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Study of maximum and minimum temperatures trends at Srinagar Garhwal Valley, Uttarakhand India

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Abstract

This paper, attempts to study the variation in temperature over Srinagar Garhwal Valley of Uttarakhand, India, during the period 2010-2016. In the study assess the seven-year change in temperature has been evaluated by Mann–Kendall rank statistics and CV. The result indicates significant slightly increase in winter temperature at 0.01 level. It is observed that in valley of Srinagar Garhwal, Uttarakhand, coefficient of variation for mean temperature for Srinagar Garhwal Valley is highest in the month of December, it is observed as 75.87 % whereas it is lowest in the month of August, it is 27.40%. This means that mean temperature is most stable in the month of August and least stable in the month of December for the Srinagar Garhwal Valley.

Keywords: srinagar, uttarakhand, garhwal valley, temperatures

1. Introduction

Numerous climatologists (Jones *et al.*, 1999 and Parker and Horton 2015, IPCC 2001, Vinnikov and Grody, 2003) [1, 2, 5, 3] agree that there has been a large-scale warming of the Earth's surface over the last hundred years or so. This warming up of the Earth during the 20th century brought with it a decrease in the area of the world affected by exceptionally cool temperatures, and to a lesser extent, an increase in the area affected by exceptionally warm temperatures (Jones *et al.*, 1999) [1]. Some analyses of long time-series of temperatures on a hemispheric and global scale (IPCC 2001) [3] have indicated a warming rate of 0.3-0.6 ºC since the mid-19th century, due to either anthropogenic causes (IPCC, 2001) [3] or astronomic causes (Soon *et al.*, 2000, Landscheidt 2000). The Third Assessment Report projections for the present century are that average temperature rises by 2100 would be in the range of 1.4-5.8 ºC (IPCC 2001 & 2001) [3]. Records show that global temperatures, averaged world-wide over the land and sea, rose 0.6 ± 0.2 ºC during the 20th century. A number of recent studies have been devoted to global, hemispherical, or regional long-term temperature variations. On a global scale, climatologically studies indicate an increase of 0.3-0.6 ºC of the surface air temperature 0.5-0.7 ºC for the Northern Hemisphere since 1860 (Jones *et al.*, 1999, Jones *et al.*, 1986, Jones 1987) [1, 4, 9], while the eighth warmest years ever recorded were observed after (Brasseur and Roeckner 2005). A broad consensus of scientists has concluded that, the earth's surface air temperature increased by about 0.6 ºC during the 20th century, that most of the warming during the latter half ofthe century is attributable to human emissions of greenhouse gases, and that temperature increases were greatest during the 1990s (IPCC, 2001) [3]. Numerous other factors such as variations in solar radiation and pollutant aerosols also contribute to climate change (Scafetta and West 2005, Pielke 2005) [12, 13]. The IPCC panel further concluded that global temperature increases are likely to persist in the 21st century and will probably be accompanied by changes in precipitation and runoff amounts. Future climate change is more difficult to predict with great certainty at the regional scale due to spatial resolution limitations of current climate models and to the likely influence of unaccounted for factors such as regional land use change (Savelieva *et al*., 2000) [14].

Several studies (Balling and Idso, 1989; Karl *et al*., 1988; Goodrich 1992) [15, 22, 17] published in the last 15 years have attempted to assess the effects of urbanization on local and regional climate. A study by (Jones *et al*. 1990) [10] on urbanization and related temperature variation indicates that the impact of urbanization on the mean surface temperature would be no more than 0.05 1C per 100 years. A similar study by (Thapliyal and Kulshreshtha 1991) [20] on temperature trends over Indian cities indicates a slight warming within the limits of 1 SD between 1901 and 1990. It is now recognized that urbanization and changing land-use influence minimum temperature. Local temperature is thus one of the major climatic elements to record environmental changes brought about by industrialization and urbanization. In view of the importance of air temperature, as indicated above, it would be of interest to study the Seven year variation of air temperature in Srinagar Garhwal Valley, Uttarakhand, India. Therefore, the objective of the present work is to investigate the annual and seasonal temperature trends and it is also of interest to find out whether the overall change in temperature is due to change in minimum or maximum temperature.

2. Study Area

Srinagar-Gahwal valley is 30°13’-13'30” North Latitude and 78° 45'-47'4" East Longitude is situated on the bank of river Alaknanda in the Lesser Himalaya, right in the heart of Garhwal region, enroute to the world famous Holy shrines of Badrinath and Kedarnath. It has an average elevation of 560 meters (1837).

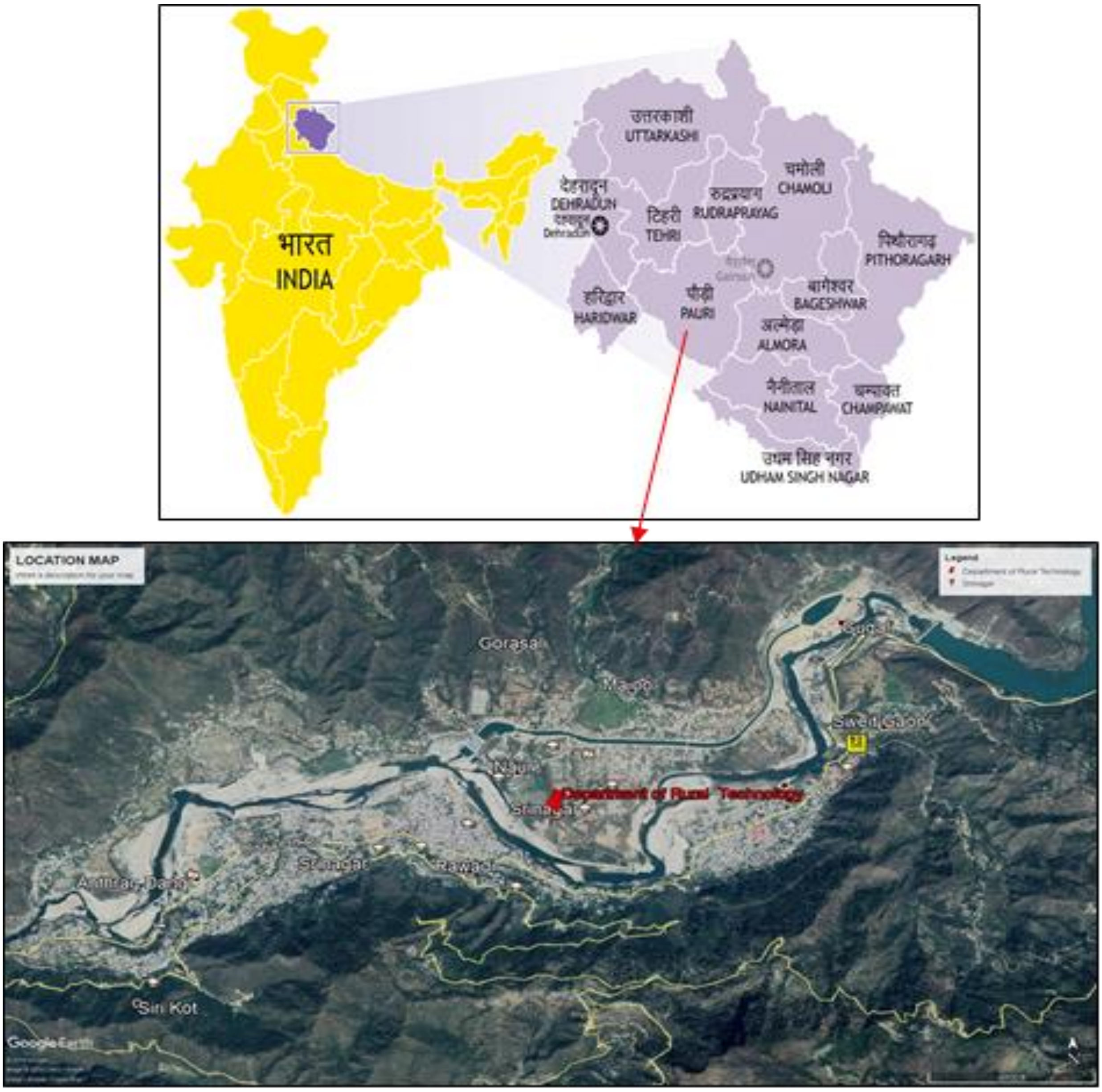


Fig 1: Location Map of Srinagar Garhwal Velley

3. Data and Methodology

Monthly maximum and minimum temperature data during the period 2010–2016 (07 Years) were obtained from Department of Rural Technology, HNB Garhwal University, Srinagar Garhwal, Uttarakhand. From the basic temperature data, mean maximum (Tmax), mean minimum (Tmin) and mean temperature, along with their standard deviation (SD) and coefficient of variation have been computed for each month and three seasons, viz summer, monsoon and winter, that are depicted in Table 1. December, January and February are considered for the analysis of winter temperature as these 3 months record lower temperatures (Table 1). 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. These data were then subjected to a 07-year running mean to find the trends. A linear trend line was added to the series to simplify the trend. Temporal changes in the annual and seasonal values were also analysed by Mann–Kendall rank statistics (t) to confirm the significance of the observed trend. The value of t can be used as the basis of a significant test by comparing it with where tg is the desired probability point of the Gaussian normal distribution. In the present study, tg at 0.01 and 0.05 points has been taken for comparison. Apart from this, the linear trend fitted to the data was also tested with t-test to verify results obtained by the Mann– Kendall test.

$$\tau_t = 0 \pm t_g \sqrt{\frac{4N + 10}{9N\,(N-1)}}$$

3.1 Study Period
Daily temperatures and Rainfall are available from January 2010 to December 2016. However, these records are incomplete with various missing observations. From 2010, onwards very few observations are missing, the most being in 2010, 2011, 2012 and 2013.

3.2 Analysis and tools
Mean, Standard Deviation (SD) and Coefficient of Variation (CV) and leniear regression were computed for temprature rainfall and RH. Excel and SPSS software package was used to study the trend of temperature rainfall and RH.

4. Result and Discussion
The Coefficient of variation for mean temperature for Srinagar Garhwal Valley is highest in the month of December and it is observed as 75.87 % whereas it is lowest in the month of August and it is 27.40%. This means that mean temperature is most stable in the month of August and least stable in the month of December for the Srinagar Garhwal Valley

Table 1: Monthly and seasonal temperature means

Month	Max Temp.	Min Temp.	Mean Temp	Standard Deviation	Coefficient of Variance
January	23.6	3.9	13.7	10.27	74.87
February	28.4	6.1	17.2	11.66	67.62
March	35.0	9.7	22.3	13.24	59.24
April	37.8	13.3	25.6	12.88	50.35
May	40.5	16.4	28.4	12.58	44.21
June	39.6	19.9	29.7	10.31	34.70
July	37.8	21.9	29.8	8.34	27.95
August	36.6	21.4	29.0	7.95	27.40
September	36.5	19.2	27.8	9.00	32.34
October	34.5	12.1	23.3	11.66	49.99
November	29.0	8.1	18.5	10.87	58.62
December	24.5	3.9	14.2	10.74	75.87

4.1 Annual temperature trends
The mean annual, temperature max and temperature min along with 07-year moving mean and trend line are presented in Fig. 1. However, it can be seen from the figure that there had been a relatively warm period 2015-2016. Similar features are also seen in annual max mean annual temprature with while slight differences in the annual min mean temprature relative dominance of warm and cool periods. However, it is observed that there is no significant trend in Temperature min, while temperature max shows cooling trend, significant at 0.05 levels.

Table 2: Result of Mann–Kendall rank statistics

Month	Temp. Max	Temp. Min	Temp Mean
January	-0.619*	0.048	-0.714*
February	-0.238	0.238	-0.048
March	-0.429	0.143	0.333
April	0.238	0.333	0.333
May	-0.143	0.238	0.143
June	-0.419	0.143	-0.143
July	0.524*	0.333	0.619*
August	-0.048	-0.429	-0.333
September	0.238	-0.048	0.429
October	0.143	-0.143	0.238
November	-0.586*	-0.143	-0.143
December	-0.810**	-0.429	-0.714*
Annual	-0.333	0.238	0.048

*Significant at 0.05 level, **significant at 0.01 level

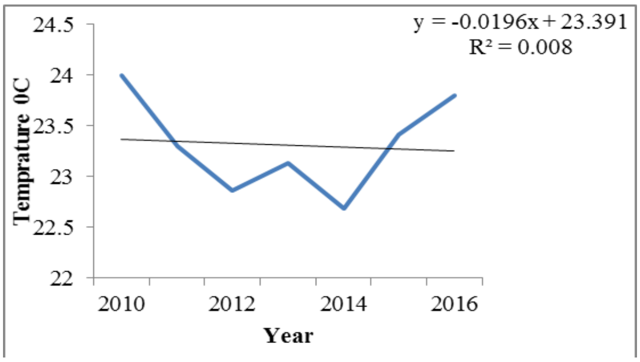
4.2 Monthly temperature trends
Performance of minimum and maximum temperature has been studied for individual months by subjecting them to the Mann–Kendall test. The results are presented in Table 2. It is interesting to note that the Temperature max, shows a significant trend in a majority of the months. The beginning of winter, though it shows increase trend in minimum temperature, is not statistically significant. The annual max temperature also shows heating trend is significant for December at 0.01 level and January July and November at 0.05 level.

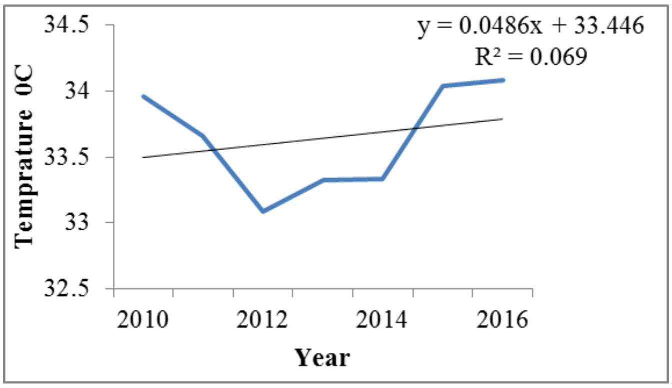
Table 3: Linear equations and their significance tested by t-test

Month	R	R^2	Calculated t	Durbin-Watson
Annual Mean Temprature	0.088	0.008	0.197	0.222
Annual Temprature Min	0.297	0.088	0.696	0.324
Annual Temprature Max	0.263	0.069	-0.609	0.293

*Significant at 0.05 level, **significant at 0.01 level.

5. Conclusion
An important aspect of the present study shows increase trend in minimum temperature is not statistically significant. The annual max temperature also shows heating trend is significant for December at 0.01 level and January July and November at 0.05 level. This heating trend in Srinagar Garhwal Valley, Uttarakhand, India temperature is supported by studies conducted by other researchers (Fujibe, 1995, Jones and Moberg 2003 [4, 16] and Rupa Kumar and Hingane, 1988,). The result indicates that significant slightly increase in winter temperature at 0.01 level. We are still a long way from understanding the complex interaction of many physical processes that determine the evolution of climate.





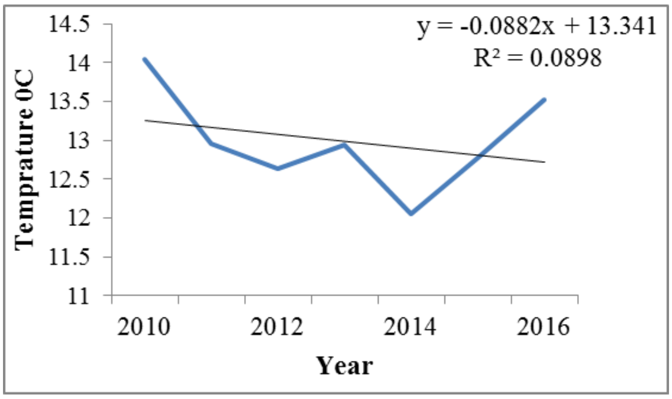


Fig 1: Annual temperature trends of Srinagar Garhwal Velley, Uttarakhand

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