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Study of Indian Summer Monsoon Rainfall Trend During the Period 1901-2013 through Data Mining.

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Abstract: Indian summer monsoon rainfall (ISMR) has significant impact on agriculture, water resources and economic development of India. Trend Analysis of annual and summer monsoon rainfall at different Spatio-temporal scale is an important feature to study the long term behavior of the rainfall pattern. The objective of the present study is to identify the trends in amount of ISMR at various temporal (decadal) and Annual scales. India Meteorological Department (IMD) Daily gridded rainfall data (0.25° X 0.25° spatial resolution) for the period 1901-2013 analysed over annual and monsoon season which indicates that, there is a weak decreasing trend (-0.18) in all-India ISMR in past 113 years. The analysis was based on linear trend analysis. There are 14 years which are excess and 17 years are deficit rainfall period calculated based on 113 years mean monsoon seasonal rainfall data. From spatial analysis of all-India rainfall climatology over the period of 1901-1950 and 1951-2013, it was concluded that Northeast India is one big cluster having highly decreasing trend whereas Northwest part of India is showing increasing trend since last two decades.

Keywords: IMD Gridded data, Indian summer monsoon, Rainfall, Trend analysis, spatial analysis

I. INTRODUCTION

Approximately 80% of the annual precipitation during monsoon season (June-Sep) is contributed by Indian summer monsoon rainfall (ISMR) over India [1]. India's agriculture, economy, and societal well-being depend significantly on the stability, variability and extremes of summer monsoon rainfall [2]. Deviations in the ISMR from the long-term mean may heavily impact the agricultural productivity and Gross Domestic Product (GDP). Understanding the rainfall trend in long term basis on the ISMR and changes in its temporal and spatial patterns poses a key research challenge [3] with implications on water resources and management policies. The monsoon season follows intense heat of the summer months in the Indian subcontinent which becomes hot and draws moist winds from the oceans. This causes a reversal of the winds over the region which is called the onset of monsoon [4]. The monsoon season in India typically begins in late May/early June. It advances gradually and covers the Indian land mass by June-end / July. After mid-August the Indian summer monsoon undergoes a gradual decaying phase and withdrawal of monsoon begins. By September, the monsoon season in India ends. Many studies over Indian summer monsoon rainfall [5, 6, 7, 8] has been done with India Meteorological Department (IMD) daily gridded rainfall data to establish a long term trend in rainfall pattern at a finer scale considering the spatio-temporal variability. In spite of its regularity, large parts of the country are severely affected due to deficit monsoon rainfall in regular interval of time. In recent past study using high resolution gridded rainfall data [8, 9] showed that there are significant increasing trends in the frequency and magnitude of extreme rainfall events over central India during monsoon season. The study also showed that significant decreasing trend in the frequency and moderate events during the same period, thus leading to no significant trend in the mean rainfall [10]. However, the monsoon rainfall statistics through the twentieth century is dominated by variations of inter annual to inter-decadal time scale. Further it is very important to analyse long term gridded rainfall data using long time series to examine its link with regional scale associated spatial and temporal pattern of rainfall. In this study we have examined variability and long term trends of ISMR in detail using 113 years (1901-2013) IMD gridded rainfall data.

II. DATA ANALYSIS

The details of data used, quality control adopted and the methodologies of interpolation are discussed in this section. The data used for the present analysis is the daily gridded rainfall data (0.25° X 0.25° spatial resolution) from IMD National Climate Data Centre (NCDC) for the period 1901-2013, based on stations that have at least 90% data availability for the same period. The gridded data thus developed have been compared with other similar global data sets. IMD operates about 6329 station observatories, which measure and report rainfall occurred in the past 24 hours ending 0830 hours Indian Standard Time (0300 UTC). In addition, most of the state governments also maintain rain-gauges, for real time rainfall monitoring. IMD digitizes quality controls and archives these

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data also. Before archiving the data, IMD makes multi-stage quality control of observed values. The major source of error is the systematic measuring error which results from evaporation out of the gauge and aerodynamic effects, when droplets are drifted by the wind across the gauge funnel.

Numerical interpolation of irregularly distributed data to a regular N-dimensional array is usually called “Objective analysis” (OA). Thiebaux and Pedder [11] grouped the OA techniques as follows: empirical interpolation, statistical interpolation and function fitting. In empirical interpolation, array values are computed from a distance-weighted sum of the data. The weighting function is usually predetermined. Some of the empirical interpolation techniques are iterative: array values are generated by successive approximation on the basis of errors of back-interpolation to the original data locations. For application to the specific project grid, the statistical optimal interpolation technique displayed the lowest root mean square errors. The Global Precipitation Climatology Project (GPCP) used a variant of the spherical-coordinate adaptation of Shepard’s method [12] to interpolate the station data to regular grid points. These regular points are then averaged to provide area mean, monthly total precipitation on 0.25 grid cells. We have created a data flow diagram (Figure 1) to compute the rainfall gridded data for the same period as discussed above.

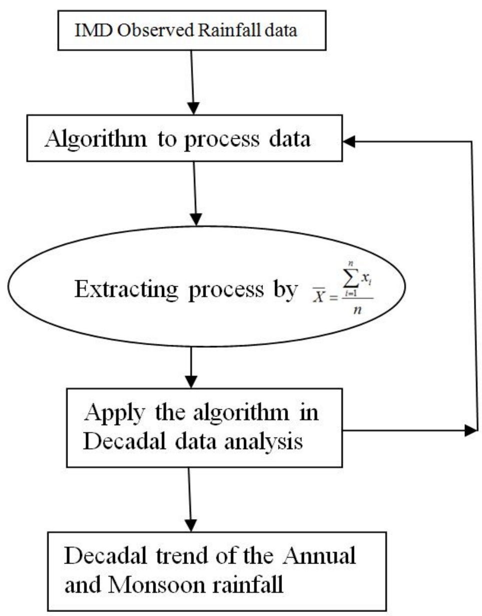

Fig. 1: Data flow diagram to compute the rainfall data in decadal basis over India

III. RESULTS AND DISCUSSION

The monsoon rainfall is very much important to the Indian economy and studies of global circulations. Hence, important statistical characteristics (Mean (M), Standard Deviation (SD) and Coefficient of Variation (CV)) of monthly and seasonal rainfall series of 30 subdivisions, 5 homogeneous regions and all-India for the period 1901-2013 have been computed. For India as a whole, the monsoon months June, July, August and September are main rainy months. The mean rainfall of June, July, August and September is 159.7, 271.7, 244.5 and 169.4 mm respectively. The rainfall of July month is the highest and contributes 25 % of annual rainfall (1085.9 mm). The August rainfall is slightly less than that of July and contributes 22.3 % of the annual rainfall. The June and September rainfalls are almost same and they contribute 14.7% and 15.6 % of the annual rainfall respectively. The year has been divided into four seasons viz., Winter (January+February), Pre-monsoon (March+April+May), Southwest Monsoon (June to September) and Post Monsoon (October +November+December) and the mean seasonal rainfall are 23.9 mm, 94.2 mm, 845.1 mm and 121.5 mm respectively. The Winter, Pre-Monsoon, Monsoon and Post-monsoon season contribute 2.1%, 8.7%, 78.1% and 11.1% of annual rainfall respectively. Abnormalities in the performance of Southwest monsoon rainfall over different parts of India have a significant impact on national economy. The abnormalities in the performance of Southwest monsoon rainfall is the occurrence of excess or deficit monsoon rainfall. Hence, all-India, homogeneous regions and sub-divisional monsoon rainfall of each year has been classified into three categories viz., Excess, Deficit and Normal as follows Excess : R > or = M+SD Deficit : R < or = M-SD Normal : M-SD < R < M+SD Where M and SD are Mean and Standard Deviation of seasonal rainfall time series, R is

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seasonal rainfall. The criteria used in this study is taken from Parthasarathy et al. [13]. For all-India, during the period 1901-2013, seasonal rainfall was excess in 14 years (green bars), deficit in 17 years and normal in 82 years (Fig. 2). It is observed that there are relatively more frequent deficit years (7) during the period 1961-1990. During the recent period (1981-2013, 33 years) deficit years are7. The linear trend in seasonal rainfall series have been examined for the entire 1901-2013 period and it is found very weak decreasing trend of -0.18 mm per year is observed.

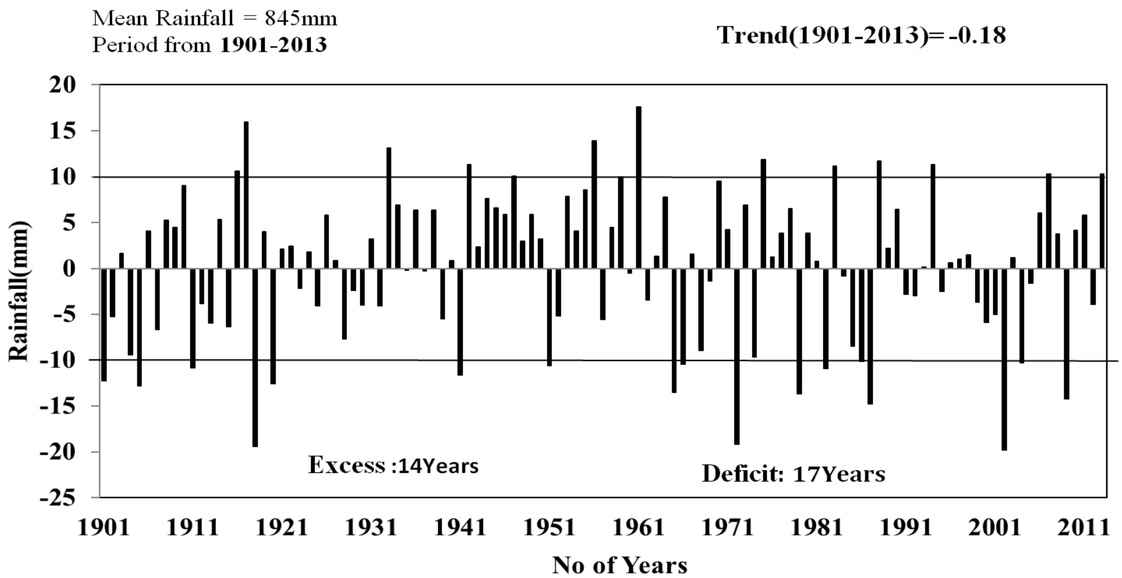

Fig. 2 All India summer monsoon rainfall: 1900-2013.Trend mm/Year significant at 10% level

We have discussed about the monsoon season daily rainfall average over the period of 10 years for past 50 years (1951-2000) (a, b, c, d, e)as window to study the behaviour of the rainfall trend (Fig. 3). It indicates that, there is a decreasing trend of all-India monsoon season rainfall in all decadal period. In the year 1951-1960 the R^2 value is 0.0003 which is comparable with 1981-1990 value of 0.0001, whereas other decadal values are having slightly more compared to all India average.

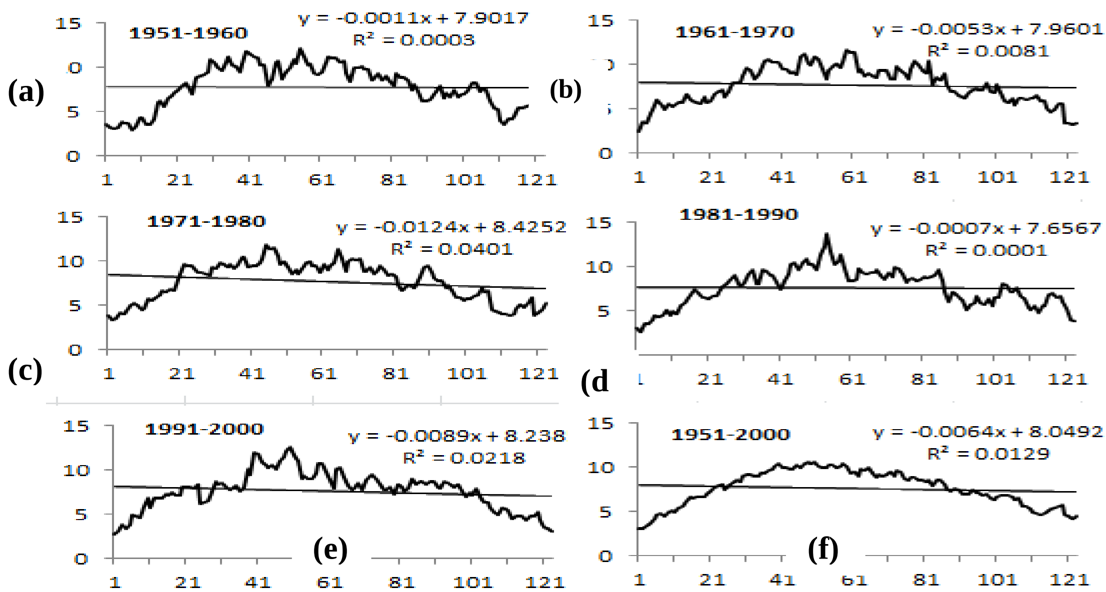

Fig. 3: Decadal trend analysis of IMD observed 0.25°X0.25° degree gridded daily rainfall (mm)data during 1951-2000.All the figures considered(a to e) here for monsoon rainfall period(1951-2000), and figure (f)showing there is an overall decreasing trend of monsoon rainfall in all the decadal analysis.

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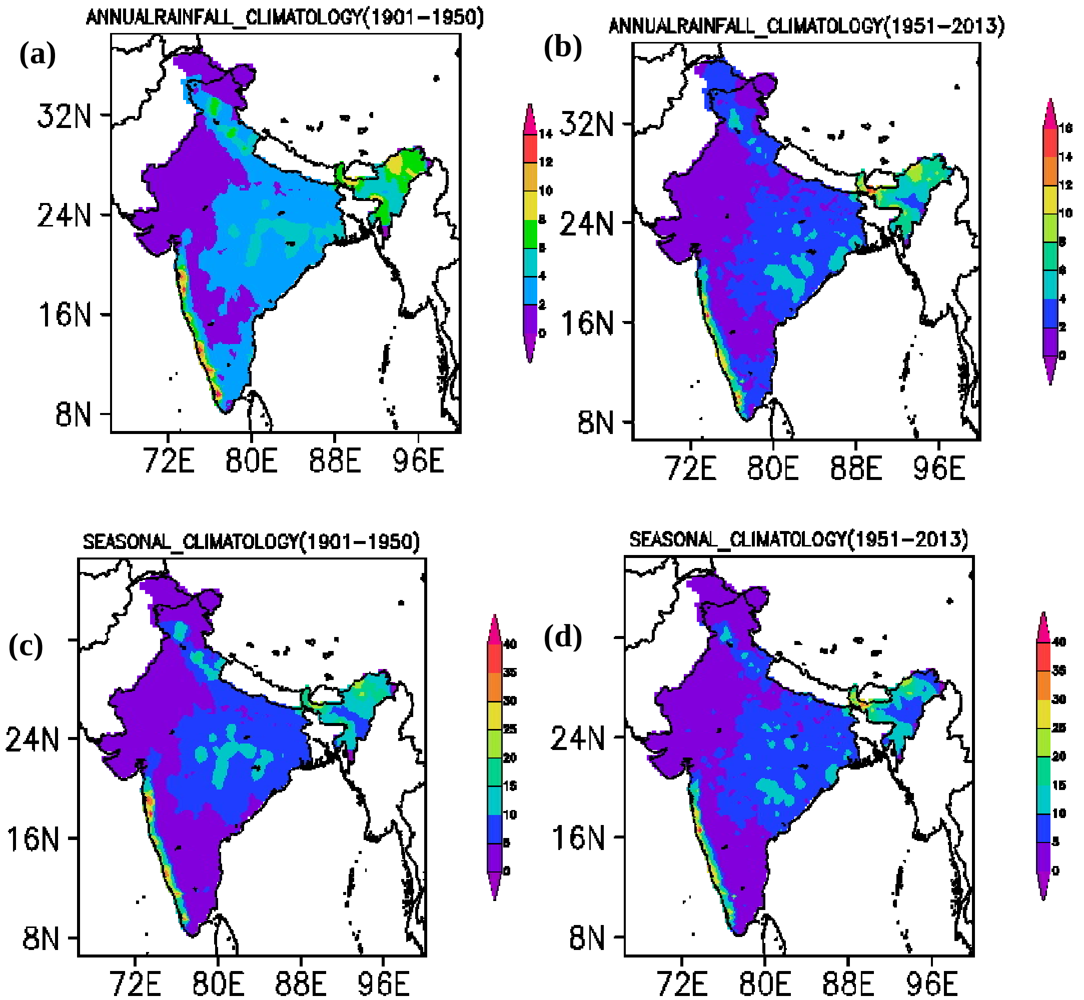

Fig.4: Annual and seasonal climatology of all India rainfall during the period 1901-1950 and 1951-2013.In the upper panel (a) and (b) represent the annual climatology over all-India rainfall where as lower panel (c) an (d) represent the monsoon period climatology for the same period.

For the country as a whole, the monsoon season rainfall and monthly rainfall for the monsoon months do not show any significant trend. But there can be large variation in the regional scale. June rainfall has shown increasing trend for the western and south-western parts of the country (Fig. 4), whereas decreasing trends observed for the central and eastern parts of the country.
July rainfall has decreased for most parts of central and peninsular India but increased significantly in the north-eastern parts of the country. August rainfall has increased significantly. This means that southwest/northeast is the heavy/ weak rainfall occurring region, whereas the central/southeast is the more moderate/less moderate rainfall occurring regions.

IV. CONCLUSION

From the present study, it can be concluded that based on the analysis of past 113 years of gridded data, there is a statistically significant decreasing trend in all India ISM rainfall. Northeast India is one big cluster having hhighly decreasing trend.
The recent period mean seasonal rainfall of India as whole is decreased from the mean rainfall based on the period 1901-2013. However, change in mean rainfall is not statistically significant.
Also, mean seasonal rainfall of Central Northeast India and Northeast India for the recent period is significantly reduced from the period 1901-1980. In addition to the trend analysis we have computed the number of occurrence of excess/deficit monsoon for all-India.

V. ACKNOWLEDGEMENT

The authors gratefully acknowledge India Meteorological Department (IMD) to provide daily gridded rainfall data for spatial and temporal analysis of Indian monsoon and annual rainfall. The CSIR 4PI high-performance computing (HPC) facility used for computing is acknowledged gratefully. The authors acknowledge Head, CSIR 4PI for support and encouragement.

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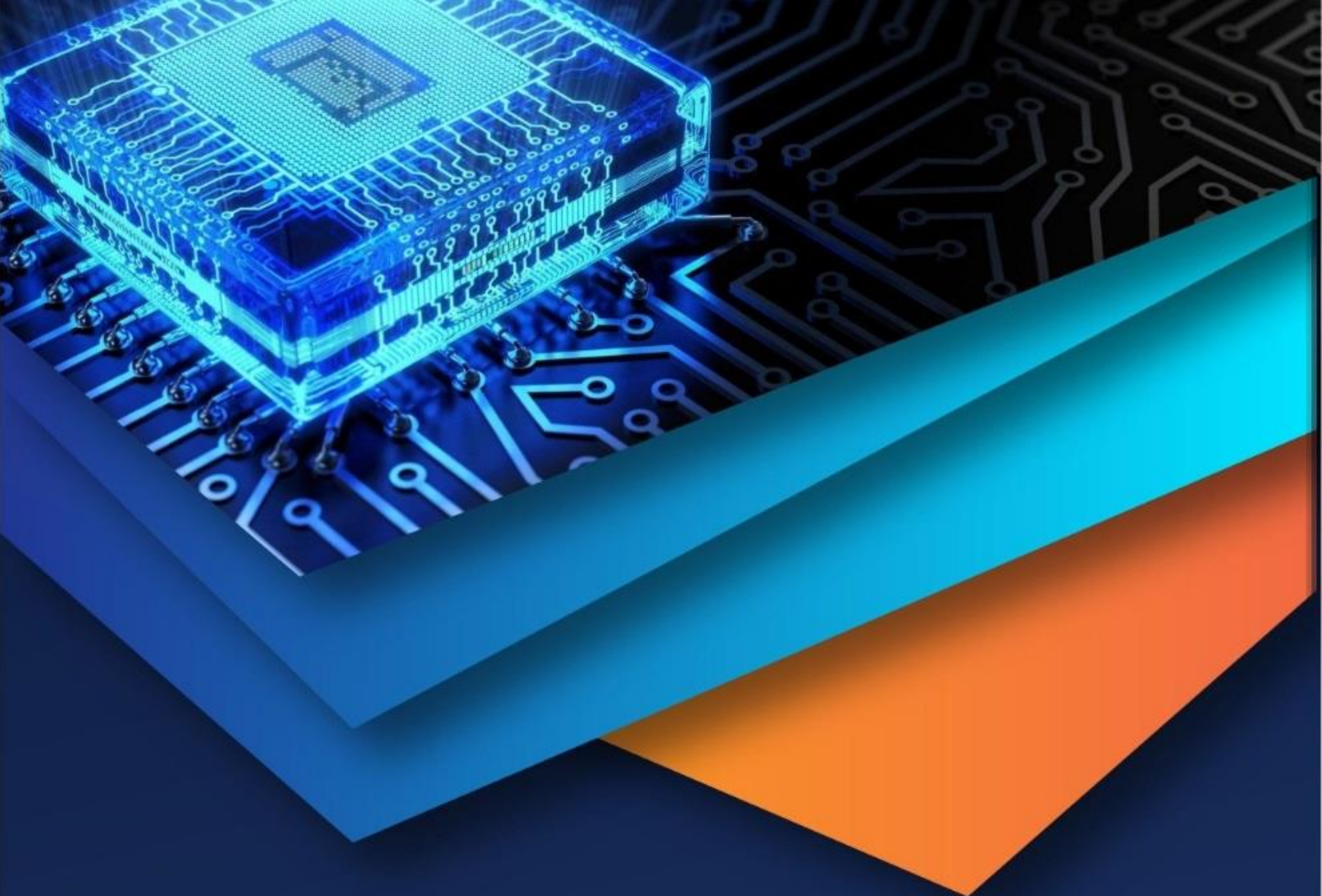

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