Vol. 9, pp. 44-49 (2009)
Journal of Agricultural Physics
http://www.agrophysics.in

Trends of Thermal Parameters and Extreme Incidences on IARI Farm, New Delhi during 1980-2008

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ABSTRACT

According to the Fourth Assessment Report by the Intergovernmental Panel on Climate Change (IPCC), global surface temperature increased 0.74 ± 0.18 °C during the 20th century and is likely to rise further from 1.1 to 6.4 °C during the 21st century as a result of increasing concentrations of greenhouse gases by human activities such as the burning of fossil fuel and deforestation. A study was conducted to examine the trends of annual mean temperature, annual mean maximum temperature and annual mean minimum temperature at IARI farm, New Delhi. Temperature extremes, which affect the growth and development of crop plants adversely, were also found out with their time of occurrence and frequencies. The trends of annual mean temperature and annual mean maximum temperature were negative whereas, the trend of annual mean minimum temperature was positive. In case of extreme values, 5 coldest mornings were more recent in nature (2006-2008) than the 5 hottest daytimes (1995-2003). An all time high temperature (46.8°C) was recorded on May 29, 1998 and an all time low temperature (-1.4°C) was recorded on January 9, 2006. Frequencies of hot days were found decreasing, whereas, hot nights, cold days and cold nights were increasing with the progress of time. The number of 'hot days' was maximum (60) in 1987 and minimum (11) in 1997 and 2008. The number of hot nights (26) was maximum in 2002 and was minimum (0) in 1983, 1997 and 2008. Except the trend of annual mean minimum temperature, all other parameters looked like contradicting the popular global warming concept. Although situated with in metropolitan city, IARI farms are full of greenery consisting of 90% area under trees and croplands during most time of the year. Probably, this has arrested and to some extent reversed the warming effect. The effect of warming may be conspicuous in the areas where rapid deforestation and urbanization has taken place. Every one is aware of global warming and hot extremities, but the cooler side is also increasing and we may have to think about protection of crops against cold extremities like cold injuries and frost in the near future.

Key words: Temperature trends, Hot days, Hot nights, Cold days, Cold nights

Introduction

According to the Fourth Assessment Report by the Intergovernmental Panel on Climate Change (IPCC), global surface temperature increased 0.74 ± 0.18 °C (1.33 ± 0.32 °F) during the 20th century(IPCC, 2007). Most of the observed temperature increase since the middle of the 20th century has been caused by increasing concentrations of greenhouse gases, as a result of human activity such as the burning of fossil fuel and deforestation (United States National Academy of Sciences, 2008). The concentration of green house gases namely, CO_2, CH_4, N_2O and CFC increased many folds in the atmosphere. The short-wave insolation can reach the earth surface through atmosphere, but increase in the concentration of the green house gases absorb the earth emitted long wave radiation more and more in the atmosphere. The atmosphere gets heated up abnormally and global heat balance is getting disturbed. Climate model projections summarized in the IPCC (2007) report indicated

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that the global surface temperature is likely to rise a further from 1.1 to 6.4 °C (2.0 to 11.5 °F) during the 21st century.

A study was conducted at the Division of Agricultural Physics, IARI farm, New Delhi to examine the trends of annual mean temperature, annual mean maximum temperature and annual mean minimum temperature. Temperature extremes which affect the growth and development of crop plants adversely, were also found out with their time of occurrence and frequencies.

Materials and Methods

The data on daily maximum and minimum temperature were collected from the Agrometeorological observatory of Agricultural Physics Division, IARI, New Delhi (Latitude: 28°38'23"N, Longitude:77°09'27"E., Altitude: 228.61m above msl) for the period of 1980-2008. The observatory is situated in the farm comprising of croplands and trees covering about 90% area within its one km radius.

Simple mean of the above two parameters were worked out to get a daily mean temperature of every day. Annual and monthly mean temperatures, mean maximum temperatures and mean minimum temperatures were calculated by taking the means (averages) of above parameters for each year and each month in MS-Excel. Extreme values were selected through MAX or, MIN options in function.

Results and Discussion

Trends of IARI New Delhi Temperatures

Trends in annual temperature for the years 1980-2008 are depicted in Fig.1. The annual mean maximum temperature (Tmax) showed a negative trend and the representative regression equation is given below:

$$Tmax = -0.0209 \times year + 31.282, R^2 = 0.075$$

The negative trend of annual mean maximum temperature might be due to decrease in irradiance/insolation to the surface over the years for one or many reasons. This reduction might be due to increase in albedo of the surface owing to changed land use pattern, or, atmosphere owing to increased cloudiness. Absorption and scattering of short wave radiation at the atmosphere by dust particles of aeolian origin from Rajasthan desert particularly during summer and smoke generated by city pollution . Decrease of irradiance or global dimming was reported by Stanhill and Cohen (2001). They concluded that the reduction has globally averaged –0.51±0.05Wm"^{2} per year, equivalent to a reduction of 2.7% per decade. The most probable cause is being an increase in man made aerosols and other air pollutants that have changed the optical properties of the atmosphere, in particular those of clouds.

The trend in annual mean minimum temperature (Tmin) increased over the years (Fig.1) and the regression equation of the trend line is given below:

$$Tmin = 0.0192 \times year + 17.364, R^2 = 0.1358$$

This increase could be supported by popular global warming theory that due to increase of green house gases, atmosphere absorbed more long wave radiation emitted by earth surface and therefore why the atmospheric temperature has increased.

The trend in annual mean temperature (Tmean) was slightly negative here which contradicted popular global warming concept. The equation for the trend line of annual mean temperature of IARI farm, New Delhi during 1980-2008 is given below.

$$Tmean = -0.0002 \times year + 24.349, R^2 = 0.0014$$

At this location, probably, the rate of decrease of annual mean maximum temperature during 1980-2008 out placed the rate of increase of annual mean minimum temperature. As a result, we obtained a decreasing trend in annual mean temperature during this period. Xian Sun *et al*. (2008) found some areas with a negative temperature change rate distributed sporadically in Southwest China.

Thermal Extremes at IARI farm, New Delhi during 1980-2008

The warmest and coldest days in the entire period of 1980-2008 obtained through selection

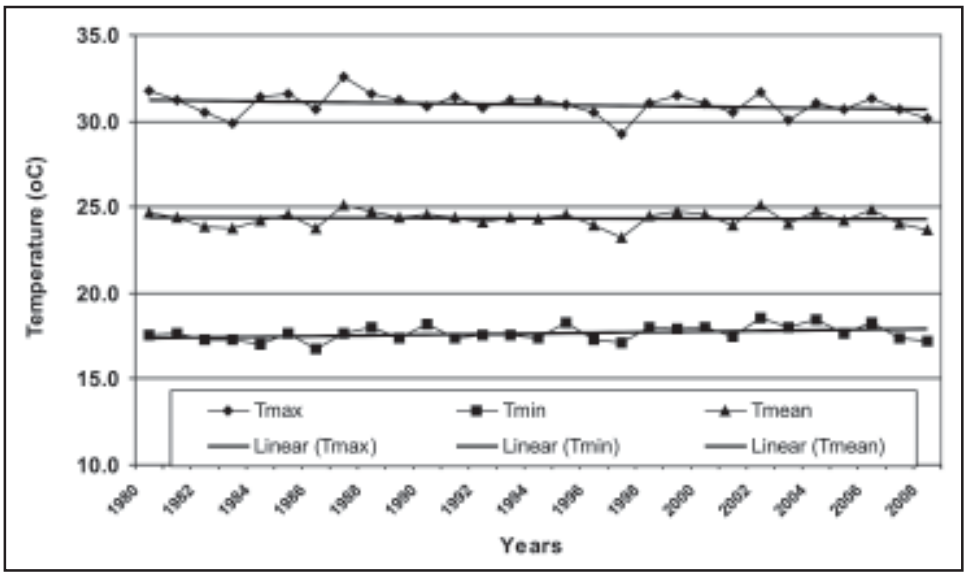

Fig. 1. Annual temperature trend at IARI during 1980-2008

based on daily mean temperature were found to be June 17, 1995 (40.2^{0}C) and January 12, 2003 (7.2^{0}C) respectively (Table 1). The coldest day, which occurred in 2003, was more recent than the warmest day, which occurred in 1995. The warmest and coldest months calculated based on monthly mean temperature were found to be June 1986 (35.8^{0}C) and January 2003 (11.0^{0}C) respectively. Here also, the coldest month is more recent than the warmest month (Table 1).

The warmest and the coldest years calculated based on annual mean temperature were 1987/ 2002 (25.1^{0}C) and 1997 (23.3^{0}C), respectively. Both the warmest years (1987 and 2002) were also the drought years. As the temperature of any place is driven by net radiation (more precisely available sensible heat). In drought years 'latent heat of evaporation' component of net radiation reduced drastically and the availability of 'sensible heat' increased significantly.

Hottest Days and Coldest Mornings

Hottest days and coldest mornings were obtained from daily maximum and minimum temperature recorded in the observatory. Five top hottest days and coldest mornings are given in Table 2. The highest daily maximum temperature recorded was 46.8^{0}C on May 29, 1998 and lowest daily minimum temperature recorded was on January 9, 2006 (-1.4^{0}C). All the five coldest mornings occurred between 2006 and 2008 during 1980-2008. On the other hand, all the five hottest days were recorded in between 1995 and 2003. The incidence of coldest mornings was more recent in occurrence than the hottest days.

Table 1. Temperature extremes at IARI New Delhi during 1980-2008

S. No.	Extreme features	Parameters considered	Values (^{o}C)	Occurrence
1.	Warmest day	Highest daily mean temperature	40.2	June 17, 1995
2.	Coldest day	Lowest daily mean temperature	7.2	January 12, 2003
3.	Warmest month	Highest monthly mean temperature	35.8	June, 1986
4.	Coldest month	Lowest monthly mean temperature	11.0	January 2003
5.	Warmest year	Highest annual mean temperature	25.1	1987, 2002
6.	Coldest year	Lowest annual mean temperature	23.3	1997

Table 2. Hottest daytimes and coldest morning at IARI, New Delhi during 1980-2008

S.No.	Hottest daytimes		Coldest mornings	
	Date	Maximum temperature (°C)	Date	Minimum temperature (°C)
1.	May 29, 1998	46.8	January 9, 2006	-1.4
2.	May 27, 1998	46.6	January 8, 2006	-0.7
3.	June 16, 1995	46.6	January 28, 2006	-0.4
4.	June 17, 1996	46.5	February 1, 2008	-0.1
5.	June 5, 2003	46.5	February 28, 2006	0.0

Annual Frequency of Hot Days, Hot Nights, Cold Days, Cold Nights and their Trends

During the period of 1980-2008, the days with maximum temperature > 40^0C were separated out and termed as 'hot days'. Number of hot days were counted for each year and plotted in Fig. 2. Similarly, the days with minimum temperature > 30^0C were termed as 'hot nights'. Minimum temperature of a day generally took place in the early morning and any morning temperature (minimum) >30^0C indicated that temperature did not fall below 30^0C during the previous night. The annual frequency of hot night was also plotted in Fig. 2.

Daily maximum temperature once crosses 40^0C creates high discomfort to all terrestrial animals including mammals and insects of agricultural importance. In the plant kingdom, the pollens get desiccated, guard cells of stomata lose the turgidity and ultimately resulting in the reduction of evapotranspiration and wilting of most of the agriculturally important plants in the tropics and sub-tropics. Very high daily minimum temperature also increases respiration in plants and net photosynthesis rate decreases.

Fig 2. revealed that number of 'hot days' was maximum (60) in 1987 and minimum (11) in 1997 and 2008. A decreasing trend was found over the period, which can be represented by the following regression equation.

No. of hot days = - 0.5054 x year + 40.409

R^2= 0.1161

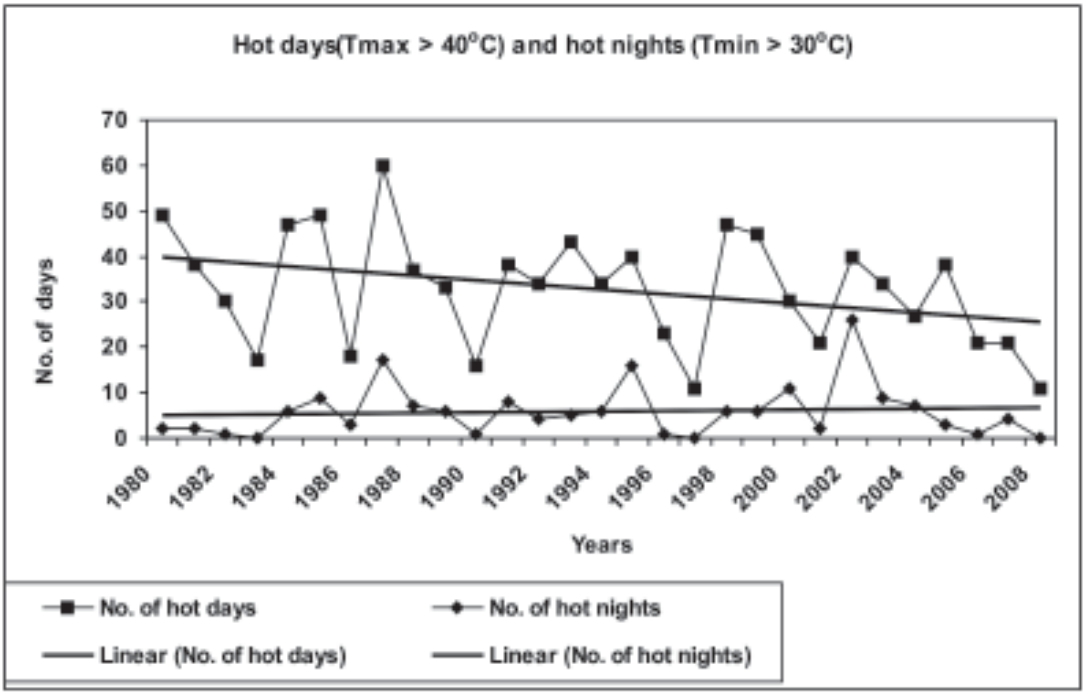

Fig. 2. Annual frequency of hot days and hot nights at IARI, New Delhi during 1980-2008

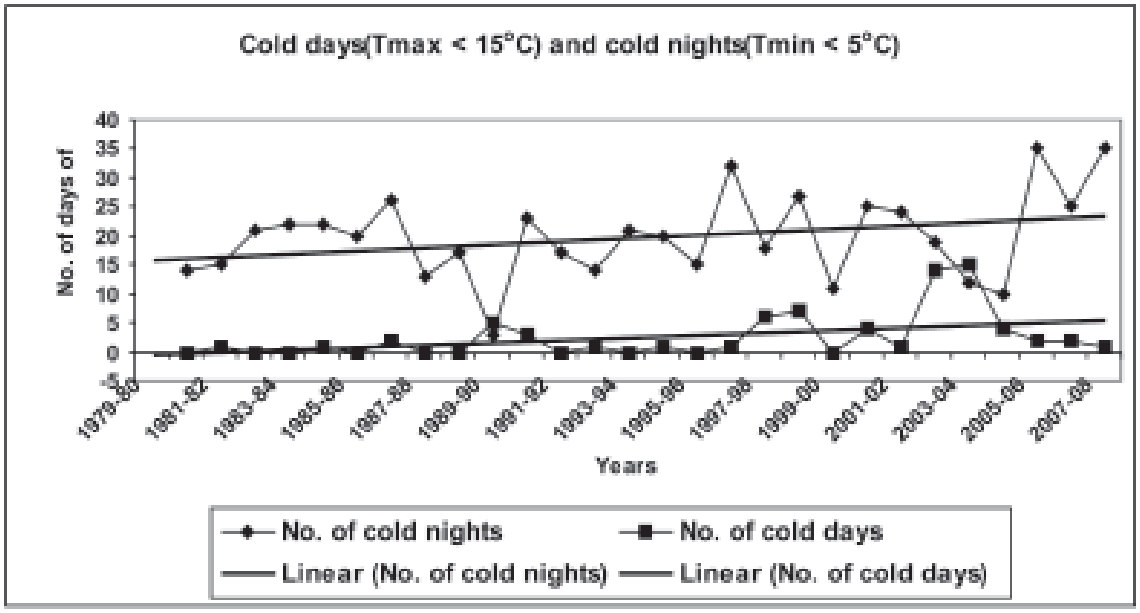

Fig. 3. Annual frequency of cold days and cold nights at IARI, New Delhi during 1980-2008

However, number of hot nights (26) was maximum in 2002 and was minimum (0) in 1983, 1997 and 2008 and an increasing trend was found over the period, which can be represented as follows:

No. of hot nights = 0.07141 x year+4.7562

R^2= 0.0109

The decreasing trend of hot days over the years may be a welcomed phenomenon, but the increase in hot nights are known to be detrimental to plants and animals. In animals, it creates discomfort and in plants it reduces the yield by decreasing net photosynthesis over an increasing period of time.

Similarly, the days with maximum temperature <15^{0}C were separated out and termed as 'cold days' as the activities of human and other animals gets affected adversely in the tropical and subtropical region if the temperature stays below 15^{0}C at all the time of the day. The mornings with minimum temperature <5^{0}C were cold mornings and proceedings nights were termed as 'cold nights'. Below 5^{0}C temperature maximum types of plants in tropics and subtropics do not grow at all and the base temperature for winter crops are taken around 5^{0}C in growing degree day and other thermal time calculation.

The year wise frequency of cold days during 1980-2008 (November to February) was plotted in Fig. 3. The number of cold days was found to be maximum (15) in 2003-04 (November to February) at IARI and lowest number of cold day (0) was observed in 10 winter seasons.

Similarly, the highest number of cold nights (35) was observed in 2005-06 (November to February) and 2007-08 (November to February) the lowest number of cold nights (3) was observed in 1989-90(November to February).

The trends of both number of cold days and cold nights were positive and can be represented by the following regression equations.

No. of cold days = 0.2094x years -0.7094

R^2= 0.1949

No. of cold days = 0.2731x years-15.624

R^2= 0.0811

(In the regression equation, winter of 1980-81 was represented as 1980 , 1981-82 as 1981 and so on).

With the progress of time, we are observing more hot nights, cold days and cold nights and less hot days on the IARI farm, New Delhi.

Conclusions

The above study revealed that the trends in annual mean temperature and annual mean maximum temperature were negative, whereas, the trend in annual mean minimum temperature was positive. In case of extreme values, coldest mornings were more recent in nature than the hottest daytimes. Frequency of hot days is decreasing, whereas, hot nights, cold days and cold nights are increasing with the progress of time. Except the trend of annual mean minimum temperature, all the other parameters looked like contradicting the popular global warming concept. IARI farms are full of greenery consisting of 90% area under trees and crop lands in most time of the year. Probably, this has arrested and to some extent reversed the warming effect. Every one is aware of global warming, but extremities towards cooler side are also increasing and we may be required to think about protection of crops against cold extremities like cold injuries and frost in near future.

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