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Variation of Temperature Trends In Srinagar and Gulmarg

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ABSTRACT:

Climate change is a cumulative change in weather patterns over a period of time. Trend analysis using non-parametric Mann-Kendall test may help to determine the existence and magnitude of any statistically significant trend in the climatic data. Another index called Sen slope may be used to quantify the magnitude of such trends. To study the temporal trend of meteorological parameters, 39 years (1970-2009) monthly meteorological data were collected for two selected stations over different agro-ecological regions of Kashmir viz; Srinagar and Gulmarg. Both the maximum and minimum temperatures were found to be rising. The overall increase in temperature for Gulmarg is found to much more than that of Srinagar.

Keywords: *climate, variability, temporal trends, non-parametric, Mann-Kendall test*

I. INTRODUCTION

Climate change is a change in the average weather conditions or a change in the distribution of weather events with respect to an average, for example, greater or fewer extreme weather events. It may be limited to a specific region, or occur across the whole earth. During past few decades much of concern has been expressed across the globe regarding climate change with particular reference to the modern climate. It may be qualified as anthropogenic climate change, more generally known as global warming or anthropogenic global warming (AGW). The modern climate is perceived to be changing worldwide and there has been growing concern as to the direction and effects of these changes. It refers to the gradual increase in the average temperature of the earth and is exemplified by the gradual decrease in the snow cover across the earth. Disappearance of glaciers has led to gradual increase in sea water level causing submergence of many islands. Increase in global temperature has drastically changed the weather patterns in many regions of the world. Methane (CH_4), ozone (O_3), nitrous oxide (N_2O), and chloro-fluoro- carbons (CFCs). There is now clear evidence for an observed increase in global average temperature and change in rainfall pattern during the 20th century around the world [1–5]. Rainfall has significantly increased in eastern parts of North and South America, northern Europe, and northern and central Asia. On the contrary rainfall has decreased in the Sahel, the Mediterranean, southern Africa, and parts of southern Asia. Xu et al. (2004) investigated the possible association between climate change and water resources variability, and detected the plausible long-term trends of the hydrologic variables by using non-parametric Mann-Kendall test [6]. Climate change scenario in India revealed that the annual mean temperature has increased by 0.48 ^{0}C in the past 100 years [7]. Temporal trend analysis is a tool to understand variations of different meteorological parameters with time. The knowledge of increasing/decreasing or no trend of an individual

climatic parameter may lead to safer designs, proper planning, required corrective measures, and sustainable practices. Many researchers have investigated the nature and pattern of trends of different climatic parameters. In India, several meteorological studies have been conducted in the context of climate change using observed data as well as model results [8–12]. Parthasarathy and Dhar (1975) found that the mean annual rainfall of India is of the order of 1190 mm with a standard deviation of 95 mm [13]. The mean areal annual rainfall in the 30 years period from 1931-1960 showed a significant increase of about 5%. Although, researchers could not find any significant trend in rainfall on all India basis [14–18] ; some of them advocated for significant regional decreasing/ increasing trends in rainfall [19–21]. Murugan et al. (2005) found rainfall has increased over all states except Punjab, Rajasthan, and Tamil Nadu, which showed slight decrease in precipitation during 1960-1990 [22]. Krishnakumar et al. (2009) revealed that there is a significant decrease in southwest monsoon rainfall while increase in post-monsoon rainfall over the state of Kerala and rainfall during winter and summer seasons show insignificant increasing trend [23]. Paramanik and Jagannathan (1954) had analysed surface temperature data series over India and inferred that the rise in annual mean temperature over India is comparable with the reported rise of global surface temperature by 0.6 ^{0}C [24]. Many studies have shown that there is observed increasing trend in surface temperature in different place of India [17, 21, 25–29]. Assessing temporal trends for different meteorological parameters are essential to understand the local climate change pattern of a region. It helps in forecasting the future climate and its effect on hydrology and agriculture. If such trends can be determined directly in reference to stations in point coverage inside a GIS environment, visualizing the spatial patterns or further spatial analysis of such trends would be greatly improved.

II. GENERAL STATISTICS OF METEOROLOGICAL PARAMETERS

The general statistical analysis may be performed to take a general overview of the data collected. The statistical parameters which are usually considered to look for gross data errors/outliers are:

1. Minimum and maximum
2. Mean
3. Standard deviation
4. Coefficient of variation

The trend analysis may be performed to determine the existence and magnitude of any statistically significant trend in meteorological parameters over the time period considered. The Mann-Kendall (MK) test has been used in this study for detection of trend. This is a non-parametric test, which makes no assumption for probability distribution of the variate and is less affected by missing values or outliers. However, MK test is a statistical yes/no type hypothesis testing procedure and, therefore, another index, Sen slope [30] has been used to quantify the magnitude of such trend. Being non-parametric, Sen slope also enjoys the same advantages mentioned earlier for the MK test. Mann-Kendall test The Kendalls statistic S is given by [31, 32]:

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \operatorname{sgn}(x_j - x_i) \qquad 1$$

Where,

$$sgn(xj - xi) = \begin{cases} 1 \; if \; x_i > x_j \\ 0 \; if \; x_i = x_j \\ -1 \; if \; x_i < x_j \end{cases} \qquad 2$$

for a time series x_k, k = 1, 2, ..., n.
When n ≥ 10, S becomes approximately normally distributed with mean = 0 and variance as:

$$\sigma^2 = \frac{(n)(n-1)(2n+5) - \sum_t (t)(t-1)(2t+5)}{18} \qquad 3$$

where, t is the extent (number of x involved) of any given tie and Σt denotes the summation over

all ties. Then Zc follows the standard normal distribution where:

$$Z_c = \begin{cases} \frac{s-1}{\sigma_s}, & S > 0 \\ 0, & S = 0 \\ \frac{s+1}{\sigma_s}, & S < 0 \end{cases} \qquad 4$$

The null hypothesis that there is no trend is rejected when:

$$|Z_c| > Z_{1-\frac{\propto}{2}}$$

where, Z is the standard normal variate and α is the level of significance for the test.
To find out the effect of auto-correlation on MK test results, the modified MK test with effective sample size (ESS) approach, as suggested in [33], was attempted on detrended series. In this method, the variance, σ_s^2, is modified as:

$$\sigma_s^{*2} = \sigma_s^2 \frac{n}{n^*} \qquad 5$$

where, n^* is the effective sample size calculated as [34]:

$$n^* = \frac{n}{1+2\frac{\rho_1^{n+1} - n.\rho_1^2 + (n-1)\rho_1}{n(\rho_1 - 1)(21)}} \quad 6$$

where, ρ_1 is the lag-1 auto-correlation coefficient, as given in [35], computed trend as:

$$x_k^* = x_k - \beta.(k-1), \quad k=1,2,\ldots,n$$

where, ρ_1 can be determined by:

$$\rho_1 = \frac{\sum_{i=1}^{n-1}(x_i^* - x^*)(x_{+1i}^* - x^*)}{\sum_{i=1}^{n}(x_i^* - x^*)^2} \quad 7.$$

Keeping the above mentioned facts in view, the present paper is taken up with the following objectives:

1. To study the monthly and seasonal variations in temperature in Srinagar from 1970-2009
2. To study the monthly and seasonal variations in temperature in Gulmarg from 1970-2009
3. To shed some light on increase in the winter mean and maximum temperature and decline in the mean and minimum of summer temperature.
4. To analyse the high correlation between temperature at Srinagar, which is a valley pit and south of main Himalayas, and northern valley station Gulmarg, which is a hill station. Since correlation of the mean temperature is much higher during spring and summer than during winter months. It is suspected that in winter, under the prevailing influence of the Tibetan anticyclone, more local conditions such as valley temperature inversion prevail
5. To elucidate that on average, the station with best seasonal correlation with other stations. For the spring and summer season the correlation coefficient for the mean temperature between the two studied stations i.e Srinagar and Gulmarg are drastically different.

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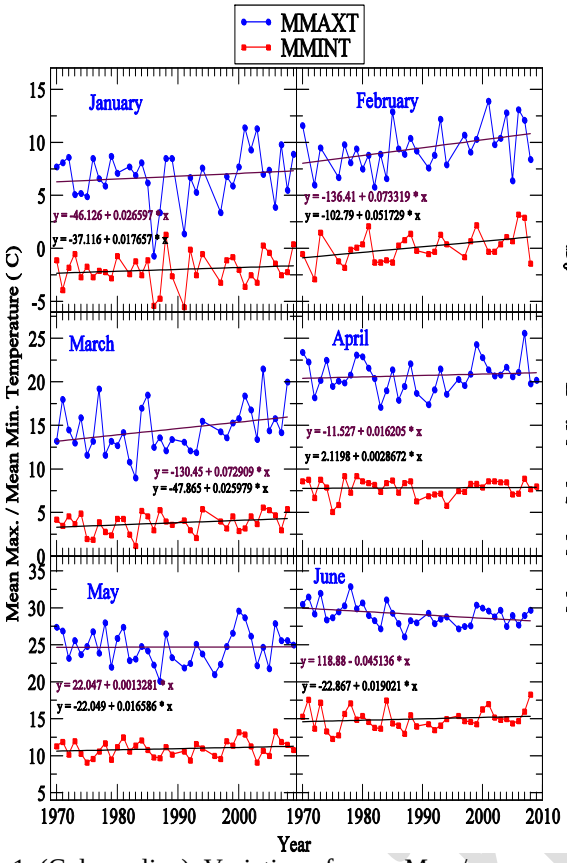

FIG. 1. (Color online) Variation of mean Max./mean Min. temperature for Srinagar from 1970-2009.

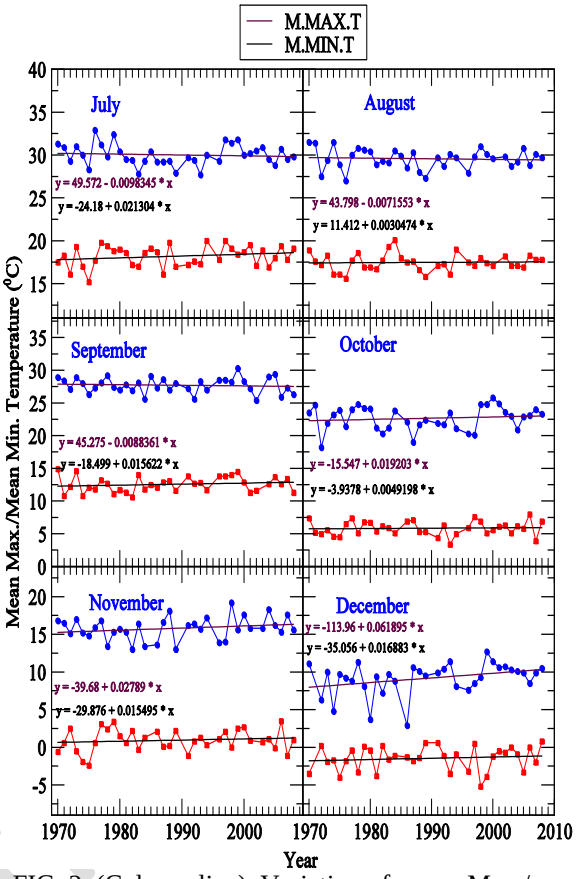

FIG. 2. (Color online) Variation of mean Max./ mean Min. temperature for Srinagar from 1970-2009

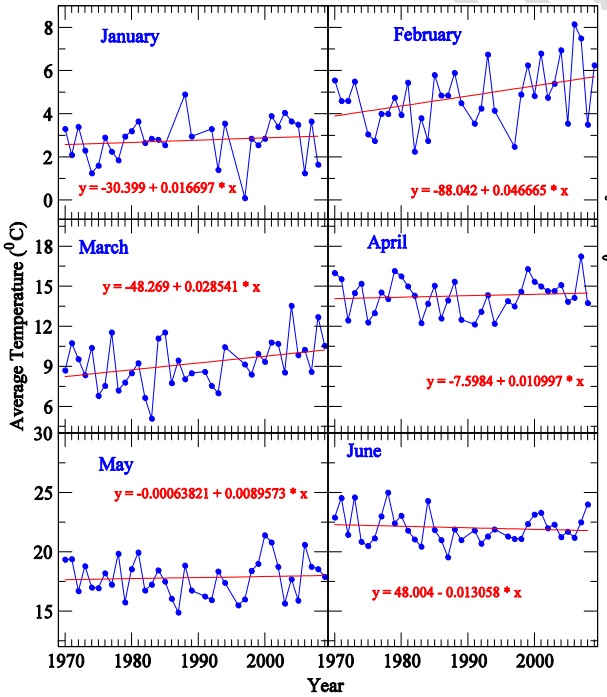

FIG. 3 (Color online) Variation of average temp. in Srinagar from January to June (1970-2009)

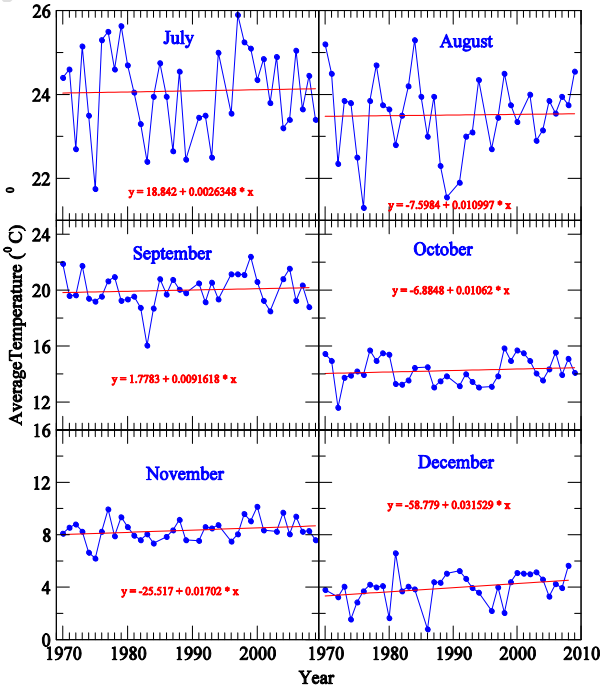

FIG. 4 (Color online) Variation of average temp. in Srinagar from July to December(1970-2009)

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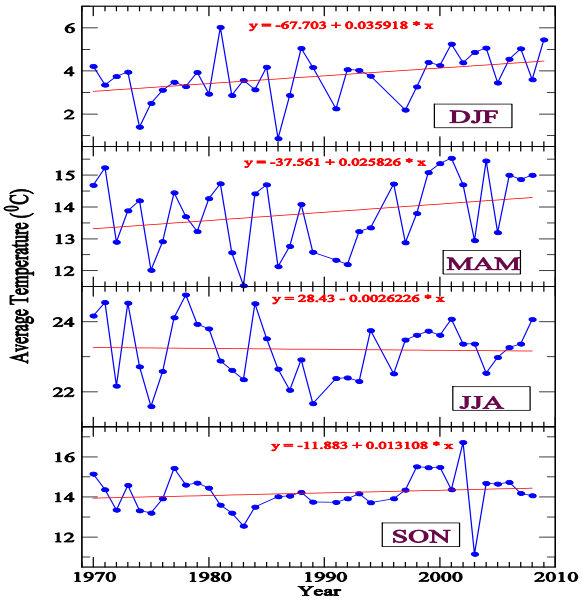

FIG.5. (Color online) Seasonal variation of average temperature in Srinagar for DJF, MAM, JJA, and SON (1970-2009).

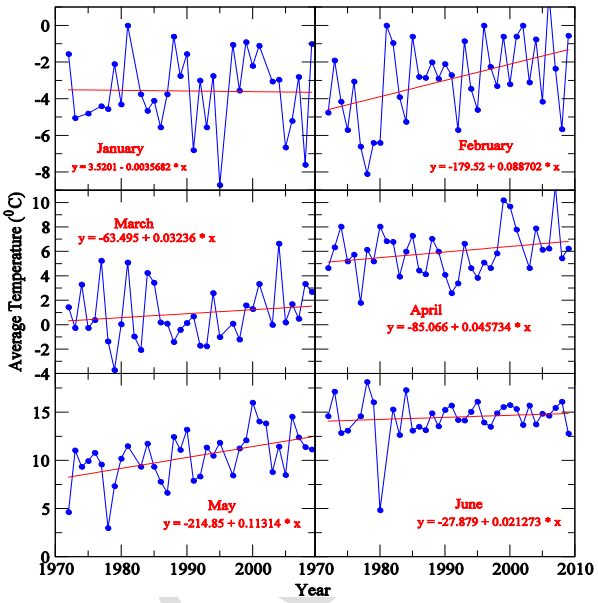

FIG.6. (Color online) Variation of average in temperature in Gulmarg from January to June (1970-2009).

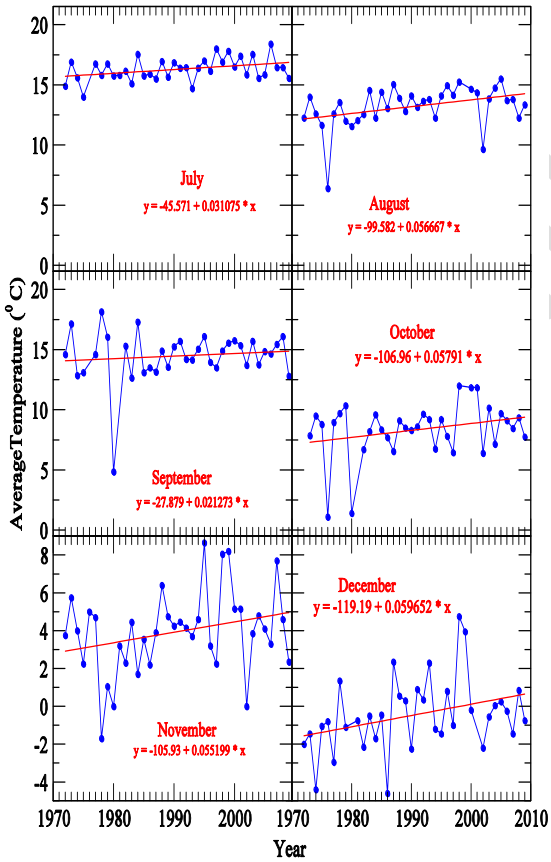

FIG.7. (Color online) Variation of average in temperature temperature in Gulmarg for July to December (1970-2009).

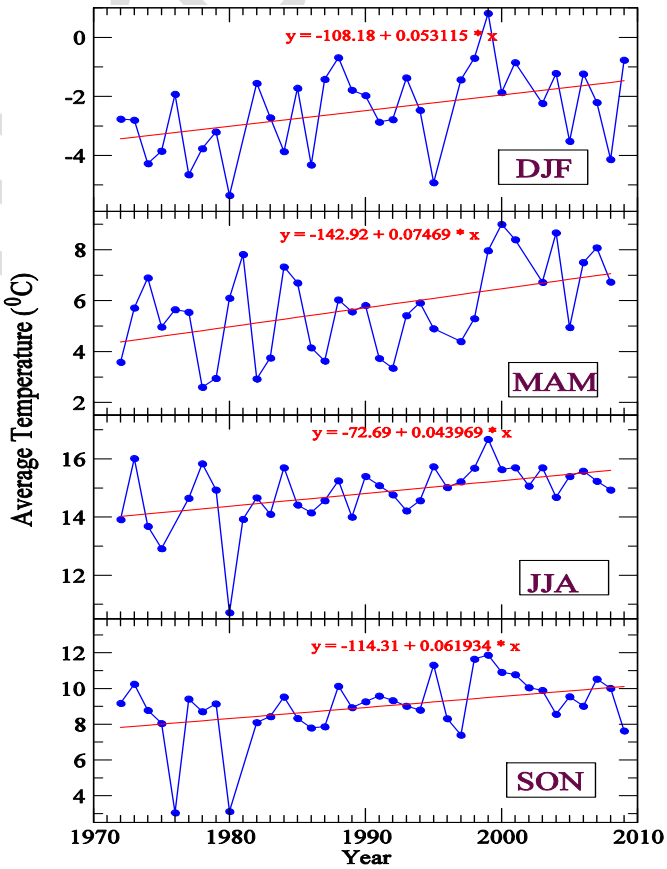

FIG.8. (Color online) Seasonal Variation of average in Gulmarg for DJF, MAM, JJA and SON (1970-2009).

III. RESULTS AND DISCUSSION

Variation in monthly mean Minimum and mean maximum temperature over Srinagar is depicted in Figures **1** and **2** for the period 1970 to 2009. The mean Minimum annual temperature of Srinagar has shown a slight increasing trend; however, it is not statistically significant. Examination of the mean monthly temperature indicated in Figs. **3** and **4** demonstrates that the months of December, February and March show warming trend as can be seen from the sharp increase in the mean monthly temperature of the said months while the months of April, August, November and October show a slight increasing trend in mean monthly temperature. The month of May, July and September is trend less while a slight decreasing trend can be seen for the month of June. Examination of the seasonal mean temperature series in Fig. **5** indicates that the winter season (December, January and February or **DJF**) and spring season (March, April and May or **MAM**) show warming trend as the seasons have shown a drastic increase in trend especially for winter season (**DJF**). It is surprising to note that Slight decrease in trend can be seen for the summer season (June, July and August or **JJA**) (However, it is not statistically significant). The autumn season also shows a slight increase in trend which is not statistically significant. Figs. **3** and **4** depicts the variation in monthly mean or average Temperature over Srinagar. Analysis of the monthly data depicts that a sharp increasing trend is seen for the months of February and December which is not a good sign as rise in temperature in winter does not allow snow to freeze for a longer time which could lead to floods and even shortage of water in summer time as the valley is dependent on snow and glaciers for its water. A slight increase can also be seen for the months of January, April, August, October and November, but statistically it is not very significant. The months of May, July and September are trend less while a slight decreasing trend can be seen for the months of June. Kumar [54] showed that the warming over India has been mainly due to increasing maximum temperatures rather than minimum temperatures. The variation in average temperature (monthly) for 1970 and 2009 are plotted in Figs**. 6** and **7** respectively. It is observed that the coldest month at Gulmarg is January. The variation of monthly average temperature and the seasonal mean temperature series along with their regression lines is shown in Figs. **6, 7** and **8**. The analysis of the temperature data on monthly and seasonal basis show mixture of temperature trends in the meteorological sub-division under study (Gulmerg). Analysis of the monthly temperature data suggests that the degree of trend differs monthly as well as seasonally. Based on our study, we have arrived at the following results:

1. The months February, May, August, September, October, November and December show a sharp increasing trend of variation of average temperature with slopes (0.008),(0.113), (0.064), (0.095), (0.057), (0.059) and (0.059) respectively.
2. A slight increasing trend line has been observed for the months March, April, June and July, but the increase is not very much.
3. It is worth mentioning here that only the month of January shows a decreasing trend with slope (-0.02) and on the contrary the month of May shows an alarming trend in temperature with slope (0.113).
4. It is quit clear from the Fig. 3 that the seasonal trends for the DJF (December, January and February), MAM (March, April and May) JJA (June, July and August) and SON (September, October and November) show a sharp increase in the temperature trend.

The present study deals with an examination of trends in seasonal and the monthly variations of the temperature for the two geographically important stations (Srinagar and Gulmarg) of the Kashmir valley. The various important results we have arrived at, are summarized as:

A. Study of Mean Maximum and Mean Minimum Temperatures for Srinagar.

1. Variation in mean maximum temperature for Srinagar over the years 1970-2009 depicts a sharp increase in temperature for the months, January, February, March, November and December.
2. Months like April and October show a slight increase in mean maximum temperature over the years 1970-2009, but the increase is not enough hence not statistically significant.
3. The months, May, July, August, September show a nearly trendless behavior. It is pertinent to mention here that mean maximum temperature for the month of June shows a decreasing trend with slope (-0.045).
4. Variation in mean minimum temperature for srinagar over the years 1970-2009 shows a sharp increasing trends for the months of January, February, March, June and July.
5. The months May, September, November, December show a slight increase in the mean minimum temperature over the years 1970-2009, but the increase is not statistically significant.
6. The months, April, August, October show a nearly trendless behaviour in case of variation of mean minimum temperatures.

B. Study of Monthly Average Temperatures for Srinagar and Gulmarg

1. Variation in monthly average temperatures over the years 1970-2009 in Srinagar depict a sharp increase in average temperature for the months, February, March and December and same is true for Gulmarg but the increase here is much more as compared to that of Srinagar.
2. In Srinagar, the months January, April, August, November show a slight increase in average temperature, but the increase is not statistically significant, while in case of Gulmarg, January shows a decreasing trend, and the other respective months show a sharp increasing trend.
3. The months May, July, September, October show almost a trendless behaviour in Srinagar but in Gulmarg same months show a sharp increasing trend.
4. Surprisingly in Srinagar the variation in average temperature for the month of june shows a slight decreasing trend with slope(-0.013) but in gulmarg it shows a sharp increase with slope(0.02).

C. Study of Seasonal variations in Temperature for Srinagar and Gulmarg

1. In Srinagar, the variation in average temperature for DJF shows an increasing trend, same is true for Gulmarg, but the increase in Gulmarg is much as compared to Srinagar.

2. The variation in average temperature for MAM at both the stations shows an increasing trend, but the variation at Gulmarg is much more(slope=0.07)than that of Srinagar(slope=0.02).
3. For the season JJA, the variation in average temperature shows a decreasing trend in Srinagar(slope=-0.002)while the same shows an increasing trend in Gulmarg(slope=0.04)
4. In Srinagar, the variation in average temperature for SON follows a trendless behavior, while as in Gulmarg same shows a sharp increasing trend.

Climate-change projections using various Global Climate Models (GCMs)and Regional Climate Models(RCMs) over India show an increasing temperature and changing patterns in rainfall during the 21st century [70]. PRECIS(a regional climate modeling system) simulations under scenarios of increasing greenhouse gas concentrations and sulphate aerosols indicated a marked increase in both rainfall and temperature towards the end of 21st century over Jammu and Kashmir [71]. Our study indicates that variation in temperatures is much more pronounced in Gulmarg than that of Srinagar, which may be ascribed to the high albedo of snow. If this behavior is sustained, it will adversely impact the economy of the adjoining areas first, and then the overall valley. Before any adverse may happen, we all need to wake up at the earnest and study the possible impacts of climate change, then take the steps to prevent or atleast minimize the use of its causative agents and mitigate its adverse effects.

IV. CONCLUSION

The result of the study is quite amazing. It is implicitly indicated that the variability of temperature on various spatio-temporal scale is significantly evident. The mean temperature for December, March and February has shown a sharp increasing trend suggesting a warm trend for the period of the year. Examination of the seasonal mean temperature series indicates that the winter season and spring season show warming trend as the seasons have shown a drastic increase in trend especially for winter season. The result of the study is quite amazing. It is implicitly indicated that the variability of temperature and rainfall on various spatio-temporal scale is significantly evident. It is noteworthy that broadly there are clear trends of both increasing and decreasing rainfall on monthly, seasonal and yearly basis during the last 40 years period. But on each scale the trend is not identical in intensity. Monthly rainfall is more variable, for example, December rainfall has shown clearly decreasing trend. The decreasing rainfall trend in December is a clear signal of delaying of winter in the region. Similarly, the mean Minimum annual temperature of Srinagar has shown a slight increasing trend. Monthly temperature is more variable, for example, January, February, March, November and December show warming trend. It is amazing to note that the annual mean temperature is trend less. Also, the mean maximum temperature for winter and autumn has shown a sharp increasing trend.

REFERENCES

i. D. R. Easterling, H. F. Diaz, A.V. Douglas, W. D. Hogg, K. E. Kunkel,J. C. Rogers, and J. F. Wilkinson, Climatic Change, 42, 285 (1999).

ii. Y. Ding, D. J. Griggs, M. Noguer, P. J.V.D. Linden, and D. Xiaosu,IPCC, Climate change: The scientific basis, (2001).

iii. H. S. Jung, Y. Choi, J. H. Oh, and G. H. Lim, Int. J. of Climatology, 22, 1327 (2002).

iv. R. C. Balling, Jr., and R. S. Cerveny, Natural Hazards,29,103 (2003).

v. N. Fauchereau, M. Trzaska, M. Rouault, and Y. Richard, Natural Hazards, 29, 139 (2003).

vi. Z. X. Xu, Y. N. Chen, and J. Y. Li, Water Resource Management,18, 439 (2004)

vii. A. K. Srivastava, Climate change over India,(2007).

viii. U. S. De, Climate change impact: Regional scenario, Mausam,52, 201 (2001).

ix. K. Rupakumar, K. Krishnakumar, R. G. Ashrit, S. K. Patwardhan, and G. B. Pant, Climate change in India: Observations and model projections, (2002).

x. S. K. Dash, and P. Rao, Assesment of climate change in India and mitigation policies, (2003).

xi. R. G. S. Prakasa, A. K. Jaswal, and M. S. Kumar, Mausam, 55, 429 (2004).

xii. D. R. Kothawale, and K. Rupakumar, On the recent changes in surface temperature trends over India, (2005).

xiii. O. N. Dhar, B. Parthasarathy, Hydrological Science Bulletin, 26, 257 (1975).

xiv. D. A. Mooley, and B. Parthasarathy, Climatic Change, 6, 287 (1984).

xv. S. M. Kulshrestha, V. Thapliyal, Mausam, 42, 333 (1991).

xvi. G. B. Pant, and K. Rupakumar, Climates of south Asia, John Wiley and Sons, (1997).

xvii. G. B. Pant, K. Rupakumar, and H. P. Borgaonkar, Climate and its long-term variability over the western Himalaya during the past two centuries, (1999).

xviii. D. H. David, B. Stephenson, and K. Rupakumar, Mausam, 52, 213 (2001).

xix. V. P. Abhyankar, A. Chowdhury, Mausam, 30, 85 (1979).

xx. R. H. Kripalani, A. Kulkarni, S. S. Sabade, and M. L. Khandekar, NaturalHazards, 29, 189 (2003).

xxi. N. A. Sontakke and N. Singh, Climatic Change, 52, 287 (2002).

xxii. P. K. Shetty, M. Murugan, and M. B. Hiremath, Caspian J. Env. Sci., 3, 132 (2005).

xxiii. G. S. L. H. V. P. Rao, K. N. Krishnakumar, and C. S. Gopakumar, India Atmospheric Environment, 43, 1940 (2009).

xxiv. S. K. Paramanik, and P. Jagannathan,Indian J. Meteorol. Geophys. , 5, 1 (1954).

xxv. L. S. Hingane, K. Rupakumar, and B. V. Ramanamurthy, J. Climatology, 5, 521 (1985).

xxvi. H. N. Srivastava, B. N. Dewan, S. K. Dikshit, G. S. P. Rao, S. S. Singh, and R. Rao, Mausam, 43, 7 (1992).