Vol. 38, No. 5 Asian Profile October, 2010

Trends of Some Climatic Parameters in North-East India in the Eastern Himalayas

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Introduction

The phenomenon of climate change is a very relevant global concern nowadays because the impacts of climate change will be felt all over the world. The effects will be felt in varying degrees on all life forms on earth. India, being home to about 16.2% of the world's total population with only about 2.4% of the earths total land surface has different landforms with different regional climatic conditions. Therefore, there will be profound practical implications of the changes in climate in India on many aspects. It is the accepted view all over the world that the main driving factor for the global climate change is the rise in the mean global temperature in the last century starting from1901. This rise in global temperature is largely due to anthropogenic activities the life styles of mankind have contributed enormous amount of green house gases in the atmosphere. These gases along with natural sources like water vapor and aerosols produced by volcanic eruptions etc. present in the atmosphere trapped the heat that is reflected from the earth's surface and redirected it towards the earth, thereby increasing the temperature of the earth. The immediate consequence of global warming is the drastic and destructive changes in the climatic conditions in different regions of the world. The increasing temperature affect the precipitation patterns and disrupt and cause damaging floods and draughts in different parts of the globe. These changes in climate will affect agriculture as well as human significantly across the regions of India. The studies conducted by various researches (Dash and Hunt, 2007; Rao *et al.*, 2000; Roy and Balling, 2006; Kothawale *et al.*, 2005; IPCC, 2001) indicated that the climate is changing in Indian subcontinent and its impact is very tremendous in urbanized area.

Most of the data set for climate studies is from urban surroundings or cities. However, few studies have been conducted for the remote area because of non-availability of the weather data in those places. The data set of the urban area is not only governed by local atmosphere, sometimes it is affected by urban pollution. Therefore, there is need to conduct climatic change studies in low less populated urbanized areas to evaluate the impact of climate change on environment. Hence, north-east region of India was taken up for study. In this study, the trends of the climatic parameters are discussed for the north-east region in the Eastern Himalayas.

Materials and Methods

The North Eastern Region of Himalaya is shown in Figure 1. North Eastern Himalayan Region is characterized by cool summer and chilly winter. The average rainfall in the area is more than in the central region, the Cherapunji area in the region receives maximum rainfall in the world. The North-East monsoon is the predominant feature in region. Average monthly weather parameters for North-east Region of India were downloaded from the Indian Institute of Tropical Meteorology (IITM) website (*www.tropmet.res.in*) for the period, 1901-2003 (for temperature) and for the period, 1871-2005 (for rainfall). The statistical trends were evaluated for maximum atmospheric temperature (based on monthly average maximum and average maximum in various seasons), minimum (based on monthly average minimum and average minimum in various seasons) and mean (monthly mean) temperature. Yearly average maximum temperature is calculated based on monthly average maximum which was derived by averaging the daily maximum temperature of the particular month. Likewise, yearly average minimum temperature is calculated based on monthly average minimum which was derived by averaging the daily minimum temperature of the particular month. The daily maximum and minimum atmospheric temperature are recorded at 5 a.m. and 3 p.m. local time in the region. The yearly mean temperature is calculated by averaging the yearly average maximum and minimum temperature.

The average seasonal maximum and minimum temperature trends were also analyzed for various seasons *i.e.*, Winter (December-February), Spring (March- April), Summer (May-June) Monsoon (July-September), and Autumn (October-November). The skewness and kurtosis based on twelve months of year for the monthly mean, maximum and minimum temperature were also determined.

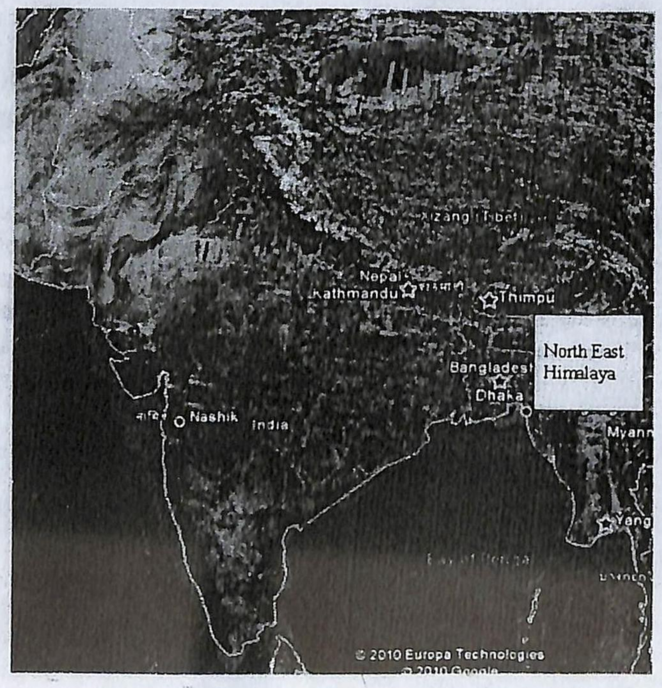

Figure 1. Location Showing Study Area (*www.googleearth.com*)

Regional Temperature Trends in North-east India

The analysis of the trend of the yearly average maximum temperature for the north-east suggested an increasing trend since 1901 at the rate of 0.0108°C per year with R^2 of 0.5284 (Figure 2). The seasonal average maximum temperature trends were analyzed for various seasons *i.e.*, winter, spring , summer, monsoon and autumn (Figure 3). The maximum rise in seasonal average maximum temperature is observed for autumn season with rate of 0.018°C per season with R^2 of 0.5263. In winter, the rise in the seasonal average maximum temperature was 0.0118°C per season with R^2 of 0.2266. It is clearly seen that kurtosis for the monthly average maximum temperature for the period is showing an increasing trend but skewness does not show any significant trend (Figure 4).

Yearly average minimum temperature in the region indicates an increasing trend at the rate of 0.001°C per year with R^2 value of 0.0083 (Figure 5). The trends of yearly average minimum temperatures in various seasons are given in Figure 6. It shows maximum rise for average minimum temperature during winter period at rate of 0.0073°C per season with R^2 of 0.1947. In autumn this rate of rise is 0.0063°C per season with R^2 of 0.0836, the rate of rise was less in spring season with the rate of 0.0016°C per season and R^2 of 0.0061. However, the seasonal average minimum temperatures in summer and monsoon period indicate a decrease in temperature at the rate of 0.0013°C per season with R^2 of 0.0092 and 0.0036°C per season with R^2 of 0.1151 respectively. It is evident from the temperature trends that the R^2 is high for the trends observed for maximum temperature than the minimum temperature trends. The kurtosis and skewness based on monthly data for a year show increasing trends since 1901. It suggests that the minimum temperatures are increasing in the region with increasing peakedness (Figure 7). The scatter diagrams between season's average temperature and rate of change in temperature for the season's average maximum and minimum temperature are shown in Figure 8a and 8b. It is evident from the figure that the rate of change is more prominent for lower temperature.

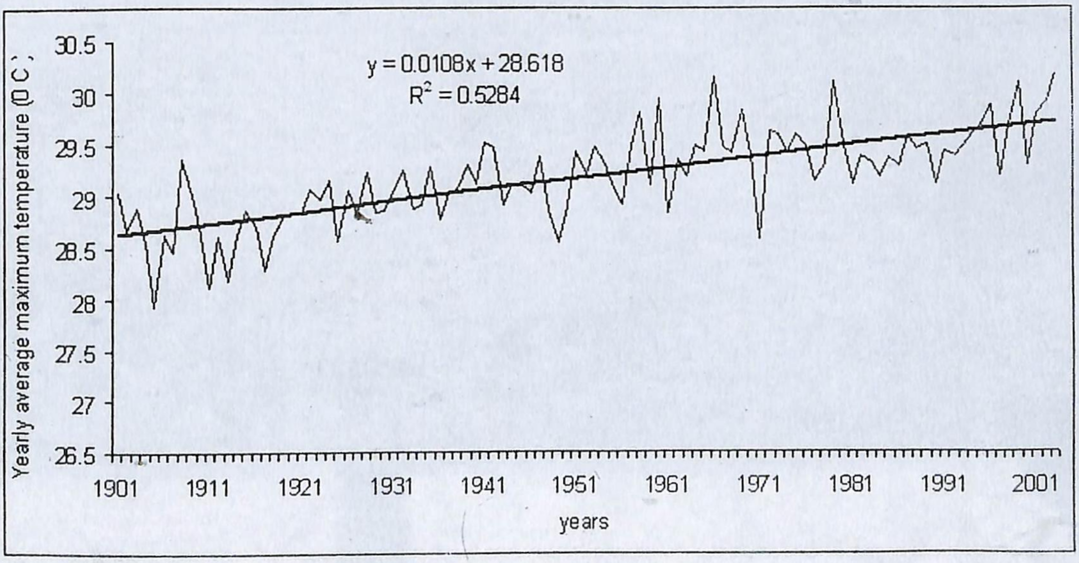

Figure 2. Trend of the Yearly Average Maximum Temperature (°C) for the Period of 1901-2003

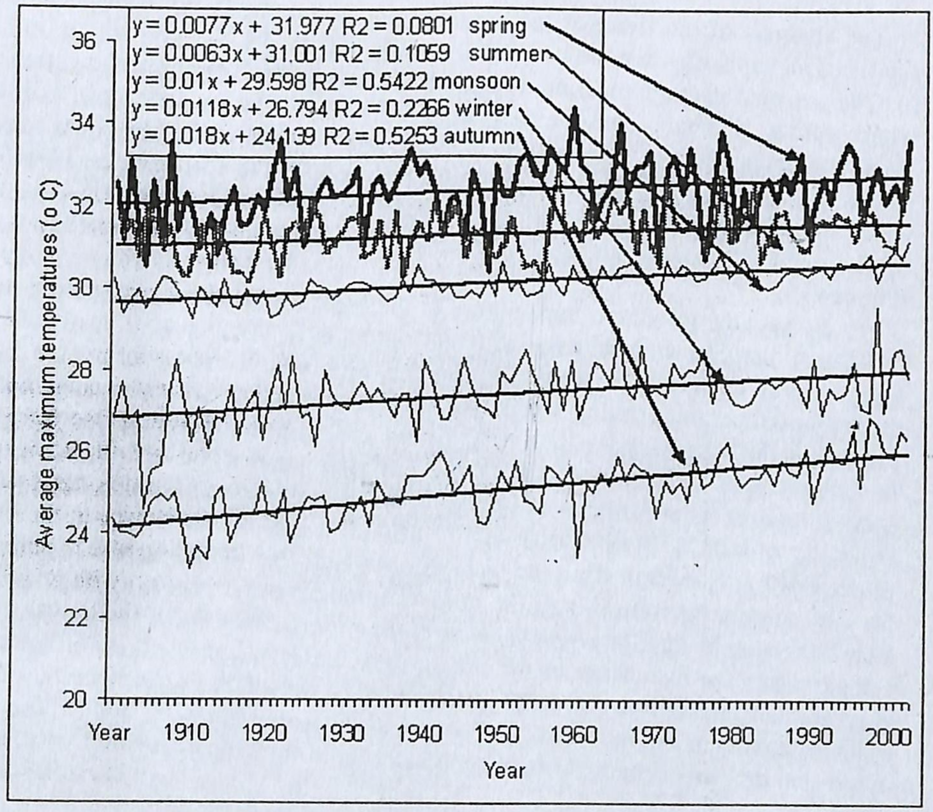

Figure 3. Trends of Average Maximum Temperatures (°C) in Various Seasons for the Period, 1901- 2003

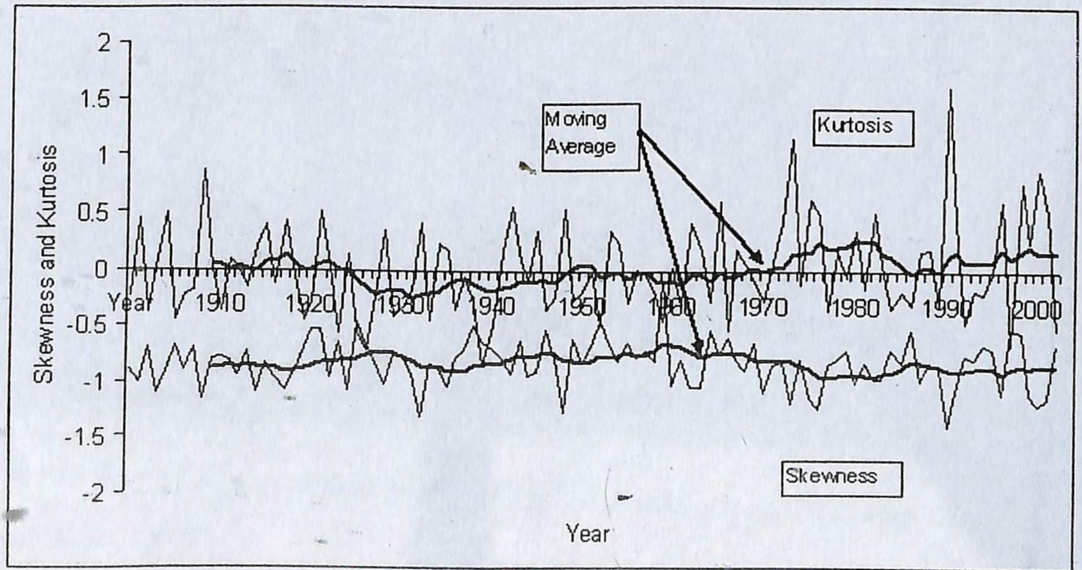

Figure 4. Trends of the Skewness and Kurtosis for Monthly Average Maximum Temperature (°C) for the Period of 1901-2003

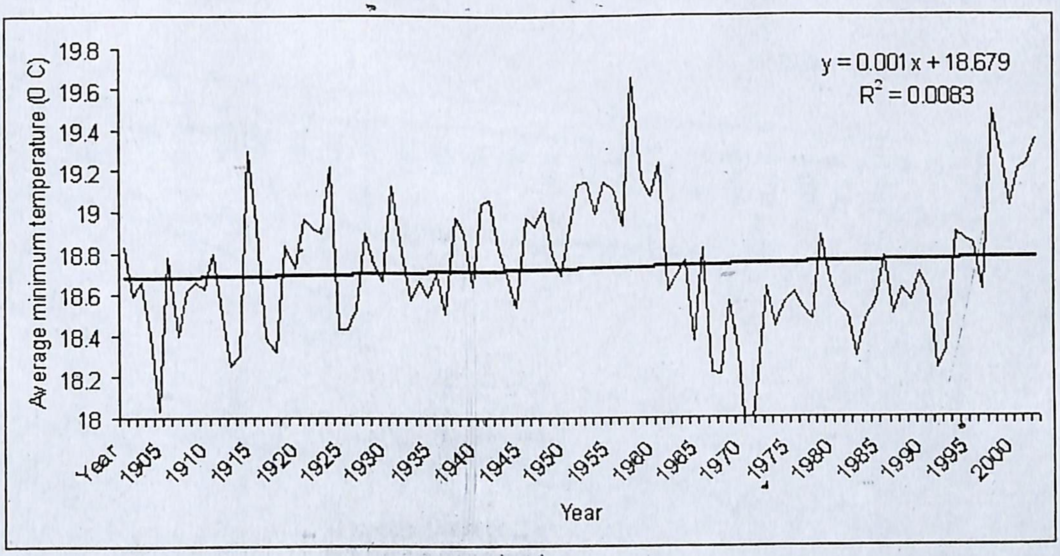

Figure 5. Trend of Average Minimum Temperature (°C) for the Period of 1901-2003

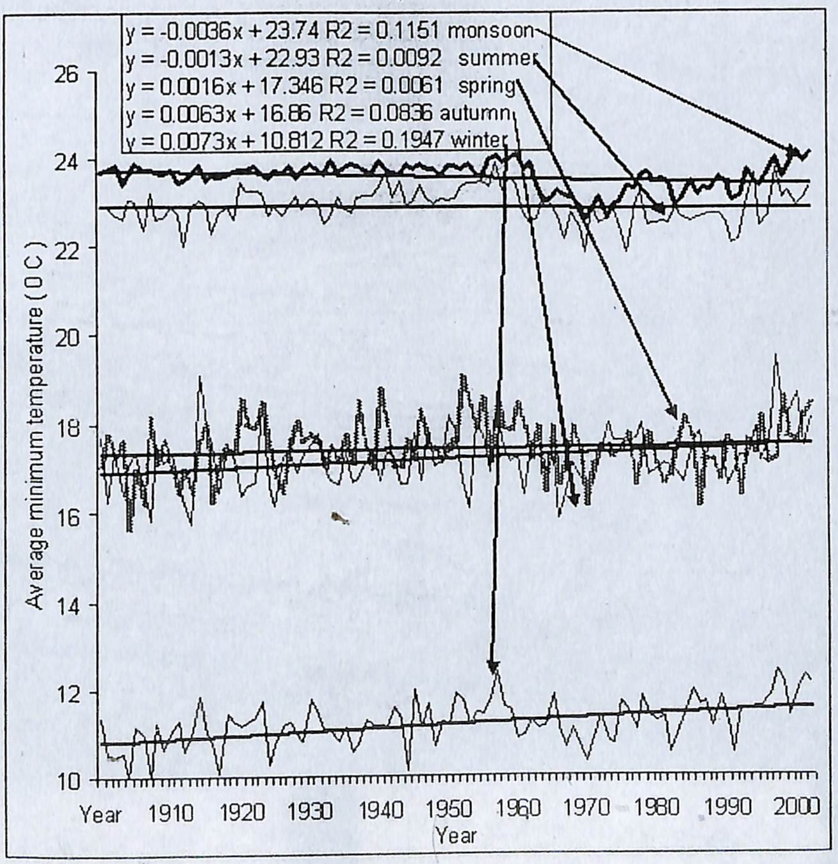

Figure 6. Trends of Average Minimum Temperatures (°C) in Various Seasons for the Period of 1901-2003

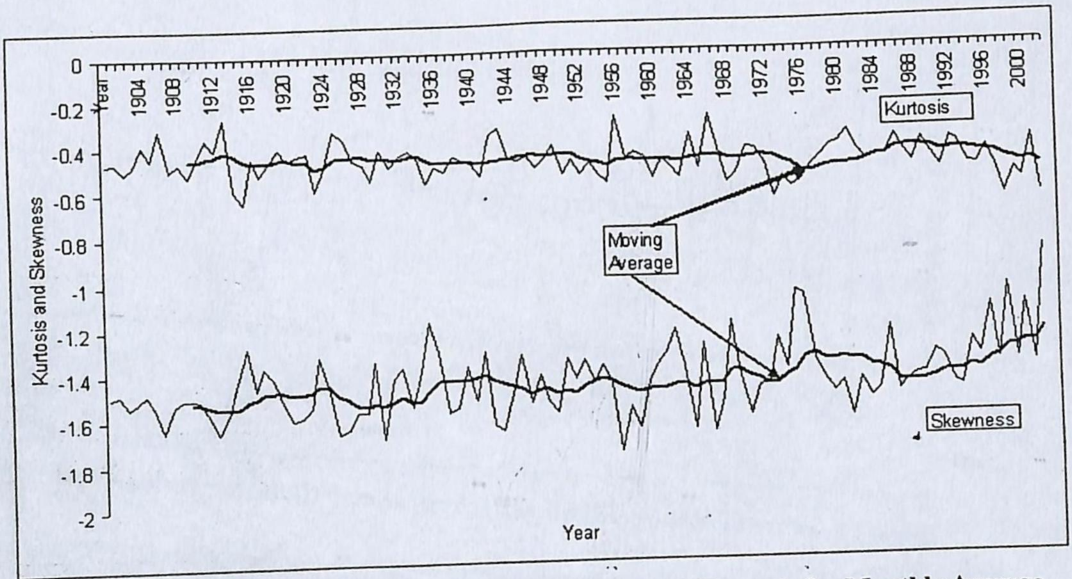

Figure 7. Trends of Skewness and Kurtosis Skewness and Kurtosis for Monthly Average Minimum Temperature (°C) for the Period of 1901-2003

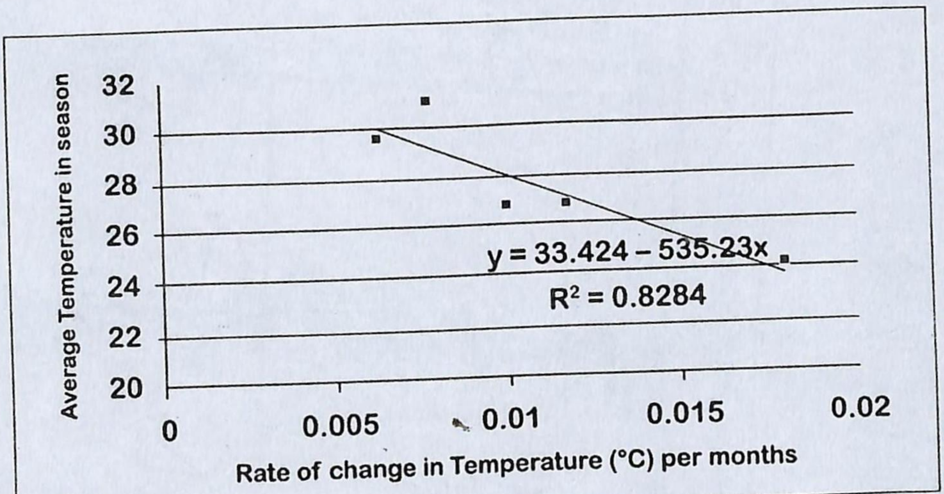

Figure 8a. Scatter Diagram between Average Maximum Seasonal Temperature and Rate of Change in Temperature (1901 -2003)

Regional Rainfall Trends in North-east India

The average monthly rainfall trend line indicates a decreasing trend with R^2 = 0.0003 and slope of -0.0054 mm per month for the period of 1871-2005 (Figure 11). The decrease in rainfall is probably related to the failure of the clouds to condense to form rains in this region due to the increase in the observed mean temperature as a result of the global warming phenomena that become intensified since three/four decades back.

The average total annual rainfall in the region is 1974.36 mm, and its shows decreasing trend since 1871 to 2005 at the rate of 0.9638 mm per year with R^2 of 0.024 (Figure 12). The continuous

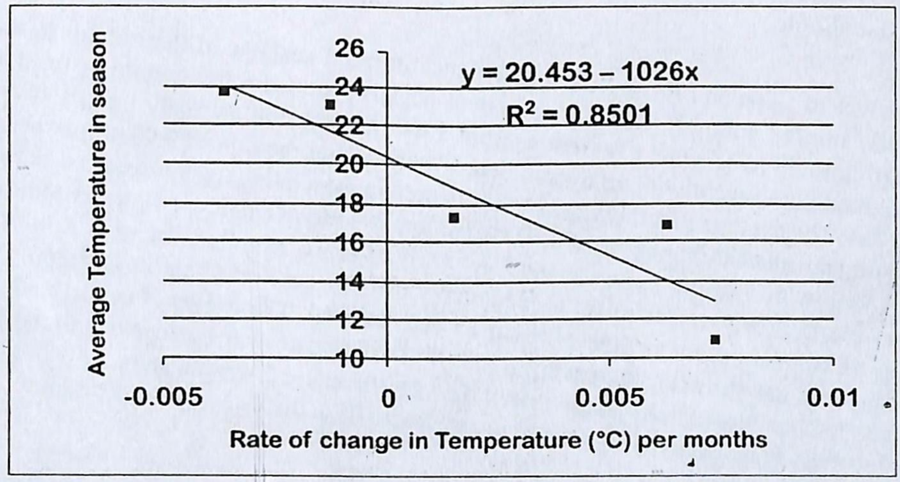

Figure 8b. Scatter Diagram between Average Minimum Seasonal Temperature and Rate of Change in Temperature (1901 -2003)

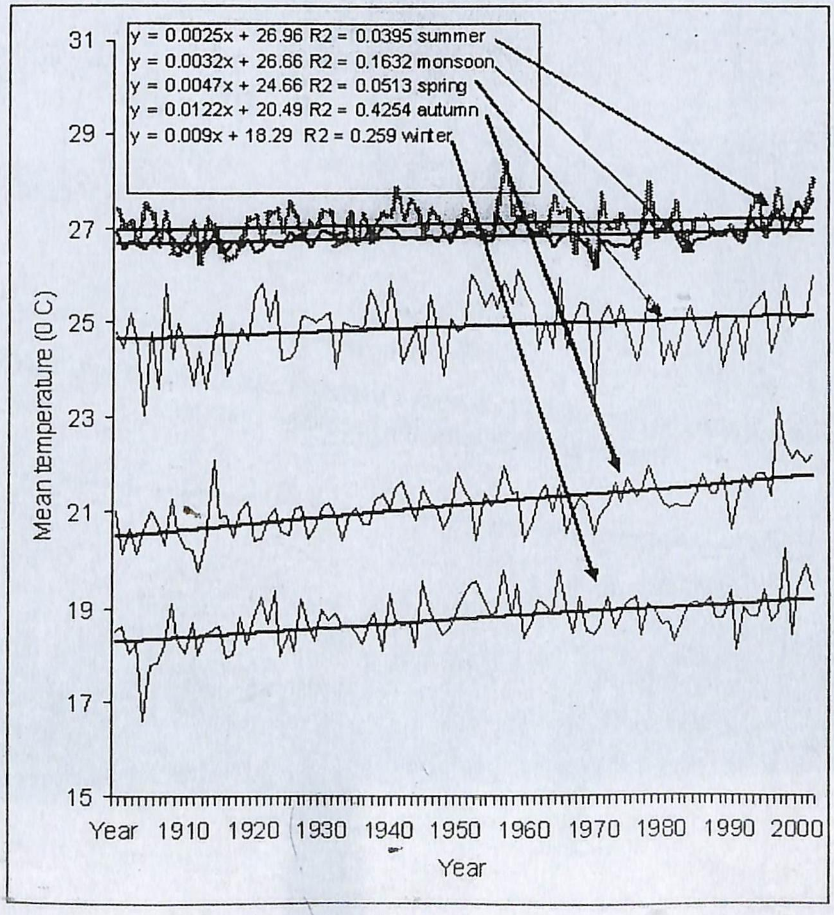

Figure 9. Trends of Calculated Mean Temperatures (°C) in Various Seasons for the Period of 1901-2003

improvement in slope and R^2 provide a confidence in trend analysis of the rainfall in the region. The yearly rainfall anomaly shows a consistent negative anomaly trend starting from 1970 and continued upto 1990 (Figure 13). While, from 1990 onwards the anomaly trend shows subdued positive trend upto recent with an overall decreasing trend at the rate of 0.9638 mm per year with R^2 of 0.024. The average monthly rainfall data is used in calculating the kurtosis and skewness. The results are presented in Figure 14. For kurtosis, the moving average for 10 years indicates cyclic observations which occur approximately at an interval of 25 years, In each kurtoses cycle, it reaches the higher value than its precedence value. In case of skew ness graph the moving average of 10 years show a cycle of about 25 year interval. The trends of cyclic peak of kurtosis and skewness are showing increasing trends which indicate that the heavier precipitations are concentrated in a few months and in rest of the year, there are fewer showers. This positive skewed rainfall pattern is responsible for intense droughts and flash floods cycles in the region.

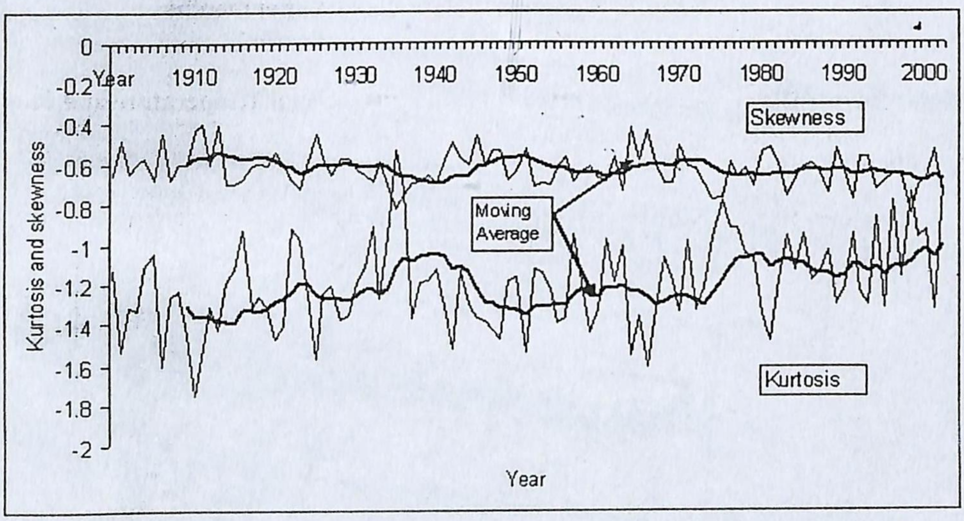

Figure 10. Trends of the Calculated Kurtosis and Skewness for Monthly Minimum Temperature (°C) for the Period of 1901-2003

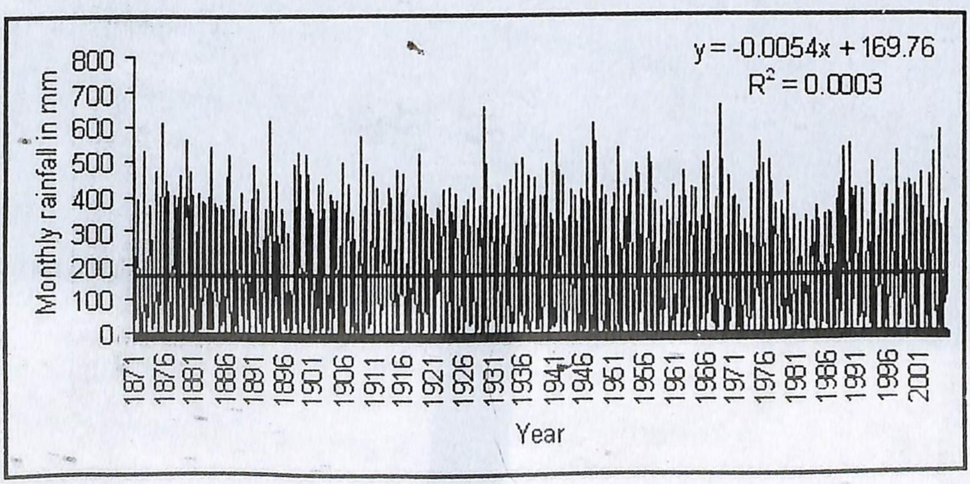

Figure 11. Trend of Monthly Rainfall (in mm) for the Period of 1871-2005

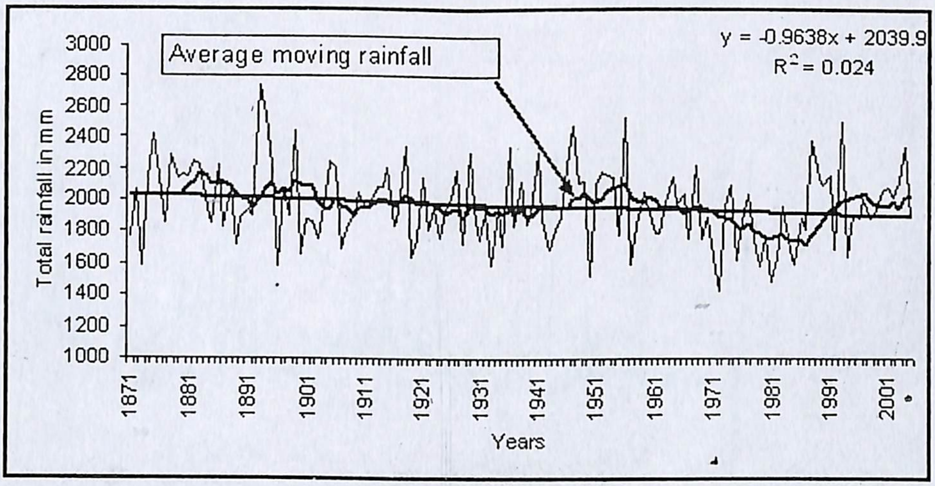

Figure 12. Trend of the Yearly Rainfall (in mm) for the Period of 1871-2005

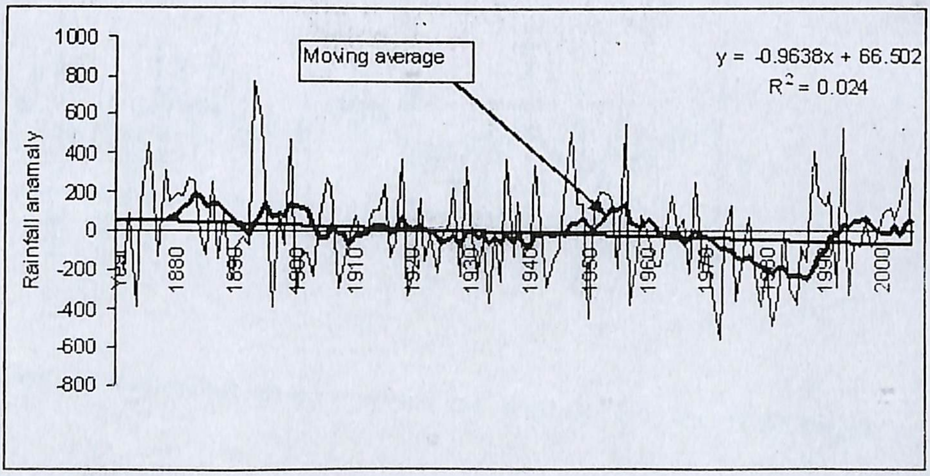

Figure 13. Trend of the Yearly Rainfall (in mm) Anomaly for the Period of 1871-2005

Conclusions

The climatic trends were studied on regional basis and on local level in North East Himalaya. The climatic trend analysis on regional basis show that monthly average maximum temperature is increasing at rate of 0.0108°C per year since 1901 and is more prominent in autumn and winter. However, minimum temperature trend shows an increase of 0.001°C per year with maximum rise of 0.0073°C per year during winter. A rapid change is observed for the kurtosis value of atmospheric temperature and approaching towards higher values. It indicates that the distribution of average monthly temperature is changing from smooth *i.e.* very platy kurtic to peak *i.e.* lepto kurtic.

The rainfall data for the period of 1871-2005 indicated a decreasing trend at the rate of 0.0054 mm per month. The decrease in rainfall is probably related to the failure of the clouds to condense to form rains in this region due to the increase in the observed mean temperature as a result of the global warmin g phenomena that become intensified since three/four decades back.

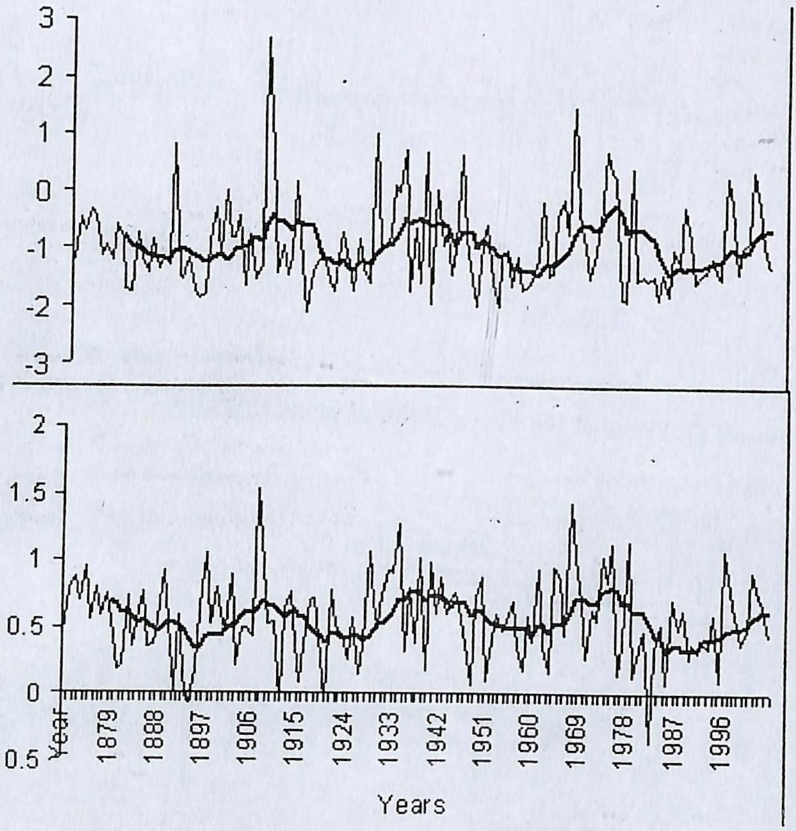

Figure 14. Trends of the Kurtosis and Skewness for the Rainfall for the Period, 1871-2005

The kurtosis and skewness of rainfall indicated cyclic observations which occur approximately at an interval of 25 years. The skewness of the data indicated that higher skewness values representing heavier precipitations are concentrated in a few months and in rest of the year, there are fewer showers.

Acknowledgments

The authors would like to express their thanks to Chairman, Department of Geology, Aligarh Muslim University for providing the laboratory and library facilities. They also appreciate the financial assistance provided by, Department of Science and Technology, New Delhi, Government

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