate of 0.025°C per year (Fig. 3). The average monthly maximum temperature found to be at peak in the month of May and lowest in July (Fig. 4). The lowest average monthly maximum and minimum temperatures were found in January (Fig. 5). Average temperature range was highest in April and lowest in August (Fig. 6).

Trends of temperature anomalies: Average maximum Temperature Averagemaximum Temperature Anomaly at Pantnagar for 1981-2015 show a showed a decrease of 0.007 per year (Fig. 7). On the other hand Average minimum Temperature Anomaly (°C) at Pantnagar for 1981-2015 show an increase of 0.025 per year (Fig. 8). Average Temperature Range Anomaly (°C) showed a decrease of 0.031 per year (Fig. 9). The rise in minimum temperature anomalies shows that it would have significant inpact on agricultural production in the region.

Standard deviation and coefficient of variation: Thestandard deviation and coefficient of variation is shown in Table 1. The standard deviation in case of maximum temperature was found lowest in November (0.79) and highest in June (2.1). In case of minimum temperature was found lowest in August (0.449) and highest in February (1.24). The standard deviation in case of temperature range was found in August lowest (0.73) and highest in May (2.48).

TThe coefficient of variation in case of maximum temperature was found in August (2.4%) and highest in January (9.07%). The coefficient of variation in case of minimum temperature was found in August (1.78%) and highest in June (15.31%) and in case of temperature range it was found in November (8.82%) and highest in January

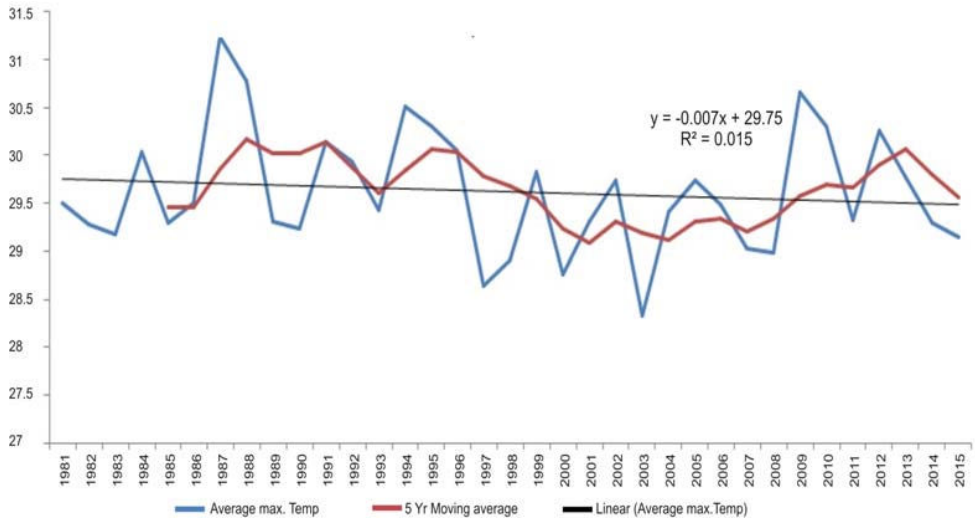

Fig. 1: Average maximum temperature (°C) at Pantnager for 1981–2015

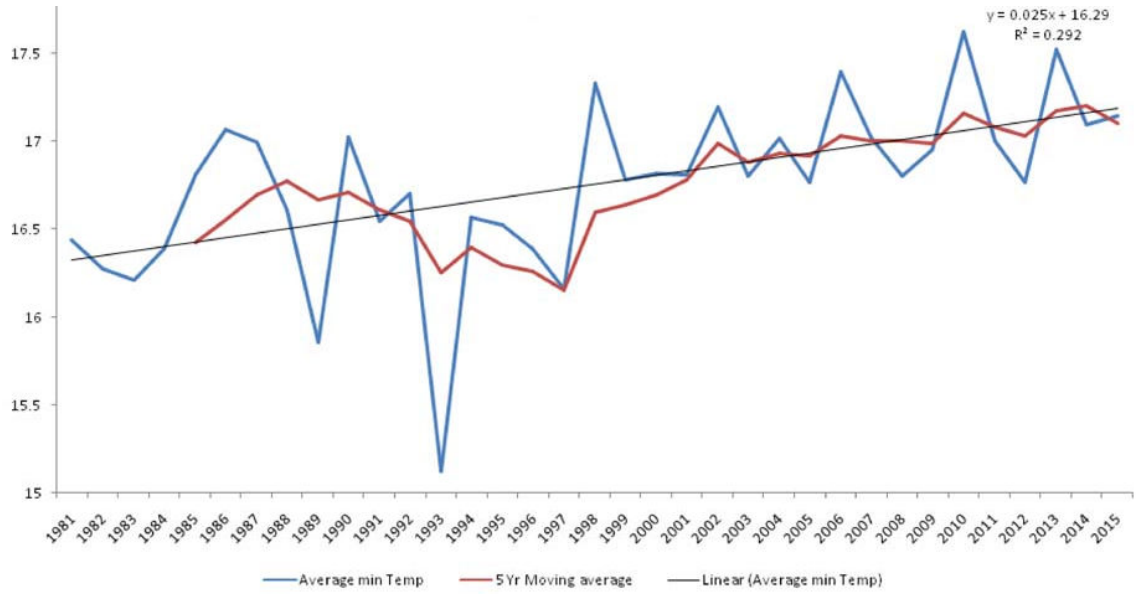

Fig. 2: Average minimum temperature (°C) at Pantnager for 1981–2015

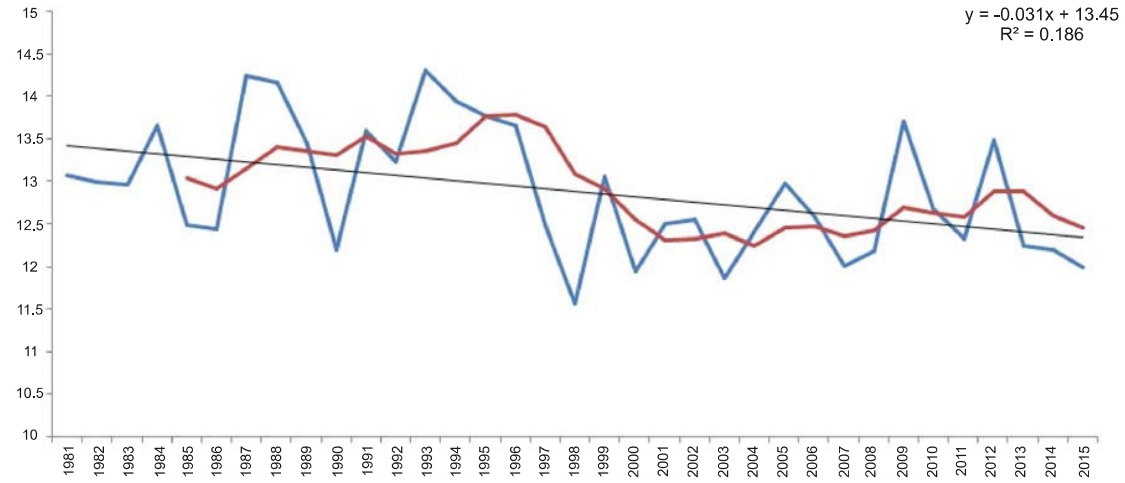

Fig. 3: Average temperature range (°C) at Pantnager for 1981–2015

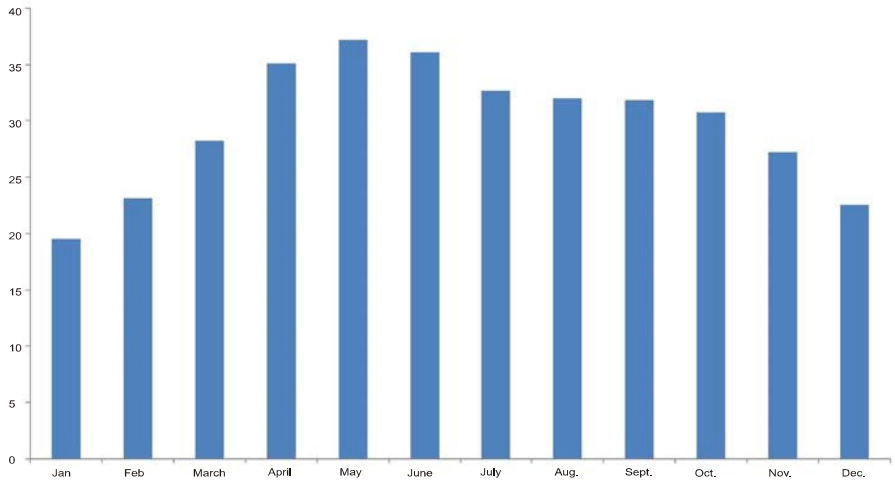

Fig. 4: Average maximum temperature (°C) at Pantnager for 1981–2015

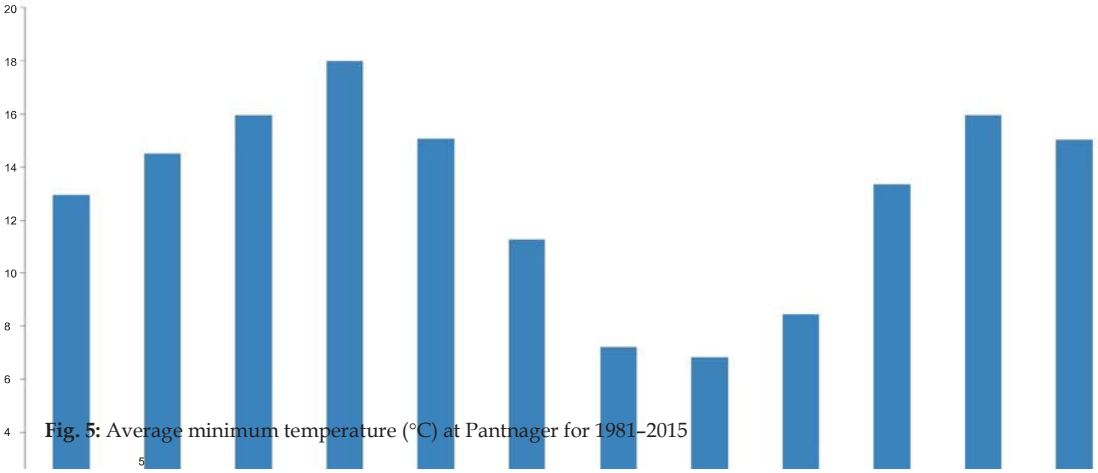

Fig. 5: Average minimum temperature (°C) at Pantnager for 1981–2015

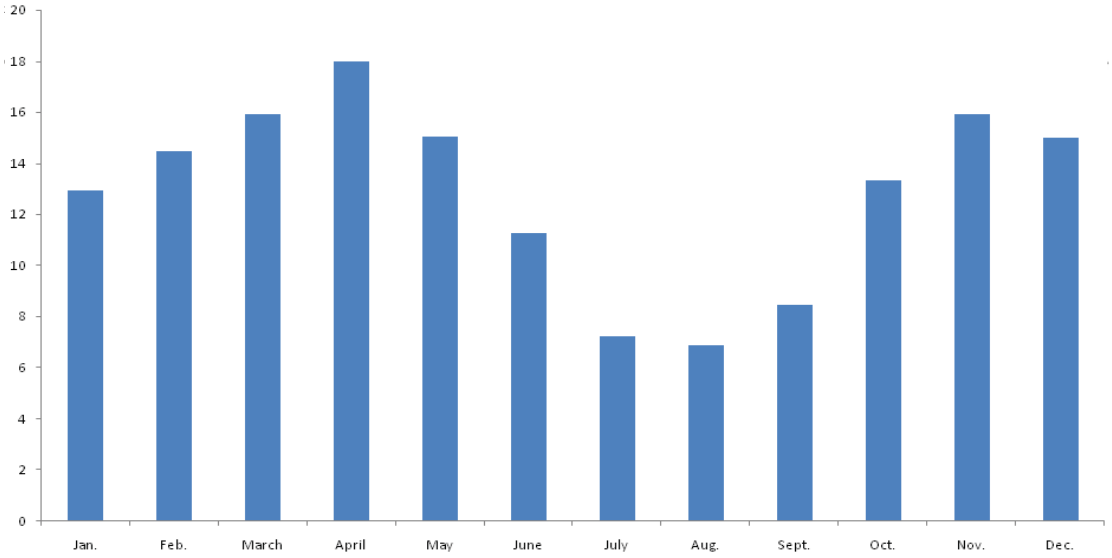

Fig. 6: Average temperature range (°C) at Pantnager for 1981–2015

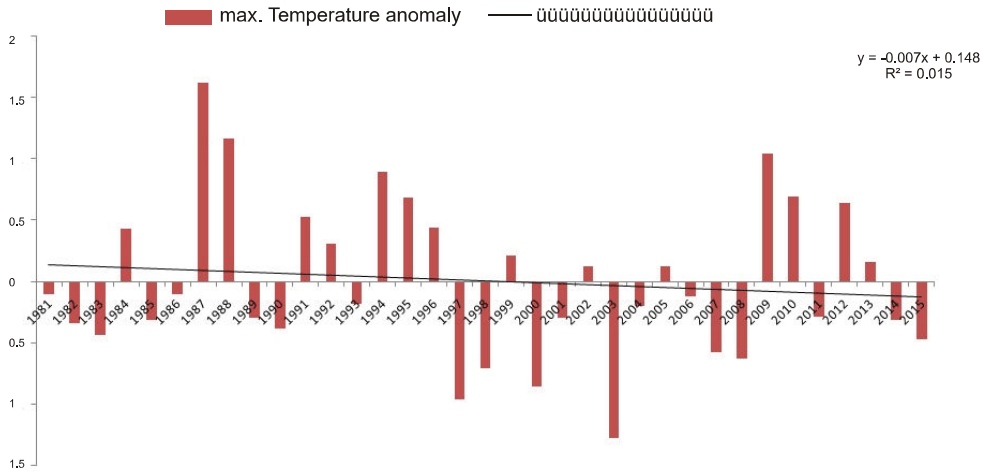

Fig. 7: Average maximum temperature Anomaly(°C) at Pantnager for 1981–2015

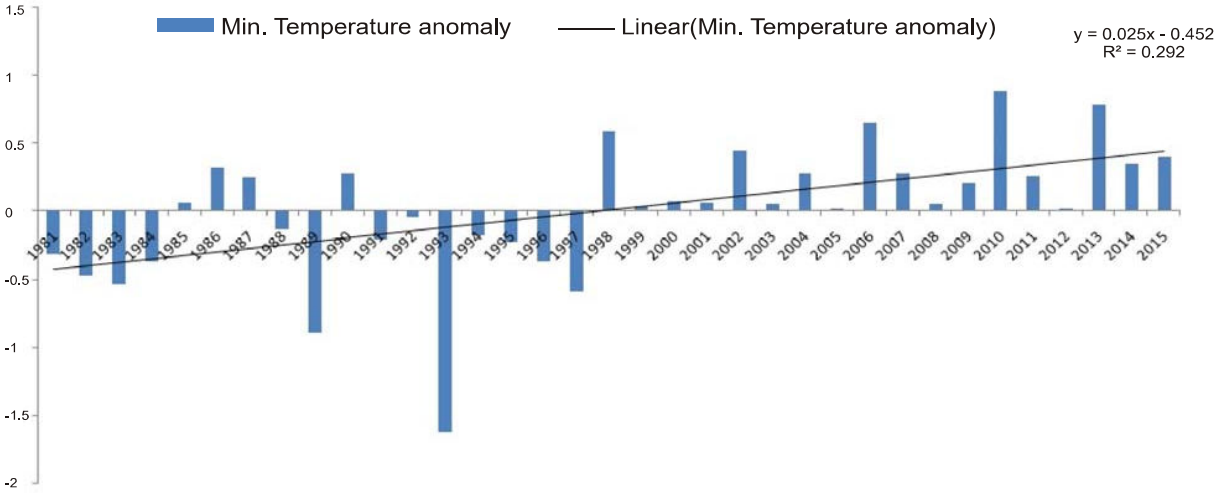

Fig. 8: Average minimum temperature Anomaly(°C) at Pantnager for 1981–2015

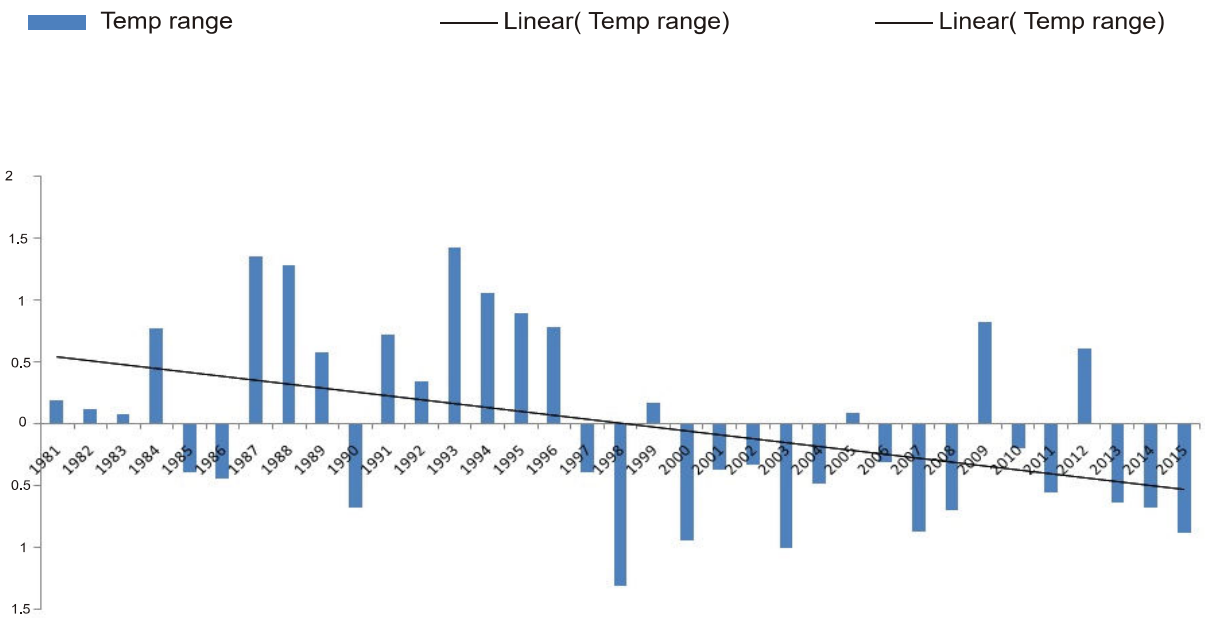

Fig. 9: Average temperature range Anomaly (°C) at Pantnager for 1981–2015

Table 1: Standard deviation and coefficient of variation (%) for Maximum, minimum and range of temperature for 1981–2015 at Pantnagar.

Month	T_{max}		T_{min}		T_{min}	
	Standard Deviation	CV(%)	Standard Deviation	CV(%)	Standard Deviation	CV(%)
Jan.	1.766699	9.070629	1.003624	15.31248	2.146144	16.60735
Feb.	1.394226	6.028153	1.245078	14.39159	1.617021	11.16947
March	1.948872	6.908093	0.917312	7.456093	1.804956	11.34581
April	1.846327	5.270347	1.113925	6.517544	1.712804	9.538288
May	1.664826	4.484985	1.811091	8.203466	2.489541	16.54966
June	2.196915	6.084675	0.70096	2.819953	2.218289	19.72063
July	1.03048	3.155289	0.564526	2.219795	0.875416	12.12487
Aug.	0.785934	2.460339	0.448815	1.787479	0.736035	10.76815
Sept.	0.843413	2.654944	0.62475	2.676935	1.006202	11.9368
Oct.	1.036453	3.371676	1.086703	6.235184	1.446857	10.86928
Nov.	0.791679	2.910892	1.005506	8.907291	1.403854	8.824515
Dec.	1.225842	5.455115	1.009753	13.50195	1.811408	12.0818

Table 2: Variation of Maximum, minimum and range of temperature for 1981-2015 at Pantnagar.

Time	*T max*	Tmin	T range
1981-1990	21.0-39.8	5.2-25.8	6.1-21.2
1991-2000	17.9-40.0	4.9-26.7	5.1-21.3
2001-2010	17.9-39.1	6.2-26.3	5.6-20.3
2011-2015	20.5-40.1	6.8-26.3	6.3-18.1

(16.60%)..

Decadal Trend: The decadal analysis oftemperature is presented in Table 2. The lower limit of Tmax was 17.9-21.0 and the higher limit was 39.1-40.1. The lower limit of Tmin was 4.9-6.8 and the higher limit was 25.8-26.3. The lower limit of Trange was 5.1-6.3 and the higher limit was 18.1-21.3. Murthy et al., 2004 also found similar results at Ranichauri in the mid Himalayan region.

The annual trend of temperature has shown the decreasing trend for all the 13 districts of Uttarakhand for maximum whereas in case of minimum temperature the trend showed (Tripathi et al., 2014) 99.9% significant increasing trend for all the districts (Yadav et al., 2014).An increasing trend is reported in surface temperature over the period of 1900-82 from 73 stations of India (Hingane et al., 1985) (Arora et al., 2005).

Conclusions

A decreasing trend has been found of maximum temperature at the rate of 0.007°C per year over the years. However minimum temperature shows an increasing trend at the rate of 0.031°C per year. Average temperature range depicts increasing trend at the rate of 0.025°C per year. Maximum temperature and temperature range anomaly shows a decreasing trend. Minimum temperature anomaly has an increasing trend. The increasing trend of minimum temperature is of great concern in respect of the production and productivity of major crops in this region.

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