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Analysis of temperature variability and trends over Tripura

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सार – 1969 से 2014 की अवधि में त्रिपुरा अगरतला और कैलाशहर- दो केंद्रों में कालिक परिवर्तिताओं और मासिक, मौसमी और वार्षिक तापमान की प्रवृत्तियों का अध्ययन करने का प्रयास किया गया है। चार तापमान सूचकों, नामत:- न्यूनतम तापमान (T_{min}), अधिकतम तापमान (T_{max}), माध्य तापमान (T_{mean}) और दैनिक तापमान अवधि (DTR) का विश्लेषण इस शोध-पत्र में किया गया है। प्रवृत्तियों का पता लगाने के लिए गैर-प्राचलिक मान-कैंडल (MK) परीक्षणों का तथा प्रवृत्तियों के परिमाण का निर्धारण करने के लिए सेन्स एस्टीमेटर ऑफ स्लोप का उपयोग किया गया। तापमान में आँकड़ों के विश्लेषण से T_{min}, T_{max}, और T_{mean} परिवर्तिताओं में वार्षिक पैमाने पर दोनों केंद्रो में महत्वपूर्ण वृद्धि की प्रवृत्तियों का पता चला, जबकि केवल अगरतला में DTR में कमी की प्रवृत्ति का पता चला। मौसमी पैमाने पर, अगरतला में शीत ऋतु में T_{max} में कमी की प्रवृत्ति को छोड़कर T_{min}, T_{max} और T_{mean} (DTR) तापमान सूचकों में सभी चार ऋतुओं-शीत, मॉनसून पूर्व, मॉनसून और मॉनसूनोत्तर में वृद्धि (कमी) की प्रवृत्ति देखी गई है। मासिक पैमाने पर, T_{min}, T_{max} और T_{mean} में अधिकांश महीनों में वृद्धि की प्रवृत्ति देखी गई तथा DTR में केवल जनवरी और दिसम्बर के महीने में महत्वपूर्ण कमी की प्रवृत्ति देखी गई।

ABSTRACT. Attempts have been made to study the temporal variations and trends in monthly, seasonal and annual temperature over two stations - Agartala and Kailashahar in Tripura, India for the period 1969 to 2014. Analysis has been carried for four temperature indices, namely - minimum temperature (T_{min}), maximum temperature (T_{max}), mean temperature (T_{mean}) and diurnal temperature range (DTR). Non-parametric Mann-Kendall (MK) test was used to detect the trends and the magnitude of the trends were determined with Sen's estimator of slope. The analysis of the temperature data revealed significant increasing trends in T_{min}, T_{max} and T_{mean} variables at both the stations on annual scale, while decreasing trend in DTR was significant over Agartala only. On the seasonal scale, the increasing (decreasing) trends were observed in T_{min}, T_{max} and T_{mean} (DTR) temperature indices in all the four seasons - winter, pre-monsoon, monsoon and post-monsoon except non-significant decreasing trend in T_{max} in winter season over Agatala. On the monthly scale, significant rising trends in T_{min}, T_{max} and T_{mean} were observed in the most of the months and significant decreasing trend in DTR was found only in the months of January and December.

Key words – Temperature, Diurnal temperature range, Trend, Mann-Kendall test, Sen's slope.

1. Introduction

Climate change is the single biggest environmental and humanitarian crisis being faced by the world in the present times. The Intergovernmental Panel on Climate Change (IPCC) has reported an increase of 0.74 °C ± 0.18 °C in global surface temperatures averaged over the land and sea during 1906-2005 (IPCC, AR4, 2007). IPCC report (2007) also states that the most of the observed increase in global average temperature during last 50 year period is likely due to observed increase in anthropogenic greenhouse gas concentration. This increase in temperature is larger than the trend observed during 1901 - 2000 (0.6 °C ± 0.2 °C) due to additional warm years in the second half of the century. The emission of anthropogenic green house gases are most influencing factor for increase in temperature on global scale but on regional scale, urbanization and changes in

land use patterns are also important (Karl and Trenberth, 2003). Among all the climatic elements, temperature plays a vital role in detecting the climate change brought about by the urbanization, industrialization and the changing land use pattern. Temperature is a good indicator of the state of the climate because of its ability to represent the energy exchange process over the earth's surface with reasonable accuracy (Vinnikov *et al*., 1990; Thapliyal and Kulshreshtha, 1991). Warming of atmosphere affects the temperature of air, land, ocean and other water bodies which in turn affects the patterns of precipitation, evaporation and wind as well as ocean current.

Many researchers across the world have studied the affect of rising temperatures on the environment on global scale. Karl *et al*. (1993) have used monthly T_{max} and T_{min} data over the global landmass and found that the rise in T_{min} is three times faster than the T_{max} during the period 1951-1990 (0.84 °C verses 0.28 °C). Analysis of the global surface temperature data for the past five centuries by Mann *et al*. (1995) clearly indicates that the 20th century temperatures are warmer than any other century. Jones *et al*. (1999) observed a decrease of 0.8 °C per decade in DTR due to much greater increase in T_{min} than T_{max} for the period 1950-1993.

Similar to Karl and Trenberth (2003), study by Wang *et al*. (2012) also found that urbanization is one of the most influencing factors for the warming of temperature on regional scale. Manton *et al*. (2001) reported significant increases (decreases) in the annual number of hot (cool) days and warm (cold) nights in Southeast Asia and South pacific region.

However, temperature fluctuations are not uniform over the globe and varies from one region to another region. In the pasts, several researchers have studied the temperature variability and trends over India and most of them agreed that temperature trends are similar to global trends (Kothawale and Rupa Kumar, 2005; Roy and Balling, 2005; Dash *et al*., 2007; Jain and Vijay Kumar, 2012). Kothawale and Rupa Kumar (2005) has shown significant warming trend of 0.05 °C/10year and 0.22 °C/10year during the period 1901-2003 and period 1971-2003 respectively. They have found that relatively rapid warming seen in second time-series is largely due to unprecedented warming during the last decade. Dash *et al*. (2007) reported that the temperatures over the country are increasing and consistent with the trends and magnitude found over the globe. Jain and Vijay Kumar (2012) reported rising as well as decreasing trends in T_{max} and T_{min} data over India. However, some scientists (Srivastava *et al*., 1992; Rupa Kumar *et al*., 1994) have found that the decadal trends in temperature data over India are quite different from those observed over other parts of the globe. Srivastava *et al*. (1992) reported that increase in T_{max} is comparatively larger than T_{min} over a major part of India. Rupa Kumar *et al*. (1994) observed that the increase in the T_{mean} over India is almost solely contributed by the T_{max}, with the T_{min} remaining practically trendless, leading to an increase in the DTR.

Several researchers have also investigated the spatial and temporal variability in surface temperature over Northeast India (Jain and Vijay Kumar, 2012; Jain *et al*., 2012; Jhajharia and Singh, 2011; Laskar *et al*., 2014). Jain and Vijay Kumar (2012) has observed that some stations in North and Northeast India showed falling trends in annual T_{mean} data. Jain *et al*. (2012) analyzed the temperature trends in Northeast India and found that all the four temperature variables (T_{max}, T_{min}, T_{mean} and DTR) showed rising trend. Jhajharia and Singh (2011) noticed decreasing as well as increasing trends in DTR over Northeast India. They have observed decreasing trends at four stations on yearly, seasonal (pre-monsoon and monsoon) and monthly (September) scale and increasing trends at other three stations on seasonal (monsoon and post-monsoon season) and monthly (June, October and December) scale.

Tripura is one of the states in northeast India covering an area of about 10,491 square kilometers. About 60% area of the state is covered by the forest with undulating topography and it is one of the important local factor influencing the weather and climate of the state. Climate of state is mainly subtropical and the monsoon season (June to September) is the rainiest season followed by the pre-monsoon season (March-May) and the post-monsoon seasons (October - December). The winter season (January - February) is mild and mainly dry. The temperature may fall to 3-4 °C for a few days in January when the cold winds from the Himalayan region blow over the State and make winter very cold. The State experiences moderately hot and humid summer season mainly in the months of April-May with daily average temperature around 32-34 °C. On-occasions, the summer temperature may rise upto about 38-40 °C.

In this part of India, the investigations of long-term variations and trends in temperature data are not getting enough attention even though this area is suffering from serious environmental, agricultural and water resources problems. In this study an attempt has been made to analyze the variability and trends of temperatures over Tripura. The daily surface temperature data from two stations, *viz*., Agartala and Kailashahar has been utilized for the analysis. The work is focused to investigate the trends in T_{max}, T_{min}, T_{mean} and DTR at annual, seasonal and monthly timescale.

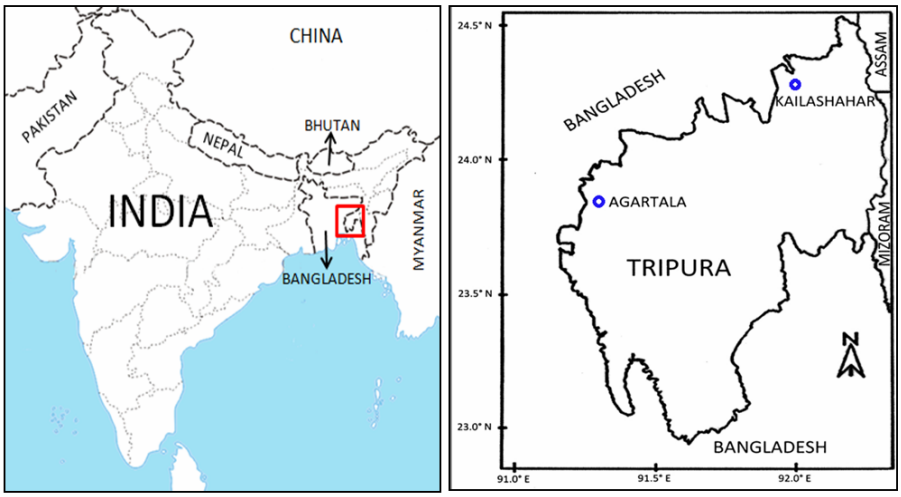

Fig. 1. Map showing study area and location of the two stations

TABLE 1

Monthly, seasonal and annual means of Temperature (°C) for Agartala and Kailashahar

Month/season	Agartala				Kailashahar			
	T_{min}	T_{max}	T_{mean}	DTR	T_{min}	T_{max}	T_{mean}	DTR
January	10.3	25.4	17.8	15.1	10.4	25.6	18.0	15.2
February	13.5	28.4	20.9	14.9	12.8	28.2	20.5	15.4
March	19.0	32.1	25.6	13.2	17.5	31.9	24.7	14.4
April	22.5	33.3	27.9	10.9	21.2	32.7	26.9	11.1
May	23.6	32.8	28.2	9.2	23.0	32.1	27.6	9.1
June	24.9	32.1	28.5	7.1	24.7	32.1	28.4	7.5
July	25.0	31.7	28.3	6.6	24.9	32.1	28.5	7.2
August	24.9	32.0	28.5	7.1	24.9	32.5	28.7	7.3
September	24.6	32.0	28.3	7.4	24.5	32.1	28.3	7.7
October	22.4	31.4	26.9	9.0	22.4	31.5	27.0	9.1
November	17.2	29.6	23.4	12.3	17.4	29.6	23.5	12.1
December	11.9	26.4	19.1	14.4	12.2	26.6	19.4	14.4
Winter	11.9	26.9	19.4	15.0	11.6	26.9	19.2	15.3
Pre-monsoon	21.7	32.7	27.2	11.0	20.6	32.2	26.2	11.5
Monsoon	24.9	31.9	28.4	7.1	24.8	32.2	28.4	7.4
Post-monsoon	17.2	29.1	23.1	11.9	17.4	29.2	23.5	11.9
Annual	20.0	30.6	25.3	10.6	19.7	30.6	25.1	10.9

2. Data and methodology

The present study area is confined to Tripura state using air temperature data of two stations, *viz*., Agartala and Kailashahar (Fig. 1) as there is no other station in the state with long period temperature data series. Agartala is the capital city of Tripura. Agartala observatory is a class-I meteorological observatory located at 23°53′ N and 91°15′ E with an elevation of 16 meter from the mean sea level. Kailashahar is a class-IIb meteorological

observatory and located towards northeast of Agartala at 24°19′ N and 92°00′ E with an elevation of 29 meter from the mean sea level.

Daily T_{max} and T_{min} data for two stations, *viz*., Agartala and Kailashahar, have been taken from National Data Centre, IMD, Pune and Meteorological Centre, IMD, Agartala for the period 1969-2014. Daily T_{mean} are obtained by averaging daily T_{max} and daily T_{min} data and daily DTR data are calculated by subtracting the daily T_{min} from daily T_{max}. The Monthly, seasonal and annual temperature data are calculated by averaging the daily temperature data for the month, season and annual respectively.

Mann Kandall (MK) statistic (Mann, 1945; Kendall, 1975; WMO, 1966) and Sen's estimator slop (Sen, 1968) were used to detect the trends and magnitude of the trends in the time-series of all temperature indices. In the present study the null hypothesis was tested at 95% significance level.

3. Result and discussion

3.1. *Temperature characteristics*

Based on the climatology of the region, the four seasons in India as defined by IMD are: winter season (January - February), pre-monsoon season (March to May), monsoon season (June to September) and post-monsoon season (October to December). The characteristics of monthly, seasonal and annual average temperatures are reported in Table 1. The coldest and hottest temperatures recorded at Agartala are 2.0 °C (30th December, 1972) and 40.2 °C (31st May, 1979) and at Kailashahar are 2.4 °C (15th January, 1976) and 38.9 °C (25th April, 2014) respectively.

The annual temperatures at the two stations are quite similar for the four temperature variables (T_{min}, $T_{max,}$ T_{mean} and DTR). The annual average T_{max} is around 30.6 °C for both the stations. The annual T_{min} are 20.0 °C & 19.7 °C, T_{mean} are 25.3 °C & 25.1 °C and DTR are 10.6 °C & 10.9 °C for Agartala and Kailashahar respectively.

The seasonal T_{max} is highest (32.7 °C) during the pre-monsoon season and lowest (26.9 °C) during the winter season. The seasonal T_{min} is lowest (11.6 °C) during the winter season and highest (24.9 °C) during the monsoon season at two stations. The seasonal average T_{mean} temperature varies from 19.2 °C to 28.5 °C and the highest (28.5 °C) is experienced during the monsoon season over both the stations. The seasonal mean DTR are also found highest (around 15 °C) during the winter season and lowest (around 7 ºC) during the monsoon season.

At both station, the highest values (28-29 ºC) of monthly T_{mean} are observed during pre-monsoon season and monsoon season. At Agartala and Kailashahar, the monthly T_{mean} is maximum during May-September period and June-September period respectively.

The monthly T_{max} is highest in April and lowest in January. The highest monthly T_{max} observed in April are 33.3 ºC and 32.7 ºC at Agartala and Kailashahar respectively. During pre-monsoon season and monsoon season, *i.e*., from March to September months the maximum temperature varies from 31.7 ºC to 33.3 ºC over two stations. January is the coldest month for both the stations with monthly minimum temperature at around 10 ºC. The monthly T_{min} are highest (24.5 ºC to 25.0 ºC) during June-to-September months (monsoon season) over both the stations.

The DTR values are highest during January-February months (winter season) and lowest during June-September months (monsoon season). At Agartala, DTR is highest in January (15.1 ºC) followed by February (14.9 ºC) and at Kailashahar, it is highest in February (15.4 ºC) followed by January (15.2 ºC). During June-September months (monsoon season) DTR varies from 7.1 ºC to 7.7 ºC at two stations.

3.2. *Trend analysis of annual temperature*

The yearly T_{min}, T_{max}, T_{mean} and DTR time-series are presented in Fig. 2 and 3 for Agartala and Kailashahar respectively. The linear trend lines, linear regression equations and value of R^2 are also depicted in these figures to indicate the linear tends in annual temperature indices. MK test statistics and Sen's slop for the annual temperatures indices namely; T_{min}, T_{max}, T_{mean} and DTR are provided in Table 2.

At both the stations, the three indices, *viz*., annual T_{min}, T_{max}, and T_{mean} show an increasing trend but DTR shows decreasing trends. The increasing trends in T_{min}, T_{max} and T_{mean} indices are statistically significant at both the stations whereas the decreasing trend in DTR is significant for Agratala only. Among the four temperature variables, the T_{min} observed the highest rate of change at both the stations. Sen's estimator of slop indicate increase of 1.3 ºC and 1.2 ºC during the period of study over Kailashahar (0.02774 ºC/year) and Agartala (0.02547 ºC/year) respectively (Table 2). The annual increase in T_{max} indices is slowest at the rate of 0.01593 ºC/year and 0.01146 ºC/year for Kailashahar and Agartala respectively. The magnitude of increase in annual T_{mean} is 0.02085 ºC/year and 0.01735 ºC/year over

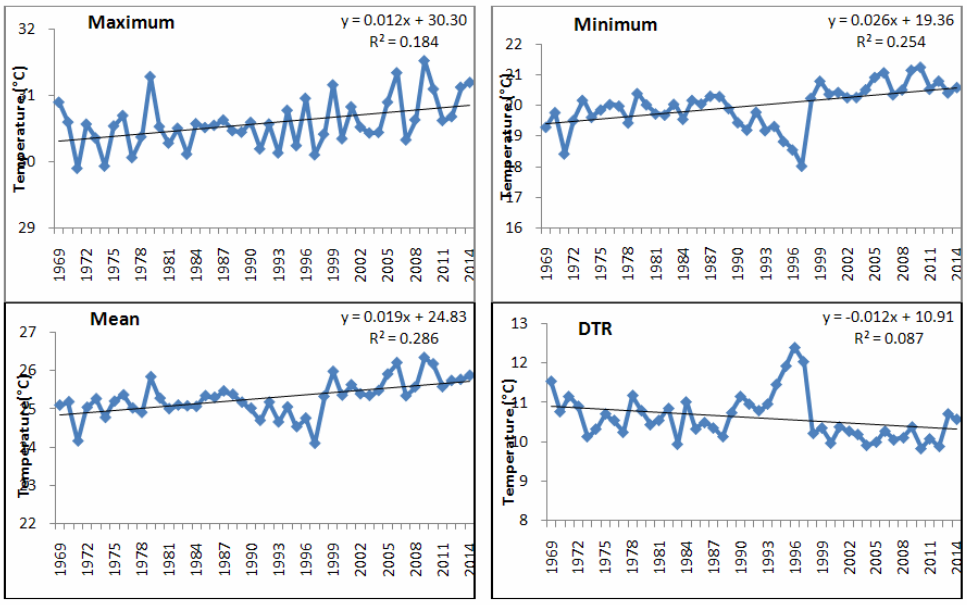

Fig. 2. Annual maximum, minimum, mean temperature and DTR plots for Agartala

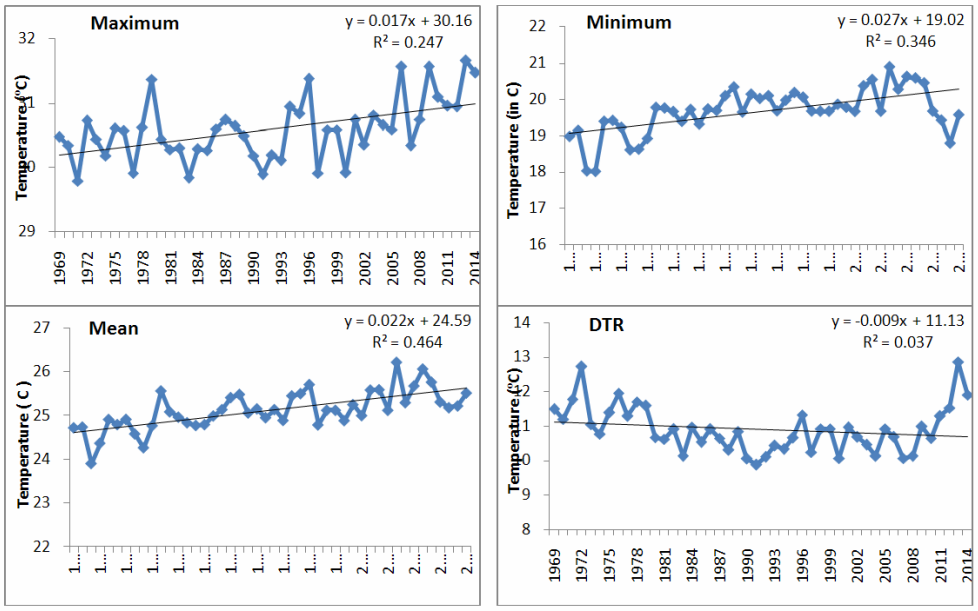

Fig. 3. Annual maximum, minimum, mean temperature and DTR plots for Kailashahar

Kailashahar and Agartala respectively. The comparatively higher increase in T_{min} as compared to T_{max} leads to significant fall of 0.01594 ºC/year (0.7 ºC during 1969-2014) in annual DTR over Agartala. At Kailashahar, the fall in annual DTR is similar (0.7 ºC during 1969-2014) to that observed over Agartala but the trends are found non-significant as per MK test.

The above results are in contrast to the finding of Srivastava *et al.* (1992), Rupa Kumar *et al.* (1994) and Jain *et al.* (2012) but are consistent with the trends observed by other scientists over India (Kothawale and Rupa Kumar, 2005; Dash *et al.*, 2007; Jhajharia and Singh, 2011) and over the globe (Karl *et al.*, 1993; Jones *et al.*, 1999) too.

TABLE 2

Sen's slop (°C/year) for monthly, seasonal and annual temperature at Agartala and Kailashahar

Month/season	Agartala				Kailashahar			
	T_{min}	T_{max}	T_{mean}	DTR	T_{min}	T_{max}	T_{mean}	DTR
January	**0.03297**	**-0.02199**	-0.00076	**-0.05415**	**0.04032**	0.00272	**0.01996**	**-0.03763**
February	0.02653	0.01000	0.02098	-0.02351	**0.03343**	**0.03262**	**0.03066**	-0.01353
March	0.02129	-0.01087	0.00659	-0.02525	**0.03032**	0.01802	**0.02581**	-0.00753
April	0.01542	0.01500	0.01642	0.00182	0.01595	0.01971	0.01659	-0.00467
May	0.02304	0.02722	**0.02665**	0.00511	**0.02553**	0.00949	0.01895	-0.00863
June	**0.02362**	**0.02596**	**0.02333**	0.00294	**0.01143**	0.01030	0.01133	-0.00594
July	**0.02241**	**0.03311**	**0.02568**	0.01060	**0.01801**	**0.02270**	**0.01978**	0.00494
August	**0.02324**	**0.02564**	**0.02354**	0.00072	**0.01976**	**0.01336**	**0.01469**	-0.00285
September	**0.02778**	**0.02549**	**0.02597**	0.00308	**0.01833**	**0.01723**	**0.01706**	-0.00172
October	**0.03243**	**0.01861**	**0.02742**	-0.01333	**0.02031**	**0.01822**	**0.02238**	-0.00119
November	0.02250	0.01452	**0.01690**	0.00424	0.02929	**0.02899**	**0.02093**	-0.00067
December	**0.06359**	0.00124	**0.03130**	**-0.05766**	**0.05149**	0.01183	**0.03466**	**-0.03561**
Winter	**0.02591**	-0.00954	0.00823	**-0.03796**	**0.03678**	0.01759	**0.02454**	-0.02496
Pre-monsoon	0.01512	0.00910	0.01355	-0.01280	**0.02236**	0.01759	**0.02039**	-0.01000
Monsoon	**0.02465**	**0.02591**	**0.02373**	0.00098	**0.01527**	**0.01545**	**0.01614**	-0.00243
Post-monsoon	**0.03720**	0.00972	**0.02404**	**-0.02954**	**0.04123**	**0.02082**	**0.03159**	-0.01503
Annual	**0.02547**	**0.01146**	**0.01735**	**-0.01594**	**0.02774**	**0.01593**	**0.02085**	-0.01550

Positive and negative values show increasing and decreasing trends respectively. Bold values indicate statistical significance at 95% confidence level as per the MK test

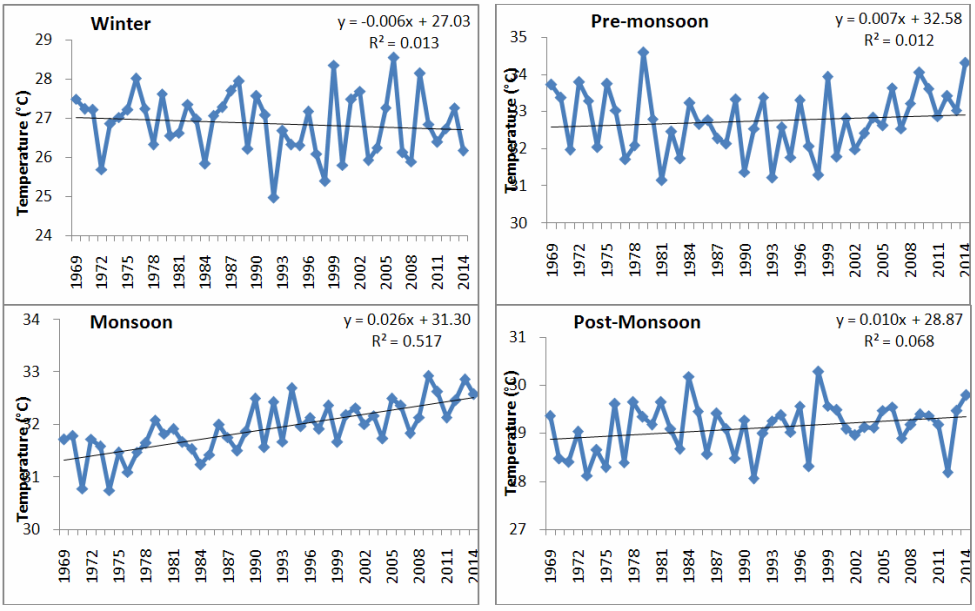

Fig. 4(a). Linear trends and times-series of maximum temperature (T_{max}) for four seasons over Agartala

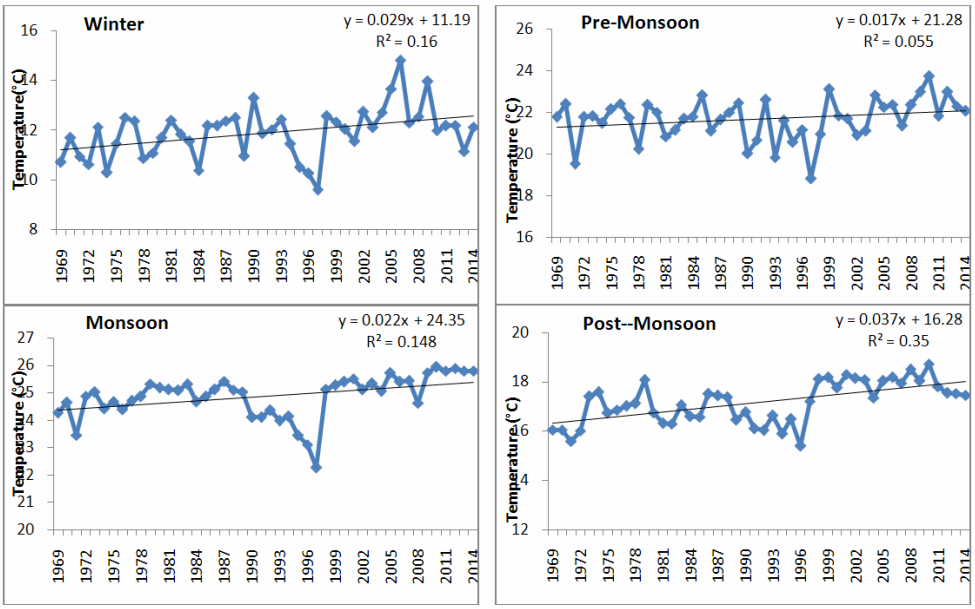

Fig. 4(b). Linear trends and times-series of minimum temperature (T_{min}) for four seasons over Agartala

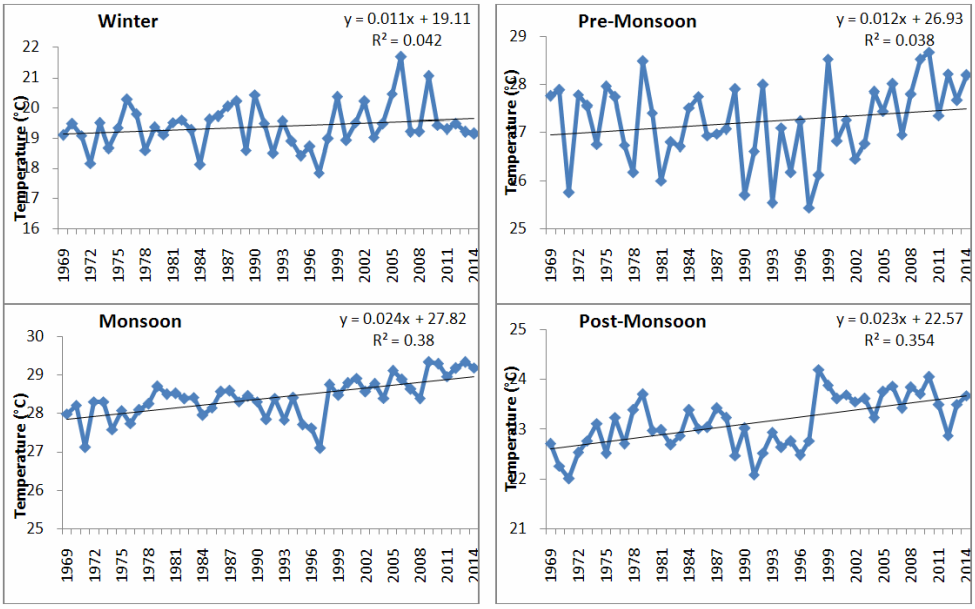

Fig. 4(c). Linear trends and times-series of mean temperature (T_{mean}) for four seasons over Agartala

3.3. *Trend analysis of seasonal temperature*

Figs. 4(a-d) & 5(a-d) show the time series and linear trend in T_{min}, T_{max}, T_{mean} and DTR variables for the four seasons- winter, pre-monsoon, monsoon and post-monsoon season over Agartala and Kailashahar respectively. During four seasons, the trends in T_{min}, T_{max} and T_{mean} are increasing over these two stations except decreasing trend observed in T_{max} over Agartala during the winter season (Table 2). The analysis indicates that the increasing trends in three temperature variable namely- T_{min}, T_{max} and T_{mean} are significant during the monsoon season over both the stations. The increasing trends in T_{min} and T_{mean} indices over Kailshahar are statistically

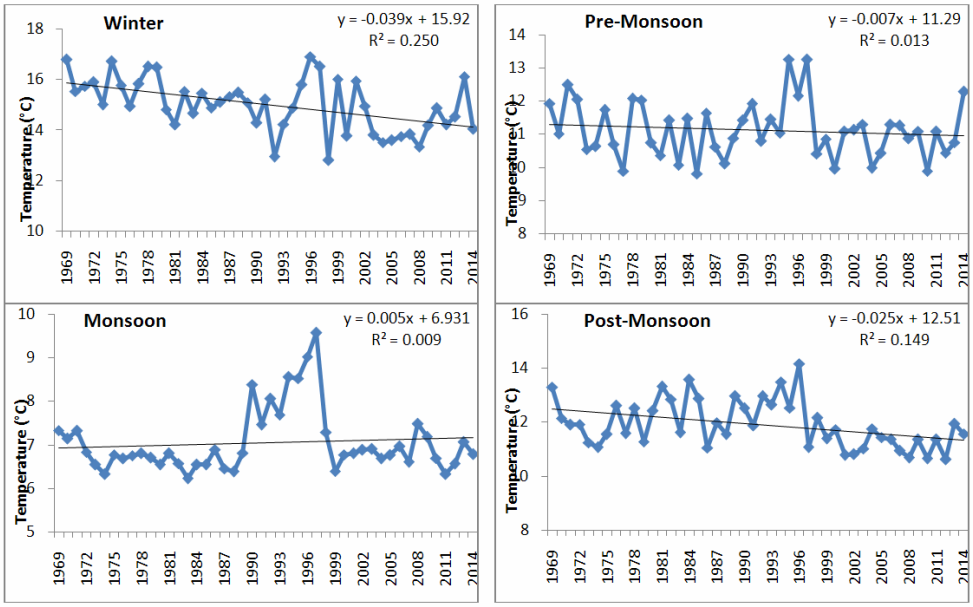

Fig. 4(d). Linear trends and times-series of DTR for four seasons over Agartala

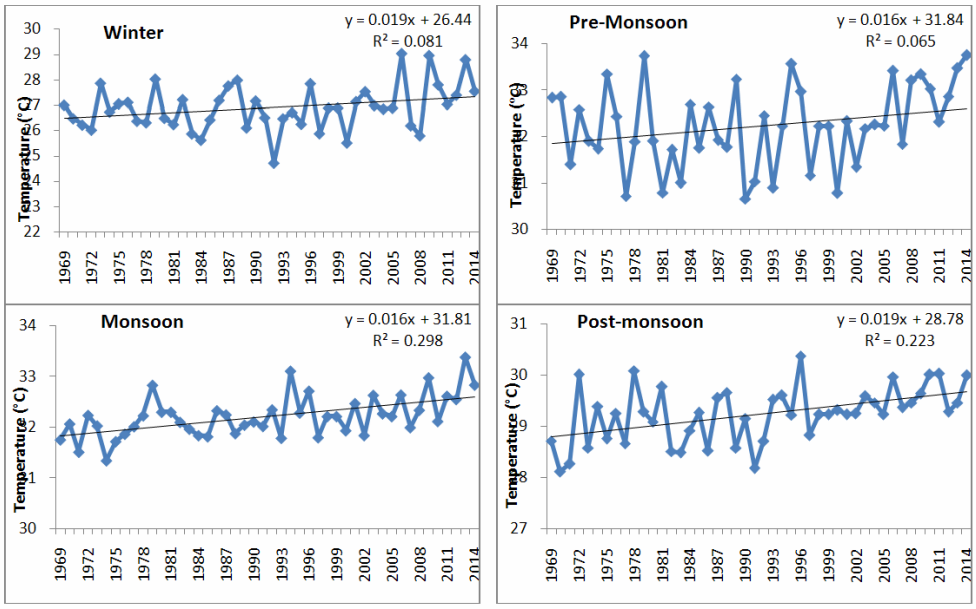

Fig. 5(a). Linear trends and times-series of maximum temperature (T_{max}) for four seasons over Kailashahar

significant for all four seasons. The highest rate of increase in T_{min}, T_{max} and T_{mean} indices are observed over Kailashahar in post-monsoon season. For post-monsoon season at Kailashahar, an increase of 1.9 ºC, 1.0 ºC and 1.5 ºC was found in T_{min}, T_{max} and T_{mean} respectively. At Agartala, the largest increase in T_{min} (1.7 ºC) and T_{mean} (1.1 ºC) are seen in post-monsoon season whereas the largest increase in T_{max} (1.2 ºC) are observed during the monsoon season. So, analysis clearly indicates higher rate of change in T_{min} than T_{max} on seasonal scale over both the sites. The highest significant increase of 1.9 ºC and 1.7 ºC during the period 1969-2014 in T_{min} are observed in the post monsoon season at Kailashahar and Agartala respectively.

The comparatively higher rate of increase in T_{min} leads to fall in DTR values at two sites for all four seasons except during the monsoon season over Agartala, where,

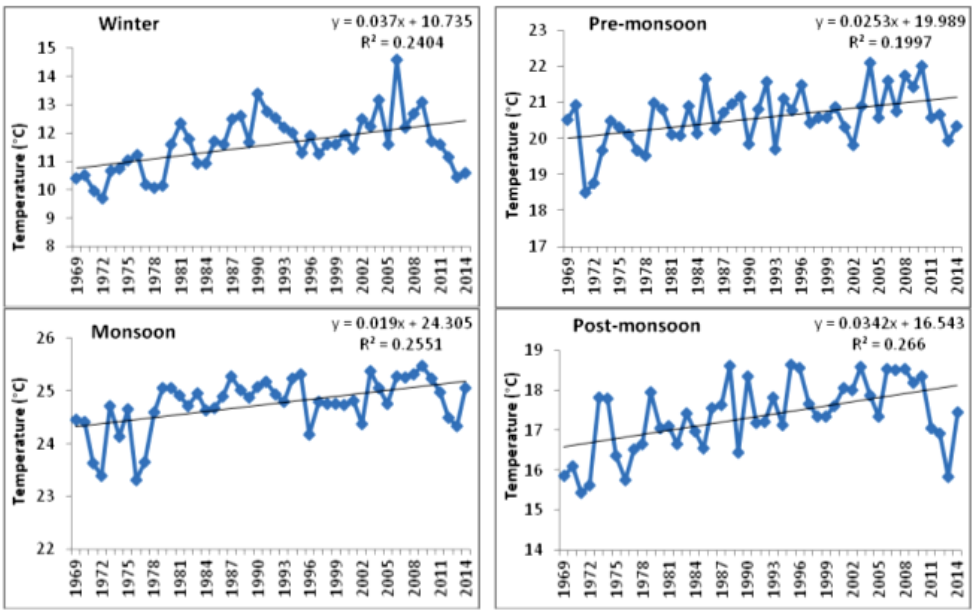

Fig. 5(b). Linear trends and times-series of minimum temperature (T_{min}) for four seasons over Kailashahar

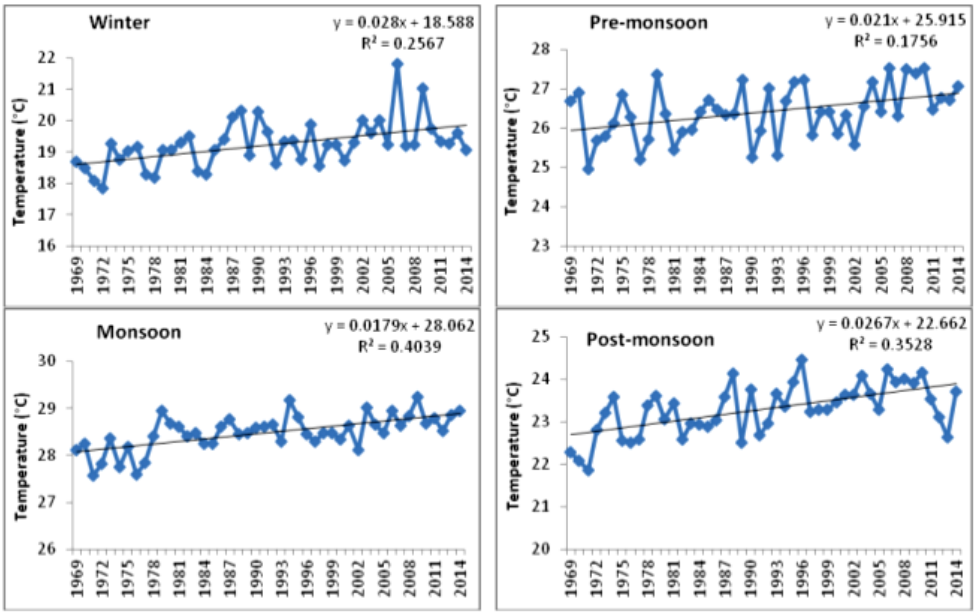

Fig. 5(c). Linear trends and times-series of mean temperature (T_{mean}) for four seasons over Kailashahar

rising trend in T_{max} is slightly higher than T_{min} (Table 2). The significant decreasing trends in DTR values are seen only over Agartala during the winter and post-monsoon season. During the period of study the DTR trends at Agartala in winter season and post-monsoon season indicates decrease of -1.7 ºC and -1.4 ºC respectively.

3.4. *Trend analysis of monthly temperature*

On monthly scale, the trend in T_{min} data indicates increase in temperature for all the months over both the stations. Quantitatively, the highest magnitudes in trend values are also observed in T_{min} as compared to magnitude

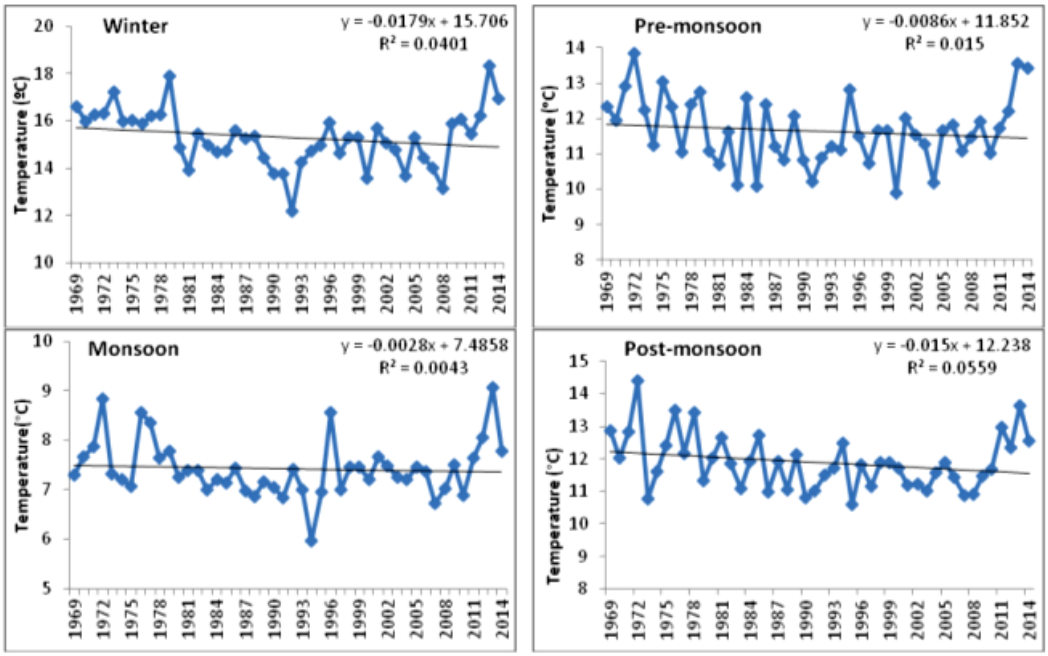

Fig. 5(d). Linear trends and times-series of DTR for four seasons over Kailashahar

of trend in other three temperature indices (T_{max}, T_{mean} and DTR) over both sites. At both the stations, the rate of increase in T_{min} is highest during December followed by January. During the period of study Sen's slope indicates a statistically significant rate of increase of about 2.9 °C and 2.4 °C in T_{min} during December at Agartala and Kailashahar respectively (Table 2). The warming trends in T_{min} over Kailashahar are significant for all months except for November and April, whereas trends over Agartala are significant for seven months.

The positive trend in T_{max} also indicates increase in temperature over both the stations except for decreasing trends in January and March over Agartala. The statistically significant highest rates of increase in T_{max} temperature are found in the month of July (0.03311 °C/year) and February (0.03262 °C/year) at Agartala and Kailashahar respectively. The decreasing trend over Agartala in the month of January (-0.02199 °C/year) is also found statistically significant.

All the T_{mean} values also show increasing trends at both the stations except a significant decreasing trend in January over Agartala. The increasing trends in T_{mean} are statistically significant from May to December at Agrtala and from July to March at Kailashahar. Similar to T_{min} index, the trends in T_{mean} are also largest in December at both the stations. The increase of 1.6 °C and 1.4 °C in T_{mean} has been detected during the period of study at Kailashahar and Agartala respectively.

At both stations, the statistically significant fall in DTR are observed in the January and December. During the period of study, Agartala witnessed a fall of 2.7 °C and 2.5 °C in DTR values in the month of December and January respectively and it was more rapid than the trend observed over Kailashahar. Monthly DTR values between Februarys to November months are mainly non-significant decreasing (increasing) over Kailashahar (Agartala).

Therefore, at both the stations the magnitudes of increase in T_{min} are higher than the magnitudes of increase in T_{max} on all timescale. These findings are consistent with the result obtained by other meteorologist (Roy and Balling, 2005; Jhajharia and Singh, 2011). According to Roy and Balling (2005) the significant increase in clouds causes the rise in minimum temperature and hence fall in DTR over the most parts of India for winter and summer season. Correlation analysis performed by Jhajharia and Singh (2011) revealed that the different meteorological parameters (sunshine duration, pan evaporation,

temperature, rainfall and humidity) influence DTR in different seasons over different sites in Northeast India. They have also observed significant decreasing trends in the sunshine duration at annual, seasonal (winter and pre-monsoon) and monthly (January, February and March) scales and suggested that the decrease in sunshine duration may be one of the potential cause for decreased DTR values over Northeast India.

4. Conclusions

An important aspect of the present study is the warming trends in T_{min}, T_{max}, and T_{mean} temperatures and decreasing trends in DTR over two cities of Tripura. At the two sites, the total numbers of statistically significant values in three temperature indices - T_{min}, T_{max}, and T_{mean} are more than total numbers of non-significant values on annual, seasonal and monthly timescale.

All the trends in T_{min} variable are increasing at both the stations on annual, seasonal and monthly scale. These increasing trends in T_{min} are significant at annual, seasonal and monthly scales over Kailshahar except during November and April months and over Agartala it is significant at annual, seasonal (winter, monsoon, post-monsoon) and in the month of January, June-October and December. In general, the magnitudes of rate of change in T_{min} are higher as compared to other variables on all time scale at both the stations.

The increasing trends in T_{max} at Agartala are significant on annual scale, monsoon season as well as in June-to-October months whereas at Kailashahar these trends are significant on annual scale, monsoon season, post-monsoon season and in April, July, August, October, November months.

Similar to the trends observed in T_{min} and T_{max}, T_{mean} shows significant increasing trends on annual, seasonal (monsoon and post-monsoon) and monthly (except January to April) scale over Agartala and at Kailashahar the T_{mean} also shows significant increase on annual, seasonal and monthly (except April, May & June) timescale.

DTR shows significant decreasing trends on annual scale, winter season, post-monsoon season and in January and December months at Agartala and in winter season and in January and December at Kailashahar.

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