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Comparison of Long Term Rainfall Trends In Urban and Nonurban Regions of Indian Land Mass and Its Probable Implication

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ABSTRACT

The paper presents a comparison of the rates of rainfall in fourteen Indian meteorological subdivisions, with fourteen major Indian cities located in those subdivisions. These comparisons of the rates have been done for both the monsoon period as well as annual rainfall. The long term trends of monsoon and annual rainfalls in fourteen major Indian cities have been reported earlier. Using WMO procedure the trends of rainfall on the meteorological subdivisions, consisting of fourteen Indian cities are calculated. The Indian cities having population more than 1 million are considered as urban. The meteorological subdivisions are considered as nonurban though a small part of it is occupied by the city.

Quantitative analysis of the rainfall data over the Indian land is done and following important results are obtained.

(i) the rainfall rates in most of the urban areas are higher than the corresponding subdivisional rates since the later part of the last century.

(ii) even with the same economic trend some cities are showing reverse trend of rainfall compared with the corresponding subdivisions.

(iii) subdivisional rainfalls, monsoon as well as the annual, are showing decreasing trend for the same period for more than 70% cases.

INTRODUCTION

With the advent of rapid and inhomogeneous occupation of land for urbanization and industrialization, an imbalance in the prevailing states of weather condition is being observed in and around the urban areas. Air and land transportation, burning of waste, building up of densely populated cities with sky scrappers, building up of large cooling towers etc. are some of the human activities, which result into urban heat island (UHI) and surface roughness against the incoming air to the city (Hjelmfelt et al. 1982). All these activities lead to inadvertent weather modification locally. But they are ultimately influencing global climate at large scale. Since the detailed US study (Changnon et al. 1968c) and the contemporary study by Atkinson (1968) on this human induced alteration of weather condition, especially precipitation and thunderstorms as major focus, many research papers have been published. Prior to Atkinson and Changnon, the work of Landsberg also pointed similar precipitation anomaly (Landsberg et al. 1956). All these findings necessitated an extensive field study on the issue, which resulted into the famous METROMEX study from 1971 to 1975 (Changnon et al. 1971) and later Chicago Area Project (CAP) study from 1976 to 1980 (Changnon et al. 1978).

Similar research works on Indian land, the urbanization effect, have also been reported (Kishtawal et al. 2009, Rao et al. 2004). The presence and reasons of presence of aerosols have been reported in detail by De et al. (2001). They have shown by quantitative analysis that the visibility of a group of Indian cities, having an airport close by, is mainly affected by the aerosols, not by the water vapour of some forms. Impact of such aerosols, affecting the meteorological parameters is also reported by Niyogi et al. (2007). A significant quantitative analysis in this regard has been done by De et al. (2004), on fourteen Indian cities consisting of 1 million or more population. They left the comparative analysis between the cities and the surrounding areas, for further study. The present work presents the analysis of the long term rainfall data of the meteorological subdivisions consisting of these fourteen cities. A detailed quantitative comparison of the trends of the rainfall on these subdivisions is made in the same line and the results supported the findings of De et. al (2004). Both the analyses are based on the same range of long term rainfall data.

DATA SOURCES

Homogenized subdivisional monthly rainfall data as well as the monsoon seasonal data for this study are taken from the website of Indian Institute of Tropical Meteorology (IITM), Pune, India. The primary data are collected by the Indian Meteorological Department (IMD). The contributing scientists of IITM for this data set are D. A. Mooley, B. Parthasarathy, K. Rupa Kumar, N. A. Sontakke, A. A. Munot and D. R. Kothawale. Analyses of the rainfall on the fourteen Indian cities are taken from De et al. (2004).

RESULTS

A comparison of the trends in the fourteen Indian cities and the corresponding subdivisions consisting of these cities are presented in the Table 1. The analysis procedure for these datasets and subsets is as per the techniques suggested in WMO, Data Processing for Climatological Purposes (1969). Each of the annual rainfall data are the result of the measurement over a range of distributed stations, mentioned in the used dataset. So, the annual data sets are normalized per station before using for analysis.

A scattered diagram of the two parameters, the rainfall and the time, is plotted for each subdivision with time as horizontal axis. The linear regression trends of rainfall against time are derived from each of the scattered diagrams. Two such graphs are shown, each one for the monsoon and the annual rainfalls in Fig. 1(a) and Fig.1 (b), respectively, as an example for Telangana subdivision. Similar trend data for other stations are calculated following the same procedure.

The sub-divisional rates are compared with the city rates for the monsoon period. It is seen from the Table 1 that for the period 1901-1950, the increasing rate of monsoon rainfall in Indian meteorological subdivisions were mostly higher than

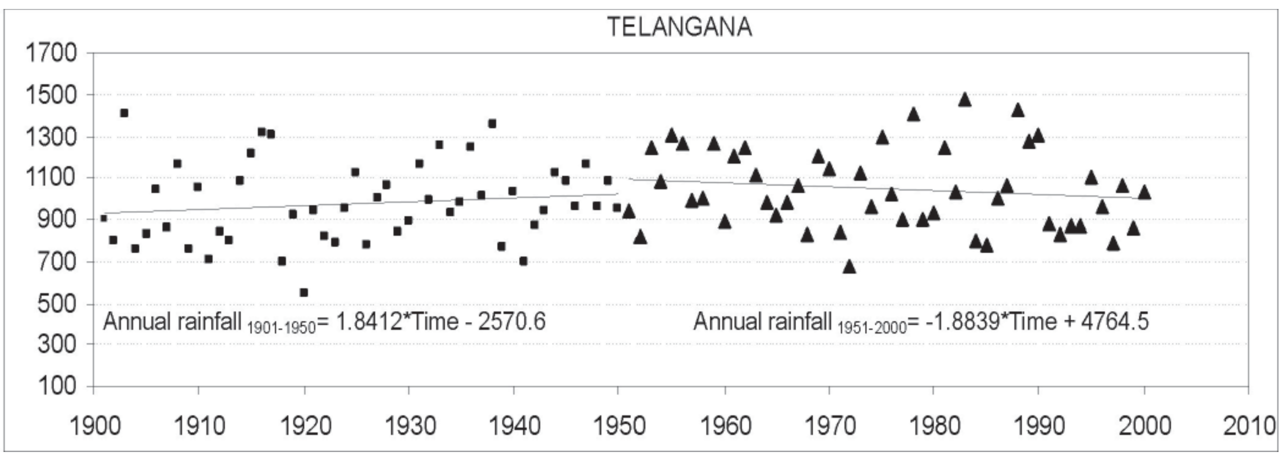

Figure 1(a). Annual rainfall trends for the periods 1901- 1951 and 1951-2000 for Telengana.

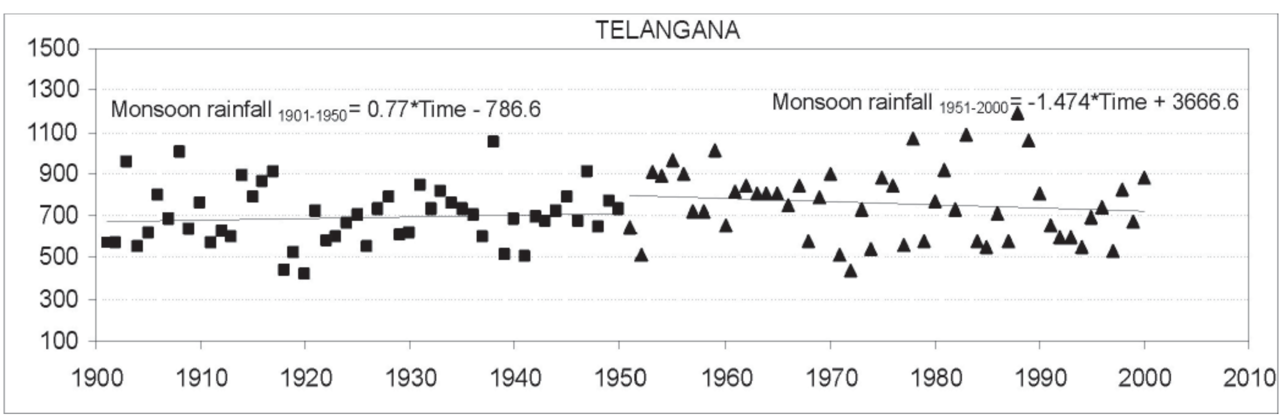

Figure 1(b). Monsoon rainfall trends for the periods 1901- 1951 and 1951-2000 for Telengana.

Table 1. Rates of Monsoon seasonal and annual precipitation for two half-centuries over different Indian subdivisions and major Indian cities.

	Monsoon season				Annual				Subdivisions
Year	1901-50		1951-2000		1901-50		1951-2000		
Cities	Subdiv.	Cities	Subdiv.	Cities	Subdiv.	Cities	Subdiv.	Cities	
Hyderabad	0.77	-0.10	-1.47	-0.09	1.84	-0.16	-1.88	0.02	Telengana
Patna	-0.01	-0.21	2.62	0.47	0.68	-0.12	3.52	0.51	Bihar Plains
Ahmedabad	3.32	0.27	-1.65	-0.12	3.18	0.28	-1.59	-0.03	Gujarat
Surat	3.32	0.53	-1.65	-0.18	3.18	0.62	-1.59	-0.20	Gujarat
Bangalore	-0.23	-0.08	0.57	0.34	0.60	0.00	1.34	0.26	South Interior Karnataka
Mumbai	8.45	0.72	-7.40	-0.40	13.88	0.83	6.45	-0.37	Konkan
Nagpur	2.06	0.14	-1.55	-0.27	-1.43	0.25	-0.07	-0.05	Vidarbha
Pune	1.21	0.01	0.04	0.28	2.36	0.03	0.17	0.20	Madhya Maharashtra
Jaipur	4.18	0.28	-0.65	-0.08	2.26	0.30	0.77	-0.09	East Rajasthan
Chennai	-1.24	-0.17	0.06	0.10	1.08	-0.53	-0.53	0.52	Tamilnadu
New Delhi	0.97	0.25	0.66	0.08	0.47	0.18	0.32	0.05	Haryana
Kanpur	2.70	-0.07	-1.67	-0.41	1.08	-0.03	-0.96	-0.61	West U.P.
Lucknow	2.86	0.04	-0.25	-0.10	1.05	0.01	-0.07	0.03	East U.P.
Kolkata	2.08	-0.05	4.08	0.83	2.96	0.03	7.27	1.24	Gangetic W.B.
Higher trends (city)	2/14 cases		10/14 cases		1/14 cases		8/14 cases		

in the corresponding major cities, considered and situated in those subdivisions. Only 2 out of 14 cities exhibited reverse rate. However, the ratios are found to change significantly for the period 1951-2000. The number of cities exhibiting higher rate of rainfall than the corresponding subdivisions have increased to 10 out of 14. It clearly shows that a significant reversing has developed in rainfall pattern in the later half of the last century.

Secondly, the subdivisional annual rainfall rates with the city rates are compared. The total number of cities showing higher increasing rate than the corresponding subdivisional rate is found to be only 1 during the years 1901-1950. But, the number has increased to 8 out of 14 cities, when the period 1951-2000 is considered.

The cities that are still showing reverse trends, i.e. rate of trend of rainfall is in line with the subdivisions or lower than the subdivisions, in spite of similar kind of change in the demography or economy, demand further study to find the real causes. May be some particular class of anthropogenic volatile compounds (AVOC) or a particular group of factors influencing the trend is absent in those cities or the vice versa.

Thirdly, another interesting result has been obtained (Table 1). 10 out 14 subdivisions are showing lower trends in the period 1951-2000 than the corresponding trends in the period 1901-1950. Long term analysis of the rainfall shows that the total rainfall over Indian landmass remains more or less the same (Srivastava, 1992) in spite of such uneven distribution of rainfall. Hence, if the trends in the cities increase there may be possibility of corresponding decrease in the surrounding areas. It fairly agrees with our results. This phenomenon may have severe repercussion for agricultural based economy, like Indian, as the agricultural lands are situated in the non-urban areas of the country.

DISCUSSION AND CONCLUSIONS

A comparative analysis of the monsoon and annual rainfall of the 14 Indian cities with their surroundings is done and it is shown that the rate of monsoon and annual rainfall is increasing over the urban areas compared to the corresponding nonurban ones. The nonurban rainfall rate is decreasing with the increasing economic activities in the urban areas situated in the surroundings of the nonurban areas. It is also observed that there are some cities, though less in number, are either maintaining the same or showing reverse trend. Though the real reason for shift in rainfall pattern is still an active area of study the result of urbanization, as reported by Rao et al. (2004), like inhomogeneous distribution of meteorological parameters over different Indian cities, change in radiation values, bright sunshine hours, wind speeds, humidity, orography, distance between the tall buildings, vehicular pollution and the industrial development may be cited as important parameters for such distribution. Due to industrial development of the urban area, pollutants may play important role to form the cloud condensation nuclei of proper dimension and this may be the cause of increase of rainfall rate over urban area with respect to nonurban area.

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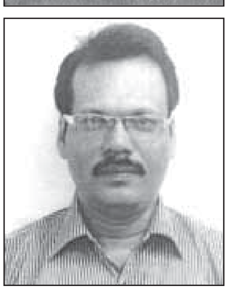

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