

## Time trends in temperature of Bastar plateau agro-climatic zone of Chhattisgarh

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*(Received 1 February 2012, Modified 18 February 2013)*

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**सार** — इस शोध पत्र में तापमान में होने वाले संभावित परिवर्तनों का अध्ययन करने के लिए आँकड़ों की प्रवृत्ति का विश्लेषण किया गया है। CRIDA हैदराबाद द्वारा विकसित वेदर कॉक सॉफ्टवेयर के माध्यम से जगदलपुर स्टेशन के 32 वर्षों (1980–2011) के दैनिक मौसम आँकड़ों का विश्लेषण करते हुए बस्तर क्षेत्र (छत्तीसगढ़ राज्य) के लिए NICRA परियोजना के अंतर्गत शहीद गुदाधूर कॉलेज ऑफ एग्रीकल्चर एंड रिसर्च स्टेशन, जगदलपुर (छत्तीसगढ़) में यह अध्ययन किया गया। विश्लेषण से पता चला है कि इस क्षेत्र में अधिकतम तापमान की विभिन्न रेंजों के अंतर्गत रिकॉर्ड किए गए दिनों की संख्या में बढ़ोतरी के पैटर्न नहीं पाए गए हैं, तथापि, शीत ऋतु के समय न्यूनतम तापमान के मानों में विभिन्न रेंजों के अंतर्गत रिकॉर्ड किए गए दिनों की संख्या में बढ़ोतरी के पैटर्न हैं, जिससे तापमान में शीतलन की प्रवृत्ति का पता चला है। दिसम्बर और जनवरी के महीनों में न्यूनतम तापमान  $\leq 10^\circ$  से. के दिनों की संख्या में और सांख्यिकीय रूप से 1 प्रतिशत स्तर पर वृद्धि देखी गई। दिसम्बर, जनवरी और फरवरी के महीनों में  $\geq 7^\circ$  से. वाले दिनों की संख्या से शीतलन की प्रवृत्ति का पता चला है। कुछ थ्रेशहोल्ड मानों  $\geq 40^\circ$  से.,  $\geq 41^\circ$  से.,  $\geq 42^\circ$  से.,  $\geq 43^\circ$  से., को पार करने वाले अधिकतम तापमान के विश्लेषण से यह निष्कर्ष निकला कि कि रैखिक समीकरणों से प्राप्त सभी प्रवृत्तियाँ महत्वपूर्ण नहीं हैं, जिससे पता चला है कि इस प्रकार के दिनों की संख्या में वृद्धि नहीं हो रही है। तथापि, अपवादस्वरूप मार्च 1996 में अधिकतम तापमान  $40^\circ$  से. पार कर गया, मई 2003 में तापमान 23 दिन  $40^\circ$  से. पार किया तथा जून 2003 तुलनात्मक रूप से गर्म रहा जिसमें 12 दिन तापमान  $40^\circ$  से. को पार कर गया जिनमें से 6 दिन तापमान  $41^\circ$  से. को पार कर गया।

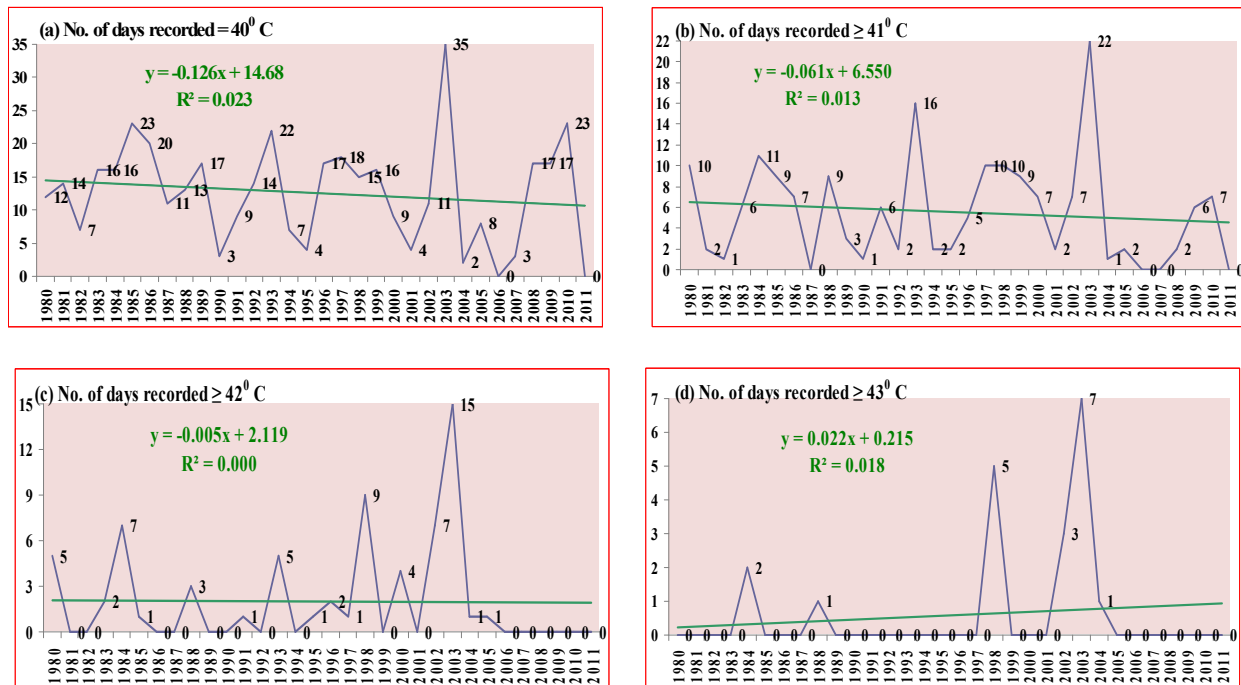
**ABSTRACT.** Trend analysis of data has been made for understanding likely temperature changes. This study was conducted at Shaheed Gundadhoor College of Agriculture and Research Station, Jagdalpur (Chhattisgarh) under NICRA project by analysing 32 years (1980-2011) daily weather data of Jagdalpur station for Bastar region (Chhattisgarh) through weather cock software developed by CRIDA, Hyderabad. The analysis showed that number of days recorded under different ranges of maximum temperature is not in increasing pattern in this region. However, number of days recorded under different ranges of winter seasonal minimum temperature values are in significantly increasing pattern showing cooling trend. Number of days with minimum temperature  $\leq 10^\circ\text{C}$  is found increasing in the months of December and January and statistically significant at 1 per cent level. Number of days with  $\leq 7^\circ\text{C}$  showed cooling trend in the months of December, January and February. Analysis of maximum temperature crossing certain threshold values  $\geq 40^\circ\text{C}$ ,  $\geq 41^\circ\text{C}$ ,  $\geq 42^\circ\text{C}$ ,  $\geq 43^\circ\text{C}$  done lead to conclusion that trends shown by linear equations are all non-significant, indicating that number of such days are not on the increase. However, as an exception, maximum temperature crossed value of  $40^\circ\text{C}$  in March 1996; in May 2003, there were 23 days which crossed  $40^\circ\text{C}$  and June 2003 was comparatively warmer with 12 days crossing  $40^\circ\text{C}$ , out of which 6 days crossed  $41^\circ\text{C}$ .

**Key words** — Temperature trends, Climatic change, Regression model for temperature.

### 1. Introduction

In the recent years, priority is given to studies of climate change/fluctuations. The regional climate swings and variability have profound influence on the regional economy. In countries like India where about 70 per cent of agriculture is under rain fed conditions, such variations have direct impact on regional economy (Baghel and Sastri, 1993). The impacts of environmental changes are

higher when examined at regional level than at global level. Even a temporary change of climate can have profound impact on agricultural production and on the use of energy and water resources (Gates 1988). Such variations, if occur frequently, then there is a need to modify the existing cropping patterns and develop suitable strategies for improving the agricultural production (Subramaniam and Raju, 1988).



**Figs. 1(a-d).** Time trends in No. of days recorded under different ranges of maximum temperatures in Bastar Plateau agro-climatic zone (1980-2011)

Bastar division having latitudes of 17° 46' N and 20°34' N latitudes and 80°15' E and 82°15' E longitudes covers seven districts, viz., Sukma, Bijapur, Dantewada, Narayanpur, Bastar, Kondagaon and Kanker. Jagdalpur, the headquarters of Bastar district is representative of Bastar division. The division covers an area of 39114 sq km. About 65.5% of the geographical area is under forests and forest produce is the major economy of tribal population of this division.

In the endeavor for improving the productivity level of any region, knowledge of the agro-climatic conditions is not only essential but also a pre-requisite. In view of this, here an analysis has been made for the climatic variable – temperature.

## 2. Data and methodology

This study was conducted at Shaheed Gundadhoor College of Agriculture and Research Station, Jagdalpur (Chhattisgarh) by using 32 years (1980-2011) daily maximum and minimum temperature data of Jagdalpur station. Time trends for various threshold values of maximum and minimum temperature were worked out using weather cock software developed by CRIDA, Hyderabad (Rao *et al.*, 2011).

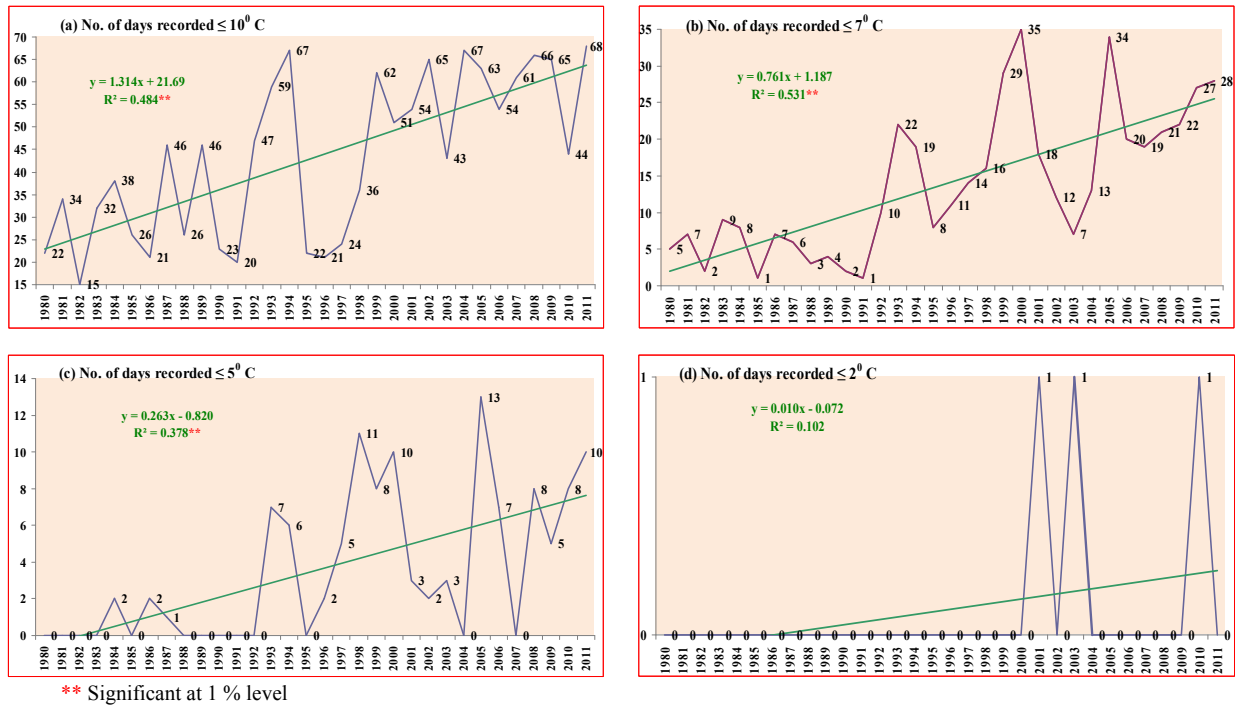
## 3. Results and discussion

### 3.1. Annual maximum temperature

Time trends for annual maximum temperature above critical threshold values 40 °C, 41 °C, 42 °C and 43 °C show that maximum temperature days are not increasing in this region [Figs. 1(a-d)]. This is partly attributable to the fact that Dense forest cover prevails in this region; though climatic extremes have been observed in this region, as such, number of days above threshold values are not indicating increasing pattern on annual basis. Linear equation fits are non-significant which confirm this observation. If May and June months are taken together, number of days are (35, 22, 15, 7, 3) for different ranges of maximum temp  $\geq 40$ ,  $\geq 41$ ,  $\geq 42$ ,  $\geq 43$ ,  $\geq 44$ , respectively occurred in the year 2003 out of 32 years considered here (Table 1). It indicates that particularly in recent years the climatic extreme events can also be observed at regional level probably due to urbanization and deforestation effects.

### 3.2. Month wise maximum temperature

Trends in maximum temperature crossing certain threshold values as above during summer season months



**Figs. 2(a-d).** Time trends in No. of days recorded under different ranges of minimum temperatures in Bastar Plateau agro-climatic zone (1980-2011)

**TABLE 1**

**Month-wise number of days which registered for different ranges of maximum temperature during last 32 years (1980-2011)**

Year	Months	Ranges of maximum temperature (°C)						
		≥ 40	≥ 41	≥ 42	≥ 43	≥ 44	≥ 45	≥ 46
1996	March	1						
2003	May	23	16	10	4	1		
2003	June	12	6	5	3	2		
2004	April	1	1	1	1	1	1	1

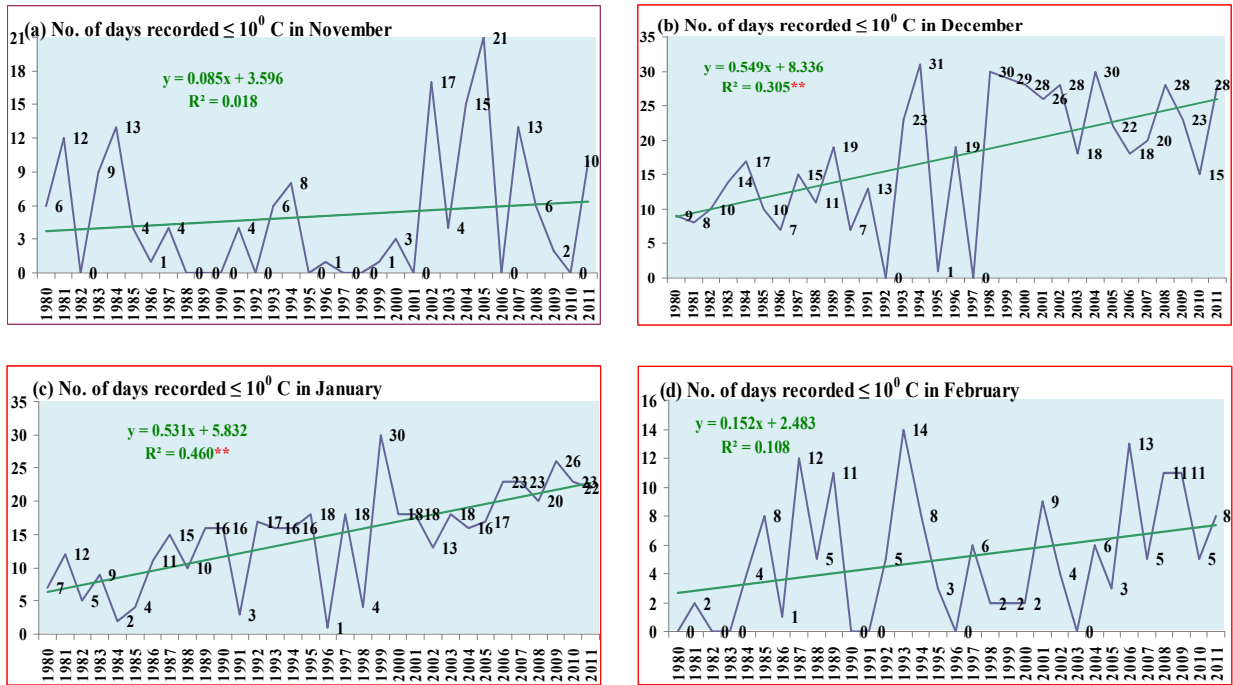
**TABLE 2**

**Month-wise number of days which registered for different ranges of minimum temperature**

Year	Month	Ranges of minimum temperature (°C)			
		≤ 10	≤ 7	≤ 5	≤ 2
2001	March	1	1	1	1
2003	January	18	7	3	1
2010	March	1	1	1	1
Total		1388	440	113	3

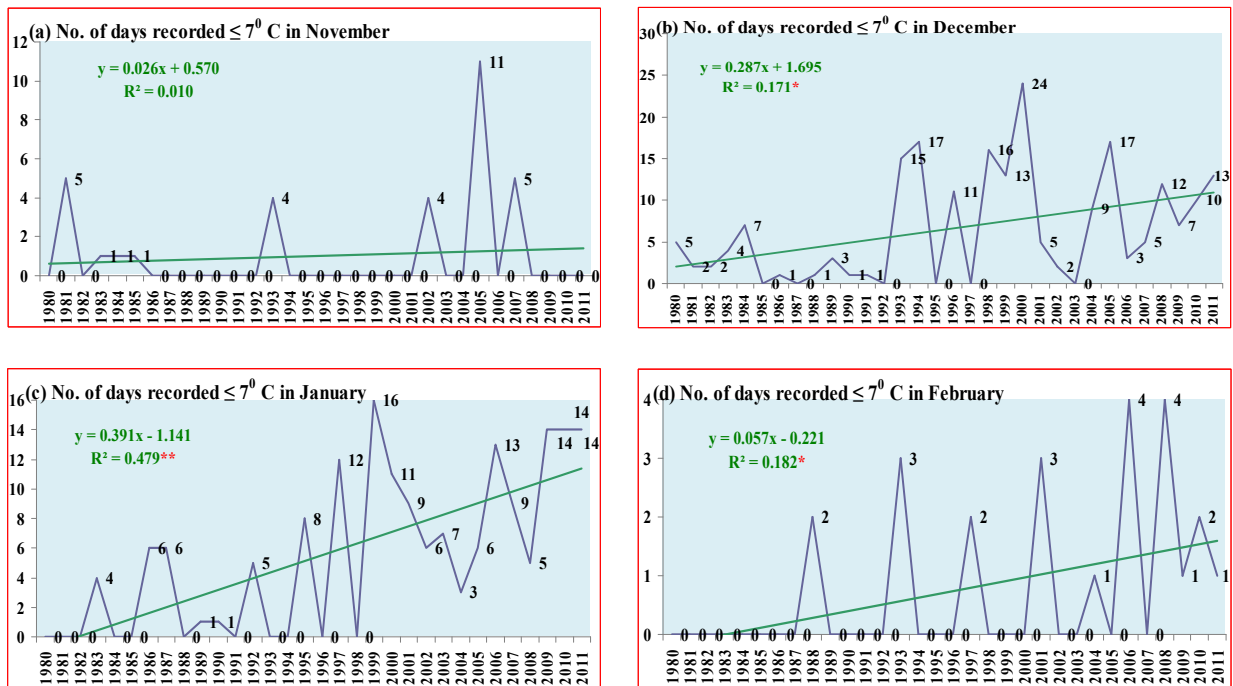
(Figs. 6 to 8) show that the fitted equations are all non-significant. This leads to conclusion that change in number of days with maximum temperature in these

ranges are mostly insignificant. Incidentally in the year 2003 in May month (Table 1) there were 23 days which crossed 40 °C, out of which 16 days crossed 41 °C and



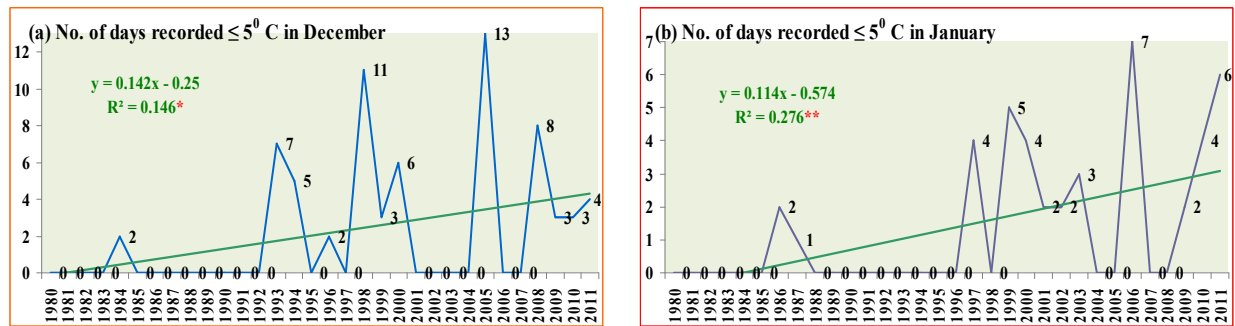
\*\* Significant at 1 % level

**Figs. 3(a-d).** Time trends in No. of days recorded  $\leq 10^{\circ}$  C minimum temperature during cool months (Nov - Feb) in Bastar Plateau agro-climatic zone (1980-2011)



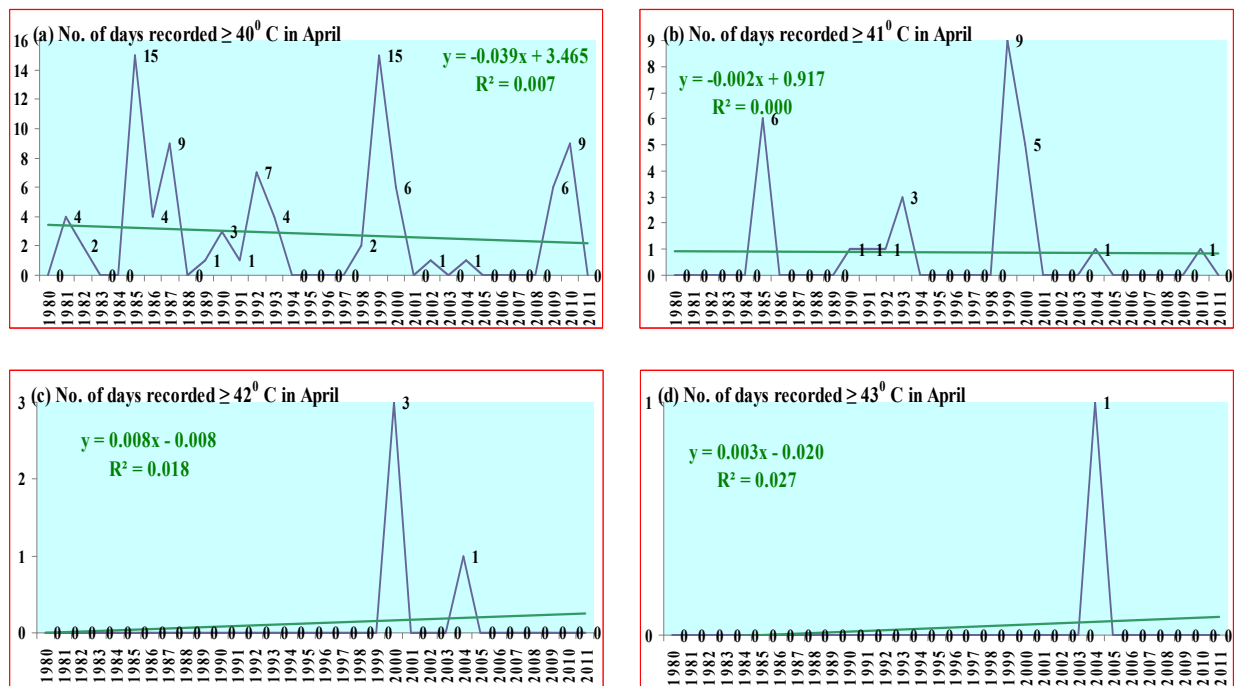
\*\* Significant at 1 % level \* Significant at 5 % level

**Figs. 4(a-d).** Time trends in No. of days recorded  $\leq 7^{\circ}$  C minimum temperature during cool months (Nov - Feb) in Bastar Plateau agro-climatic zone (1980-2011)



\*\* Significant at 1 % level \* Significant at 5 % level

**Figs. 5(a&b).** Time trends in No. of days recorded  $\leq 5^{\circ}\text{C}$  minimum temperatures during cool months (Dec - Jan) in Bastar Plateau agro-climatic zone (1980-2011)



\*\* Significant at 1 % level \* Significant at 5 % level

**Figs. 6(a-d).** Time trends in No. of days recorded under different ranges of maximum temperature during April in Bastar Plateau agro-climatic zone (1980-2011)

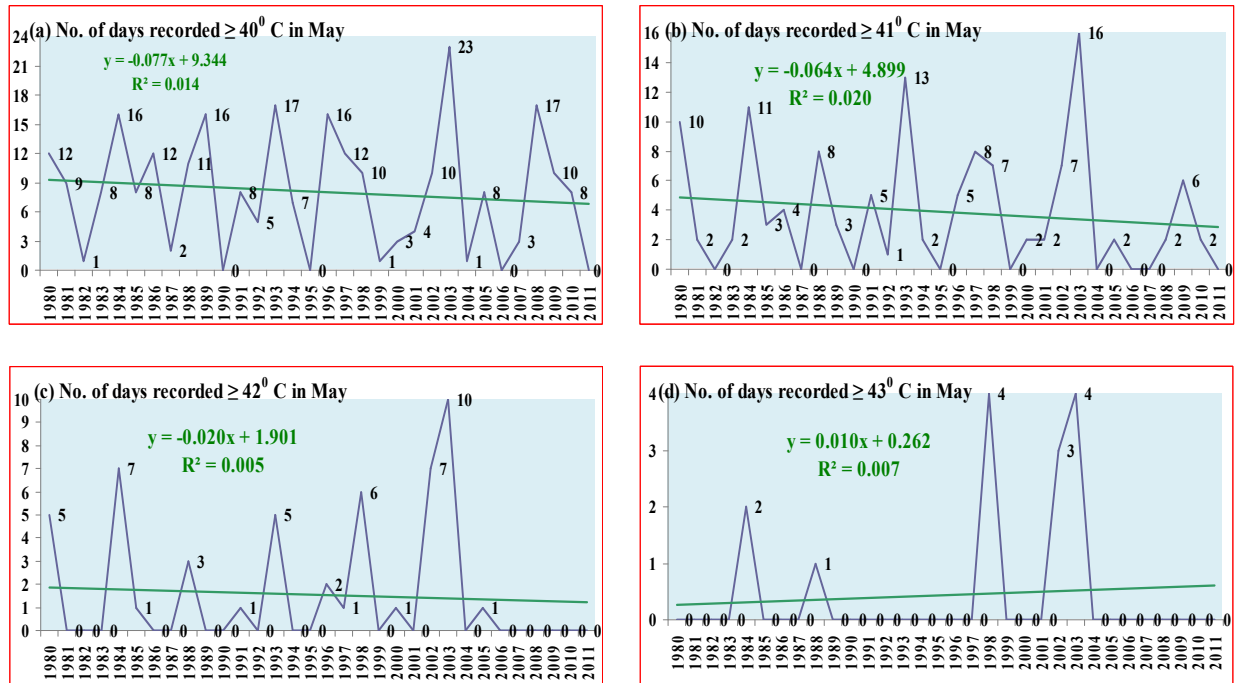
like that there was one day which crossed value of  $44^{\circ}\text{C}$ . Also, in recent years, June month of the year 2003 happened to be comparatively warmer (Table 1) with 12 days crossing  $40^{\circ}\text{C}$ , out of which 6 days crossed  $41^{\circ}\text{C}$ .

### 3.3. Annual minimum temperature

An analysis of annual minimum temperature Figs. 2(a-d) has been done. Linear equations are found to be significant at 1 per cent level for minimum temperature critical threshold values less than or equal to  $10^{\circ}\text{C}$ ,  $7^{\circ}\text{C}$  and  $5^{\circ}\text{C}$ ; equation for  $2^{\circ}\text{C}$  is non-significant. Therefore,

number of days with low minimum temperature values are in increasing (cooling trend) and creating favourable thermal conditions for rabi crops in this region.

The values of mean, standard deviation and coefficient of variation for month wise minimum temperature is depicted in Table 3. Average monthly minimum temperature has varied in between  $9.9^{\circ}\text{C}$  (December) to  $23.8^{\circ}\text{C}$  (May), It can be seen that CV values are higher in case of January, February, November and December months which indicates that variability is more in these months. Further, number of days having



**Figs. 7(a-d).** Time trends in No. of days recorded under different ranges of maximum temperature during May in Bastar Plateau agro-climatic zone (1980-2011)

**TABLE 3**

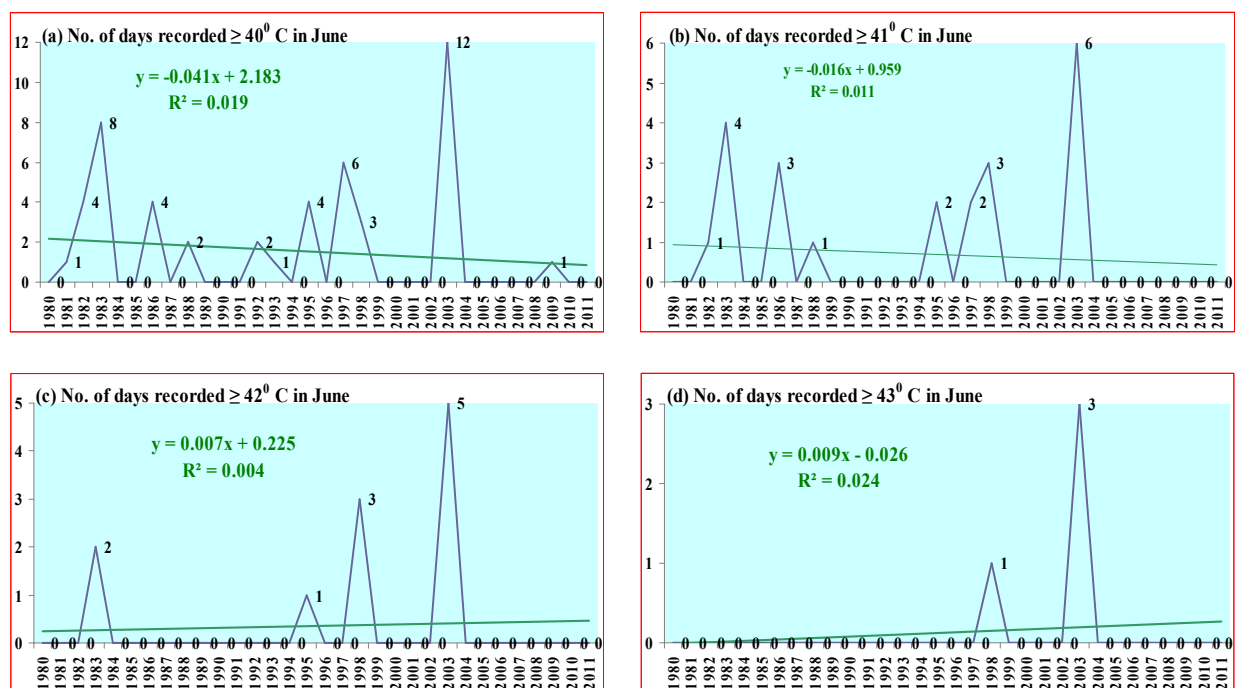
**Monthly mean and coefficient of variation of minimum temperature (1980-2011)**

Month	Mean minimum temperature ( $^{\circ}\text{C}$ )	SD	CV(%)
January	10.5	2.0	18.7
February	13.4	1.6	11.8
March	17.7	1.2	6.6
April	21.9	1.0	4.7
May	23.8	1.2	5.2
June	23.3	1.2	5.0
July	22.4	0.8	3.7
August	22.1	0.8	3.7
September	21.9	0.9	4.0
October	19.1	1.2	6.3
November	14.1	2.3	16.1
December	9.9	2.3	22.7

the threshold values of less than 10 degree centigrade [Figs. 2(a-d)] are indicating increasing pattern which can have wide ranging effects on the rabi cropping particularly in Kondagaon and Bastar districts of this tribal belt. Further studies in Bastar region at regional level will help in developing sustainable crop pattern since temperature is not a limiting factor as far as expansion of acreage in rabi season and provision of irrigation are concerned.

### 3.4. Month wise minimum temperature

Upon month wise analysis of number of days with minimum temperature  $\leq 10^{\circ}\text{C}$  [Figs. 3(a-d)] it was found that there is increasing pattern in the months of December and January and statistically significant at 1 per cent level. However for the months of November, February and March, the fitted equation are non-significant except for



**Figs. 8(a-d).** Time trends in No. of days recorded under different ranges of maximum temperature during June in Bastar Plateau agro-climatic zone (1980-2011)

February month for  $\leq 7^{\circ}\text{C}$  case [Figs. 4(a-d)]. Generally intercept in the equation indicates the change per year. In the month of December, there could be an additional day with  $\leq 7^{\circ}\text{C}$  in approximately once in 4 years as intercept is 0.287. In case of minimum temperature  $\leq 5^{\circ}\text{C}$  [Figs. 5(a&b)], there is rising trend in number of days in the months of December and January. Intercepts in these months being 0.142 and 0.114, there could be an additional day in this range in December month after approximately 7 years and an additional day in this range in January month after 9 years.

An important statistics of minimum temperature is shown in Table 2 in which all instances of minimum temperature below  $2^{\circ}\text{C}$  for 32 year period are taken into account. In March 2001 due to cold wave condition, there was one day with minimum temperature value less than  $2^{\circ}\text{C}$  and repeated in the year 2010. If grand total of 32 years is taken into account (1980-2011 database), there are 1388 days with minimum temperature less than  $10^{\circ}\text{C}$  out of which 440 days are below  $7^{\circ}\text{C}$ , 113 days are below  $5^{\circ}\text{C}$  and only 3 days are below  $2^{\circ}\text{C}$ .

#### 4. Conclusion

Analysis of trends in temperature of Bastar plateau agro-climatic zone of Chhattisgarh state showed that the no. of days under different ranges of minimum temperature (less than or equal to 10, 7, 5 and 2 degree

centigrade) of winter season (November, December, January, February and March) are increasing significantly indicating likely favorable conditions for winter season crops if appropriate soil water conservation and management techniques are adopted. However, number of days under different ranges of maximum temperature (greater than or equal to 40, 41, 42, 43, 44, 45 and 46 degree centigrade) during summer (March, April, May and June) are not showing any increasing trends indicating no effect of global warming at this regional level possibly due to having dense forested area.

#### Acknowledgement

Authors would like to express sincere thanks to Dr. G. P. Pali, PI, NICRA Project and other team members for providing cooperation to carry out this work. Thanks are also due to Shri Sohan Pandey, Lab Technician for data collection and compilation work.

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