



Research Article

Trend in Frequency of Hot Days and Cold Days at Five Locations of Chhattisgarh State

HEMANT KUMAR SINHA^{1*}, J.L. CHAUDHARY¹, SAKHA RAM SHORI² AND N. MANIKANDAN³

¹Department of Agricultural Meteorology, IGKV, Raipur-492 012, Chhattisgarh

²ICAR-Indian Institute of Water Management, Bhubaneswar-751 023, Odisha

ABSTRACT

This study used non-parametric Mann Kendall test to find out trend in frequency of hot and cold days during summer and winter months at five locations viz., Ambikapur, Bilaspur, Jagdalpur, Pendra and Raipur of Chhattisgarh state. The results revealed that the hot days (maximum temperature $e > 40^{\circ}\text{C}$) frequency in summer months are showing non-significant increasing trend at Ambikapur, Bilaspur and Pendra and non-significant declining trend was noticed at Jagdalpur and Raipur during summer months except in the month of June and May, respectively. Trend in frequency of cold days (minimum temperature $d < 10^{\circ}\text{C}$), indicates that significant increasing trend at Ambikapur in the month of January and in the months of December, January and February at Jagdalpur. At the same time, declining trend in occurrence of cold days during winter months is observed at Raipur. The results of this study might be utilized to develop strategies to alleviate the impact on production major crops like paddy and wheat due to high and low temperature events.

Key words: Hot days, Cold days, Temperature trends, Mann-Kendall's test, Chhattisgarh

Introduction

In the recent years, priority is given to studies of climate change/variability. The regional climate variability has profound influence on the regional economy. Despite increase in area under irrigation, still 56 per cent of total cultivated area (Suresh *et al.*, 2014) is under rainfed condition, where climatic variability have direct impact on regional economy. 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). Many studies of global or regional climate changes have focused on those with long-term average, such as annual or seasonal temperature. It is clear from the observed record that there has been an increase in the global mean surface air temperature of about 0.7°C over the last century (IPCC, 2007). Given these identifiable changes, it is expected that there would also be changes in extreme temperature events, such as the frequency of days with extremely low or high temperatures.

In the recent decades, India is facing ill effects of global warming owing to temperature induced changes in climate and ecosystems. A

*Corresponding author,
Email: hemantsinha333@gmail.com

warmer climate leads to intensification of the hydrological cycle, resulting in higher rates of evaporation and increase of liquid precipitation. These processes, in association with a shifting pattern of precipitation, will affect the spatial and temporal distribution of runoff, soil moisture, groundwater reserves and increase in the frequency of droughts and floods. Higher day and night time temperature influence crop physiology and phenology processes. Welch *et al.* (2010) reported that increase in minimum temperature beyond threshold level reduced the yield of paddy and other cereals. Likewise wheat senescence process would be accelerated if maximum temperature crosses 34°C during winter season affecting the grain filling of wheat (Lobell *et al.*, 2012). Keeping the above facts in view, the present study was aimed to find out the trend in frequency of maximum temperature of 40°C or more during summer season and lowest minimum temperature of 10°C or less during winter season at five selected locations of Chhattisgarh state.

Materials and methods

Daily maximum and minimum temperature data for five stations located across the Chhattisgarh stations was collected from Department of Agrometeorology, Indira Gandhi Krishi Vishwa-vidyalaya, Raipur and the period of database is furnished in Table 1.

Number of hot days (days with maximum temperature of 40°C or more) during summer months (March, April, May, June) and number of cold days (days with minimum temperature of 10°C or less) during winter months (November, December, January, February) has been computed using weathercock software (Rao *et al.*, 2011).

Table 1. Temperature data base for selected stations of Chhattisgarh

Sl. No.	District	Station	Database period
1	Surguja	Ambikapur	1981-2013
2	Bilaspur	Bilaspur	1983-2013
3	Bastar	Jagdapur	1980-2013
4	Raipur	Raipur	1971-2013
5	Bilaspur	Pendra	1981-2012

Mann-Kendall's test: Several tests are available for the detection and estimation of trends. In this study, Mann-Kendall's test was employed. Mann-Kendall's test is a non-parametric method, this method tests whether there is a trend in the time series data. The n time series values ($X_1, X_2, X_3, \dots, X_n$) are replaced by their relative ranks ($R_1, R_2, R_3, \dots, R_n$) (starting at 1 for the lowest up to n).

The test statistic S is:

$$s = \sum_{i=1}^{N-1} \sum_{j=i+1}^N \text{sgn}(R_j - R_i)$$

$$\text{sgn}(X) = \begin{cases} +1 & \text{for}(X) > 0 \\ 0 & \text{for}(X) = 0 \\ -1 & \text{for}(X) < 0 \end{cases}$$

If the null hypothesis H_0 is true, then S is approximately normally distributed with:

$$\mu = 0$$

$$\sigma = n(n-1)(2n+5)/18$$

The z -statistic is therefore (critical test statistic values for various significance levels can be obtained from normal probability tables):

$$Z = |S|/\sigma^{0.5}$$

A positive value of S indicates that there is an increasing trend and vice versa. In the present study, Mann Kendall test was performed using a trend / change detecting software Trend v1.0.2 and followed the instructions given by Chiew *et al.* (2005).

Results and Discussion

Trend in frequency of hot days

Frequency of days with maximum temperature $\geq 40^\circ\text{C}$ showed an increasing trend at Ambikapur, Bilaspur and Pendra stations during summer months which are not statistically significant. Hot day events at Raipur station showed non-significant decreasing trend during summer months (March, April, and June) but increasing trend in May. Panda *et al.* (2014) studied extreme temperature events over India and

their results also indicated non-significant increasing trend of hot days with above 40°C during summer in south and central India. Further, they mentioned that large inter-annual variability in occurrence of hot days might be possible reason for non-significance. Increased events in day time temperature extremes may lead to heat

related deaths especially in megacities (Shakoor *et al.* 2005). Interestingly, declining trend was observed in the frequency of days with maximum temperature e” 40°C during summer (March, April, May and June) at Jagdalpur station (Table 2). This indicates no effect of global warming at this regional level possibly due to dense forested

Table 2. Trend pattern of hot day events

Sl. No.	Station Name	March	April	May	June
1	Ambikapur	Increasing NS (0.046)	Increasing NS (0.12)	Increasing NS (0.085)	Increasing NS (0.128)
2	Bilaspur	Increasing NS (0.052)	Increasing NS (0.138)	Increasing NS (0.267)	Increasing NS (0.053)
3	Jagdalpur	Decreasing NS (-0.000)	Decreasing NS (-0.058)	Decreasing NS (-0.010)	Increasing NS (0.004)
4	Raipur	Decreasing NS (-0.001)	Decreasing NS (-0.088)	Increasing NS (0.044)	Decreasing NS (-0.014)
5	Pendra	Increasing NS (0.006)	Increasing NS (0.142)	Increasing NS (0.048)	Increasing NS (0.025)

NS: Non-significant; Values in brackets are linear regression slope

Table 3. Trend pattern of cold day events

Sl. No.	Station Name	November	December	January	February
1	Ambikapur	Increasing NS (0.061)	Increasing NS (0.078)	Increasing S** (0.258)	Increasing NS (0.067)
2	Bilaspur	Increasing NS (0.045)	Increasing NS (0.115)	Increasing NS (0.108)	Increasing NS (0.009)
3	Jagdalpur	Increasing NS (0.055)	Increasing S*** (0.458)	Increasing S*** (0.397)	Increasing S* (0.116)
4	Raipur	Decreasing NS (-0.053)	Decreasing NS (-0.063)	Decreasing NS (-0.037)	Decreasing NS (-0.018)
5	Pendra	Increasing NS (0.026)	Increasing NS (0.035)	Increasing NS (0.209)	Increasing NS (0.041)

***Significant at 1% level; ** Significant at 5% level; * Significant at 10% level; NS: Non-significant: Values in brackets are linear regression slope

areas. 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.

Trend in frequency of cold days

Trend in the frequency of days with minimum temperature 10°C or less showed that at four locations viz., Ambikapur, Bilaspur, Jagdalpur and Pendra the frequency of cold days are non-significantly increasing during winter months. However, number of days with minimum temperature 10°C or less is significantly ($p < 0.05$) increasing at Ambikapur in the month of January with the regression slope 0.258 during the period of study 1981-2013. Likewise, at Jagdalpur also statistically significant increasing pattern was found in the months of December, January and February (Table 3). From the regression slope it is understood that the occurrence of cold days are increasing by 0.458, 0.397 and 0.116 days per year in December, January and February months respectively, during the period 1980-2013. This increase in frequency of cold days are consistent with the findings of Shiv Kumar Bhuarya *et al.*, (2017) as they found that minimum temperature was significantly declining at Ambikapur and Jagdalpur during winter months viz., January and February. On the other hand, at Raipur declining trend in number of cold days is noticed during winter months which are not statistically significant.

Conclusion

The present study was carried out to find out the trend in frequency of hot and cold days during summer and winter months respectively at five selected locations over Chhattisgarh state. The Mann Kendall test results revealed that the number of days with 40°C or more during summer months (March, April, May and June) are showing non-significant increasing trend at Ambikapur, Bilaspur and Pendra stations. At the same time, non-significant declining trend was noticed at Jagdalpur and Raipur during summer months except in the month of June and May at Jagdalpur and Raipur respectively. In the case of

frequency of cold days, significant increasing trend is seen at Ambikapur in the month of January and at Jagdalpur in the months of December, January and February. Regression slope indicated that at Jagdalpur, the occurrence of cold days is increasing by 0.458, 0.397 and 0.116 days per year in December, January and February months respectively, during the period 1980-2013. The present study may be useful to develop mitigation and adaptation strategies in order to reduce the ill effects of extreme temperature events on agricultural production especially major crops like paddy and wheat.

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