

## Frequency of Extreme Temperature Events in Sub-Montane Punjab

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### ABSTRACT

*Patterns of temperature and precipitation are changing due to global warming, resulting in their impact on crop productivity. During the summer season the maximum temperature in Punjab reaches upto 44-50°C and also heat waves have adverse effect on fauna and flora. Thirty eight years (1984-2012) of maximum temperature of Ballawal Saunkhri, located in the Submontane region of Punjab state at an altitude of 355m above the sea level for the months of April to June have been collected and classified into various groups for interpretation. Results show that the lowest and the highest maximum temperatures recorded during the study period were 31.6 and 41.3°C in the months of April and May, respectively. The Coefficient of Variation for three months varied from 4.57 to 20.99% and standard deviation of average maximum temperature varies from 1.77 to 7.29°C. Minimum persistence in maximum temperature over five days is found to be 8 to 33%. Analysis indicate that maximum number of heat waves occurred during the month of June. The decade wise analysis shows that maximum number of extreme events occurred during the last decade (2000-2012) and it is also found that maximum number of extreme temperatures of all categories at Ballawal Saunkhri occurred during the month of May.*

**Key words:** Heat wave, Maximum temperature, Extreme events.

### 1. Introduction

Global warming is the serious threat for the human civilization in the recent era. The increase in intensity and frequency of extreme events in different parts of the world is more pronounced in the last two decades of the 20th century particularly in developing countries like India. Heat waves are very harmful during the summer and these are experienced over the Deccan and Central parts of India from March to May. The harmful effects include: shedding of fruits, leaves, drying of water resources, loss of water by evaporation from irrigation channels, Transpiration increases from plants beyond recouping levels, hot winds cause shriveling effect at milk stage of all agricultural crops. An increase in extreme weather events has been attributed to man-made global warming. Floods, droughts, heat waves / cold waves and associated weather phenomena caused several deaths. According to the Intergovernmental Panel on Climate Change (IPCC) 4<sup>th</sup> Assessment Report (IPCC, 2007), projected globally averaged surface warming, for the low scenario is (B1) 1.8 °C (likely range is 1.1 °C to 2.9 °C), and for the high scenario (A1F1) it is 4.0°C (likely range is 2.4°C to 6.4 °C)

with a general reduction of potential crop yields and a decrease in water availability for agriculture [Parry *et al.* (1999); Parry *et al.* (2004)] by the end of the 21<sup>st</sup> century. In general for kharif crop production, temperature is not a major constraint but rapid rise or fall of temperature, low or high rainfall/sunshine hours is a constraint for many kharif crops. High night temperature increases respiration. The temperature is the most important climatic factor that influences growth, development and yield of crops. Both the maximum & minimum temperatures are playing important role in agriculture. Higher night temperatures resulted in increase in respiration hence reducing the net gain in the form of grain yield.

The warming of climate system is unequivocal as indicated by increases in average global temperature, snow melting, rise in sea levels and frequent occurrence of extreme events according to Fourth Assessment Report (AR4) of Intergovernmental Panel on Climate Change (IPCC). They will lead to climate related disasters like hurricanes, droughts, floods, heat waves, cold spells, landslides and cyclones etc. There is an evidence of prominent increases in the intensity /

frequency of extreme events in the Asian region. In India the frequency of extreme weather events in recent decades particularly from 1991- 2000 have showed increase in persistency, severity and spatial coverage of severe heat wave conditions as compared to the earlier decades from 1971-1980 & 1981-1990. The 2/3rd of all the time series (1910-2000) reveal increasing trends in the indices of precipitation extremes in India (De *et al.*2005).

## 2. Data and Method

The daily maximum temperature values for April, May and June months used in the study were recorded at Ballawal Saunkhri (31°6'N to 76°23' E at 355 m above msl) in sub-montane region of Punjab for the period from April 1984 to June 2012 from the Meteorological observatory, Ballawal Saunkhri and State Meteorological Centre, Chandigarh and used for the study. These data were analyzed using statistical methods for finding extreme values, standard deviation and variation, daily departure of maximum temperature from the normal and persistence in maximum temperature continuously for number of days. Departure of daily maximum temperature from the normal was analysed by its classification into seven categories viz. nearly normal ( $\pm 1.5$  to  $-1.5^{\circ}\text{C}$ ), above normal ( $+1.5$  to  $3.0^{\circ}\text{C}$ ), appreciably above normal ( $+3.0$  to  $5.0^{\circ}\text{C}$ ) and markedly above normal ( $>+5.0^{\circ}\text{C}$ ), below normal ( $-1.5$  to  $3.0^{\circ}\text{C}$ ), appreciably below normal ( $-3.0$  to  $-5.0^{\circ}\text{C}$ ) markedly below normal ( $>-5.0^{\circ}\text{C}$ ). Occurrence of persistence in maximum temperature for a number of continuous days expressed in percentage was studied by classifying it into five different categories i.e. 1,2,3,4 and 5 or above days for three conditions of departure from normal i.e. no change (Within  $\pm 1^{\circ}\text{C}$ ), rise ( $>1^{\circ}\text{C}$ ) and fall ( $<1^{\circ}\text{C}$ ) (Samra and Singh 2004). Number

of heat waves were computed as per criteria given by India Meteorological Department (IMD) viz. if daily departure of maximum temperature from normal is positive by  $e^{\circ}$  6 to  $7^{\circ}\text{C}$  it is known as moderate heat wave and if departure is  $>-7^{\circ}\text{C}$ , it is severe heat wave condition. This data analysis for 28 years was done during 2013 to study the behaviour of maximum temperature during the three particular months.

## 3. Results and Discussion

### 3.1. Extreme values

The extreme lowest maximum temperature values recorded were 18.0, 19.7 and  $24.0^{\circ}\text{C}$  and extreme highest maximum temperature values were 44.0, 48.2 and  $46.6^{\circ}\text{C}$  for April, May and June, respectively. The month of April depicted maximum range of maximum temperature as the extreme lowest ( $18.0^{\circ}\text{C}$ ) and May month recorded the highest ( $48.2^{\circ}\text{C}$ ) temperature for the study period. Whereas, the average temperature for April, May and June months are 34.7, 38.4 and  $37.6^{\circ}\text{C}$  with standard deviation of 3.3, 3.1 and  $3.7^{\circ}\text{C}$ , respectively. The standard deviation was found to be higher for the month of June (3.7) and lower for the month of May (3.1) indicating higher fluctuations from mean value during April and June months. Similar is the case for coefficient of variation being highest for the month of June (Table 1). Similar results were reported by Gill and Kukal (2015) .

### 3.2. Departure of maximum temperature

Percentage number of cases of departure of maximum temperature from the normal values under different categories are presented in Table 2. During the month of April, maximum temperature remained nearly normal for 30%, above normal for

**Table 1**  
**Extreme values of maximum temperature ( $^{\circ}\text{C}$ ) at Ballawal Saunkhri (1984-2012)**

Month	Lowest			Highest			Mean max ( $^{\circ}\text{C}$ )	SD	CV (%)
	Value	Date	Year	Value	Date	Year			
April	18.0	3	1997	44.0	30	1999	34.7	3.3	9.6
May	19.7	9	1987	48.2	29	1999	38.4	3.1	8.3
June	24.0	15	2013	46.6	27	1995	37.6	3.7	10.0

**Table 2**  
**Number of events of departure of maximum temperature from**  
**normal (%) at Ballawal Saunkhri (1984-2012)**

Month	Nearly Normal +1.5 to -1.5°C	Above Normal +1.5 to +3.0 °C	Appreciably Above Normal +3.0 to +5.0 °C	Markedly above Normal >5.0 °C	Below Normal -1.5 to -3.0 °C	Appreciably Below Normal -3.0 to -5.0 °C	Markedly Below Normal >-5.0 °C
<b>April</b>	30	14	14	11	12	11	8
<b>May</b>	33	18	13	5	13	9	9
<b>June</b>	28	11	14	7	12	14	14

14% and below normal for 12% of the total events. Similar trend was observed in May as the maximum temperature was nearly normal for 33%, above normal for 18% and below normal for 13%. Whereas, during June months the maximum temperature was nearly normal for 28%, above normal for 11% and below normal for 12% of the total events. The analysis indicate that the maximum temperature remained nearly normal ( $\pm 1.5^\circ\text{C}$ ) for the highest period in May followed by April and June. Markedly below normal maximum temperatures were found with fourteen events in

June and eight and nine in April & May, respectively.

### 3.3. Persistence in maximum temperature

The results on percentage occurrence of persistence in maximum temperature (no change, rise or fall) are presented in Table 3. Data indicates the persistence for all categories in respect of three months of study. On an average, highest number of cases i.e. 231.9% was observed for the persistence lasting for one day and lowest number of cases i.e. 2.8% for more than five days for the month of April. The percentage of occurrence for

**Table 3**  
**Percentage of occurrence of persistence in maximum temperature at**  
**Ballawal Saunkhri (1984-2012)**

Month	Number of continuous days				
	No change				
	1	2	3	4	>5
<b>April</b>	82.8	15.6	1.6	0.0	0.0
<b>May</b>	83.1	12.3	4.6	0.0	0.0
<b>June</b>	92.2	6.3	1.6	0.0	0.0
	Rise > 1°C				
<b>April</b>	72.0	12.1	10.3	2.8	2.8
<b>May</b>	56.3	25.8	10.9	4.7	2.3
<b>June</b>	69.2	20.0	10.0	0.0	0.8
	Fall < 1°C				
<b>April</b>	77.1	18.1	3.6	1.2	0.0
<b>May</b>	74.2	21.3	2.2	2.2	0.0
<b>June</b>	78.4	14.9	5.4	1.4	0.0
	Total				
<b>April</b>	231.9	45.8	15.5	4.0	2.8
<b>May</b>	213.6	59.4	17.7	6.9	2.3
<b>June</b>	239.8	41.4	17.0	1.4	0.8

**Table 4**  
**Frequency of heat waves at Ballawal Saunkhri (1984-2012)**

	Month Moderate	Number of heat waves Severe
<b>April</b>	21	12
<b>May</b>	19	7
<b>June</b>	34	13

continuous two, three and four days was 45.8%, 15.5% and 4.0%, respectively (Table 3).

### 3.4. Frequency of heat waves

The maximum numbers of moderate and severe heat waves were recorded during June followed by April and May (Table 4). Similar trend has been observed in cases of severe heat wave. Highest number of heat waves occurred in June (13) followed by April (12) and May (7).

### 3.5. Changes in frequency of occurrence of extreme temperature events

The occurrences of extreme temperature events (number of days) within 37-40°C, 40-44°C and >44°C have been examined over the past three decades at Ballawal Saunkhri (Table 5). The occurrence of such temperature events of all categories was highest during the month of May in almost every decade. But during 1984-90, the month of June reported highest temperature event of category 37-40°C and other two categories followed similar trend in other decades. Amongst the three decades under study, the occurrence of extreme temperature of all categories has been noticed in the recent decade i.e. 2001-2013. Temperatures between 37- 40°C are observed for 110, 146 and 115 days in April, May and June, respectively. Temperatures in the range 40 - 44°C are found for 18, 114 and 76 days while temperature

>44.0°C occurs for 0, 15 and 10 days respectively.

## 4. Conclusion

Results indicate that in the sub-mountain regions the maximum numbers of extreme temperature events have occurred during the recent decade of 2001-2013 and also during all the summer months. Thus the maximum temperature may increase day by day and it will hamper the crop water requirements. The number of moderate heat waves recorded during the past 29 years is 74. This is again a concern for the kharif crops grown in these regions since these are rainfed areas and heat waves very much affect the agricultural productivity. Thus there is need for moisture and rain water harvest in these regions for the growth of the kharif crops.

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**Table 5**  
**Occurrence of extreme of maximum temperature (No. of days) over the past three decades in Ballawal Saunkhri**

Decade	Maximum temperature range								
	37-40 °C			40-44 °C			>44 °C		
	April	May	June	April	May	June	April	May	June
<b>1984-90</b>	53	71	65	0	41	57	0	9	2
<b>1991-00</b>	54	120	102	14	64	46	0	8	12
<b>2001-13</b>	110	146	115	18	114	76	0	15	10