Temperature Trends at Four Stations of Assam during the period 1981-2010

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Abstract- One of the very important issues discussed in the recent two decades is climate change. Temperature is one of the indicative factors of climate change. The present research aimed at studying temporal variation in temperature over Guwahati, Tezpur, Dibrugarh (Mohanbari) and Silchar stations, Assam, India, during the period 1981–2010. Trends in annual and seasonal temperature series were analyzed using Mann-Kendall test. The analysis reveals that majority of the trends, both annual and seasonal, showed increasing tendency in temperature during the period 1981-2010.

Index Terms- Climate change, Temperature, Trend, Mann-Kendall test.

I. INTRODUCTION

Earth's linearly averaged surface temperature has increased by 0.74°C during the period 1901-2005 as reported by the latest estimates by IPCC (2007). The rates of climate change are significantly different among regions (IPCC 2007). According to Hingane, Rupa Kumar and Ramana Murty (1985) during the last century, surface temperature over India has shown significant increasing trend which is attributed to rise in maximum temperature. Rupa Kumar and Hingane (1988) investigated long-term variations of seasonal and annual surface air temperature at six Indian industrial and non-industrial cities each and have concluded that the non-industrial stations did not show significant trends and there was either a cooling tendency or cessation of warming after the late 1950s at most of the Industrial cities. Thapliyal and Kulshreshtha (1991) study on temperature trends over Indian cities indicates a slight warming trend between 1901 and 1990. Hingane (1996) study estimates rising trends of 0.84 and 1.39 1C per 100 years in the mean surface temperature calculated for Mumbai and Kolkata, respectively. Rupa Kumar et al. (2002) highlighted that the warming trends were visible during all the four seasons in all-India mean surface air temperatures during 1901-2000 from a network of 31 well-distributed representative stations over India. The results showed higher rate of temperature increase during winter (0.04°C/decade) and post-monsoon (0.05°C/decade) seasons compared to that of annual (0.03°C/decade). The variability of minimum and maximum temperature in Poland reveals that the strongest increase in minimum and maximum temperatures occurs in mid and late winter which has been studied by Wibig and Glowicki, (2002). Though beginning of winter and summer indicates decreasing tendencies. Rao, Murty & Joshi (2005) analysed the extreme weather events such as high and low temperatures, heavy rainfall in connection with the climate change over India and concluded that during summer 60-70% of the coastal stations are showing an increasing trend in critical extreme maximum day temperature and increase in night temperatures. Dhodre et al. (2009) research aimed at quantifying the change in surface air temperature at India's four most populated cities - Delhi, Kolkata, Mumbai and Chennai. While Mondal et al. study (2012) dealt mainly concerned with the changing trend of rainfall of a river basin of Orissa near the coastal region.

Therefore, this study is proposed to investigate the annual and seasonal temperature trends at four stations in Assam namely Guwahati, Tezpur, Dibrugarh (Mohanbari), and Silchar. Our interest also arises to find out whether the overall change in temperature is due to change in minimum or maximum temperature giving a clue to know changes in night and day temperatures as well.

The study area Assam is located south of the eastern Himalayas. The study area Assam comprises the Brahmaputra and the Barak river valleys along with the Karbi Anglong and the Dima Hasao district. Guwahati (26° 11'N, 91° 44'E) city is between the southern bank of the Brahmaputra River and the foothills of the Shillong plateau. Tezpur (26° 38'N, 92° 48'E) is a town in the state of Assam in northeastern India. Tezpur is on the banks of the river Brahmaputra. The town of Dibrugarh (Mohanbari) (27° 48'N, 95° 02'E) is situated in the eastern part of Assam. Silchar (Kumbhirgram) (24° 49'N, 92° 48'E) town is located in the southern part of Assam. It is situated on the banks of the Barak River.

II. MATERIALS AND METHODS

For this study, monthly mean series of maximum and minimum temperature were obtained from Regional Meteorological Centre, Guwahati, India. From the monthly mean maximum and mean minimum temperature we calculated the monthly mean temperature separately for each month. Accordingly the yearly totals were calculated for each year. From the monthly mean maximum, mean minimum and mean temperature mean, standard deviation and coefficient of variation have been computed for each month and each season namely winter, summer, monsoon and post monsoon. For the analysis of winter temperature December, January and February months are considered as these three months record lower temperatures. While computing the mean for winter season December of the previous year is included. March, April and May are months with highest mean maximum temperatures and, therefore, represent

the summer season. June to September months constitute monsoon season and October and November form the post monsoon season. Temporal changes in the annual and seasonal values were analysed by Mann–Kendall rank statistics to confirm the significance of the observed trend. Mann-Kendall test had been formulated by Mann (1945) as non-parametric test for trend detection and the test statistic distribution had been given by Kendall (1975) for testing non-linear trend and turning point.

According to Mavromatis and Stathis (2011) Mann Kendall test is a statistical test widely used for the analysis of trend in climatologic and in hydrologic time series (Yue et al., (2004)). The Mann-Kendall S Statistic is computed as follows

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} sign(T_j - T_i)$$

where T_j and T_i are the annual values in years j and i, j > i, respectively. (Motiee and McBean (2009)). If n < 10, the value of |S| is compared directly to the theoretical distribution of S derived by Mann and Kendall. For n ≥ 10, the statistic *S* is approximately normally distributed with the mean and variance as follows

$$E(S) = 0.$$

The variance (σ^2) for the S-statistic is defined by

$$\sigma^2 = \frac{n(n-1)(2n+5) - \sum t_i(i)(i-1)(2i+5)}{18}$$

in which t_i denotes the number of ties to extent i. The summation term in the numerator is used only if the data series contains tied values. The standard test statistic Z_s is calculated as follows

$$Z_S = \begin{cases} \frac{S-1}{\sigma}; S > 0 \\ 0; S = 0 \\ \frac{S+1}{\sigma}; S < 0 \end{cases}$$

The test statistic Z_S is used a measure of significance of trend. Another statistics obtained on running the Mann-Kendall test is Kendall's tau, which is a measure of correlation and therefore measures the strength of the relationship between the two variables (Kendall's Tau).

III. Results and Discussion

The maximum temperature, minimum temperature and mean temperature can be characterized by mean, standard deviation and coefficient of variation. The study reveals that Silchar received the highest mean of annual monthly mean maximum temperature amount during Indian summer. In addition, it can be concluded that Guwahati received the highest mean of annual monthly mean minimum temperature amount during Indian winter.

In Guwahati, the winter mean temperature shows an increasing trend, which is highly statistically significant at 0.01 level. The trend of minimum temperature is significant at 0.001 level. The maximum temperature during winter shows increase, statistically significant at 0.05 level. Significant increase in winter mean temperature can be endorsed to increase in minimum temperature. The summer mean temperature also shows increasing trend, significant at 0.001 level. This increase is caused by significant rise in maximum temperature unlike winter season. The Mann–Kendall test indicates that minimum temperature increase is significant at 0.001 level, while maximum temperature shows significant increase at 0.01 level. Therefore, it can be said that daytime temperatures in summer are significantly increasing. The monsoon season, depicts significant increase in the mean temperature. This is due to the increase in minimum temperature being significant at 0.001 level giving an indication that night temperatures during recent years have gone up during monsoon. The post monsoon mean temperature also shows increasing trend, significant at 0.001 level. Minimum temperature increase is significant at 0.001 level, while maximum temperature also shows significant trend at 0.01 level. Therefore, it can be inferred that daytime temperatures in post monsoon are significantly increasing. Mean minimum and mean maximum temperature has been studied for individual months by subjecting them to the Mann–Kendall test. It is interesting to note that the minimum temperature and maximum temperature value shows significant trend in majority of the months. The beginning of winter, shows increasing trend in minimum temperature, statistically significant at 0.001 level. The later part of winter (i.e. January and February) shows increasing trend significant at 0.01 level. The increasing trend of maximum temperature is seen during the monsoon months statistically significant.

The winter mean temperature, minimum temperature, maximum temperature in Tezpur shows an increasing trend, however not statistically significant. The summer mean, maximum, minimum temperature also shows an increasing trend. This increase is caused by significant rise in maximum temperature. The monsoon season, depicts a significant increase in the mean temperature. This is due to the increase in minimum temperature depicting the fact that the night temperatures during recent years have gone up during monsoon. In Tezpur, the post monsoon mean temperature also shows increasing trend, however not statistically significant. Behaviour of minimum and maximum temperature has been studied for individual months. The beginning of winter shows increasing trend in minimum temperature. The later part of winter shows increasing trend. The increasing trend of maximum temperature is seen during the monsoon months statistically significant in Guwahati and Tezpur.

The winter mean temperature in Mohanbari shows an increasing trend, which is highly statistically significant at 0.001 level. The summer mean temperature also shows an increasing trend, significant at 0.001 level. We can therefore conclude that daytime temperatures in summer are significantly increasing in Mohanbari. The monsoon season, depicts a significant increase in the mean temperature. This is due to the increase in minimum temperature being significant at 0.001 level. The post Monsoon mean temperature also shows an increasing trend, significant at 0.001 level. Therefore, it can be inferred that daytime temperatures in post monsoon season are significantly increasing.

In Silchar, the winter mean temperature shows an increasing trend, however not statistically significant. However, the trend of

minimum temperature is significant at 0.05 level. The summer mean temperature and minimum temperature also shows an increasing trend, significant at 0.001 level. The monsoon season, depicts a significant increase in the mean temperature. This is due to the increase in minimum temperature being significant at 0.001 level. This indicates that the night temperatures during recent years have gone up during monsoon season in Silchar. The post monsoon mean temperature also shows an increasing trend. The Mann–Kendall test indicates that minimum temperature increase is significant at 0.01 level, while maximum temperature shows a decreasing trend, not statistically significant. Therefore, it can be inferred that in Silchar, daytime temperature in post monsoon season are significantly increasing. In majority of the months the minimum and maximum temperature show significant trend. The beginning of winter shows increasing trend in minimum temperature, statistically significant at 0.05 level. The later part of winter though shows increasing trend, not statistically significant. The increasing trend of maximum temperature is seen during the monsoon months statistically significant. However, the month of June show decreasing trend.

IV. Conclusion

The present study analyzed the temperature data for 30 years from 1981 to 2010 at four stations in Assam for the determination of the trend of temperature. From the above results it is clear that majority of the trends, both annual and seasonal, showed increasing tendency in temperature during the period 1981-2010. The winter mean temperature shows significant increase in all the four stations in Assam. The day time temperature is significantly increasing. The night temperature also increased during recent years. However the limitations of this works are that the period of 30 years may be regarded as short duration for the determination of trend.

ACKNOWLEDGMENT

The authors wish to thank, Department of Science and Technology (DST), New Delhi for providing financial support through Women Scientists Scheme (WOS-A) in the Department of Statistics, Gauhati University, Guwahati.

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