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Research Article

TREND ANALYSIS OF RAINFALL DATA -A COMPARATIVE STUDY OF EXISTING METHODS

***R. Stella Maragatham**
Department of Mathematics, Queen Mary's (Autonomous) College, Chennai-04 (South India)
**Author for Correspondence*

ABSTRACT
Rainfall studies are of utmost utility for understanding nature & hence the behavior of climate changes. Time series is a set of observations taken at specified times usually at equal interval. Thus a set of data depending on time is called a Time series. Here, Rainfall series represent the time series. The time series analysis is helpful to compare the actual performance and analyze the cause of variations. By comparing different time series we can draw important conclusion. There are four types of movements called the four components of time series namely Secular Trends, Seasonal variation, Cyclical variations, Irregular or random movement.
Out of four components 'Trend' is a common terminology used. There are many types of Trends, the series may be increasing or decreasing at various rate. These variables are observed over a long period of time and any changes related to time or noted and calculated and a Trend of these changes is established. Some remain relatively constant and reverse from growth to decline or from decline to growth over a period of time. A change in these conditions would affect the forecast.
In the present study secular changes in the annual rainfall of 1476 rain gauge stations for the period of 100 years from 1901 – 2000 in India have been studied. We present various test to detect the best suitable trend for the rainfall time series.

***Key Words*:** *Time Series, Trend, Variations, Moving Averages , Precipitation*

INTRODUCTION
Changing precipitation pattern, and its impact on surface water resources, is an important climatic problem facing society today. Associated with global warming, there are strong indication that rainfall changes are already taking place on both the global and regional scales (India receives about 80% of its total rainfall during the summer monsoon season, from June to September (Sahai *et al.*, 2003). Goswami et al. (2006) using a high resolution daily gridded rainfall data set showed that there are significant rising trends in the frequency and the magnitude of extreme rain events over central India during the monsoon season. The study also showed that significant decreasing trend in the frequency of moderate events during the same period, thus leading to no significant trend in the mean rainfall. Variation in the monsoon rainfall has both social and political impact as in India agriculture largely depends on rain. For observed data that exhibit high seasonality, methods to analyze trends should be those that incorporate the seasonal component. Spatial differences in trends can occur as a result of spatial differences in the changes in rainfall and temperature and spatial differences in the catchment characteristics that translate meteorological inputs into hydrological response (Burn and Elnur, 2002).
Trend is present when a time series exhibits steady upward growth or a downward decline, at least over successive time periods. Trend may be loosely defined as "long-term change in the mean level", but there is no fully satisfactory mathematical definition. But trend analysis helps in finding 'forecasting'. The base of scientific forecasting is statistics.
Trend analysis was carried out to examine the long term trends in rainfall over different subdivisions. The rainfall trend is very crucial for the economic development and hydrological planning for the country. Long term trends of Indian Monsoon rainfall for the country as a whole as well as for smaller regions have been studied by several researchers.

In this paper, several approaches have been proposed for analyzing time series such as Graphical, Semi Average., Moving Average., Least square method. The purpose of this research is to detect best trend for the time series taken into account.

In recent years the techniques of forecasting have improved to a marked degree and are applicable everywhere. Though there are several methods, techniques have been developed in finding the trend and forecasting, the finding suitable method is an important task, because the rainfall trend is very crucial for the economic development and hydrological planning for the country.

Details of Data and Processing:

The study area covers 36 meteorological sub divisions of the country. From 1476 rain gauge stations for the period 1901-2000, we have considered 458 districts for the present analysis. The district rainfall is calculated as the arithmetic average of rainfall data of stations in the district. Thus the rainfall data series is constructed as spatially and temporally homogeneous. The Rainfall data are given in table 1.

Climate change is one of the most important challenges among researchers. In the context of climate change, it is pertinent to ascertain whether the characteristics of Indian monsoon are also changing. No one can deny that climate change and rainfall pattern are inter related.

Rainfall is a key input in management of agriculture and irrigation projects and any change in this variable can influence on sustainable management of water resources, agriculture and ecosystems.

Determining trend of rainfall (especially) will be useful for better water management in the study area. From the data available, by applying suitable trend detection method, we can forecast the pattern of rainfall.

Trend Analysis:

The annual rainfall series in respect of 1476 rain gauge stations were tested for the presence of trends by applying the one or more of the below maintained methods.

1. Graphical method
2. Semi Average method
3. Moving Averages
4. Least squares method

a. Conventional approach
b. Window based approached

Graphical Method:

In Graphical method by fig (1), significant trend does not appear. During rainfall seasons in each year, the rainfall in average of 306 rain-gauge stations appears to be slightly decreasing. ie., decreasing trend appears marginally.

Semi Average Method:

In fig.(2), the data gives an increasing trend which give raise to the increase of rainfall in the country. But in fact, in the normal observation, it is not so.

Moving Averages (3 yrs & 5 yrs):

The concept of moving averages is based on the idea that any large irregular components of time series at any point in time will have a less significant impact on the trend, if the observation at that point in time series is averaged with such values immediately before and after the observation under consideration (Fig. 3) the Moving Averages shows that there is an increasing trend after 1990. Rainfall was above normal in winter and below normal in pre monsoon and post-monsoon.

It is seen that the behavior of Monsoon rainfall is almost similar to all the years from 1900 to 2000 except the year 1955, 56. The characteristics of rainfall changed during those years may be due to so many reasons especially climate change, plateau movements in lands.

Least Square Method:

a) Conventional approach:

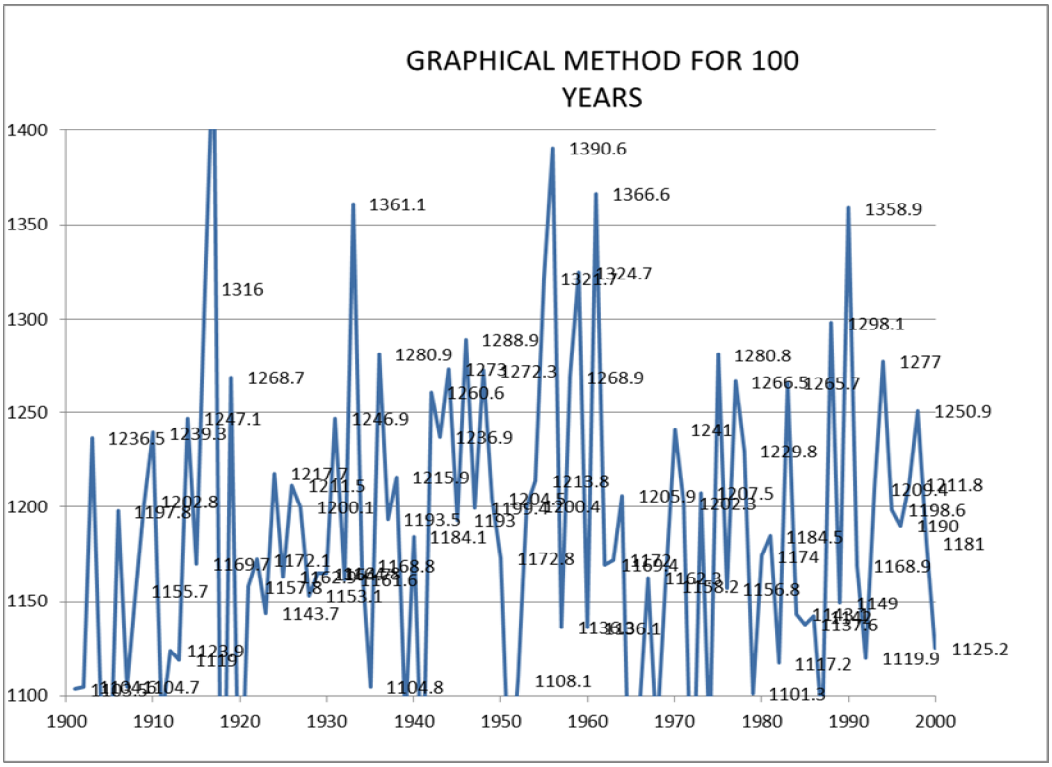

Figure 1: Graph by Graphical method

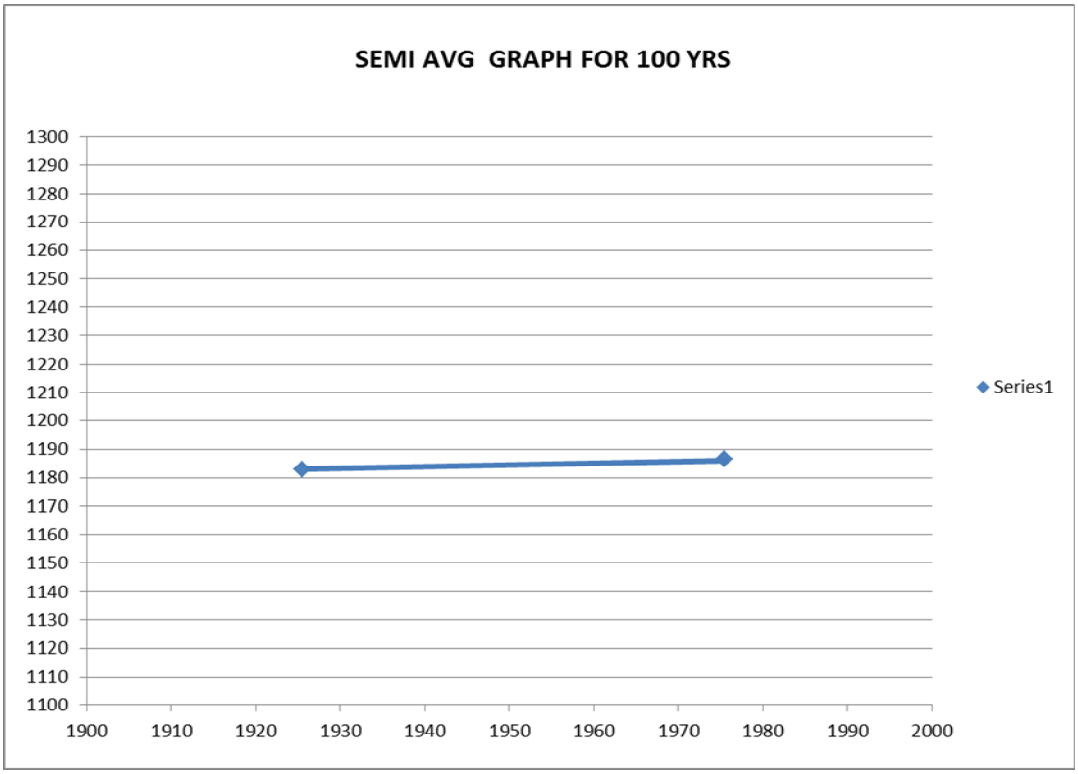

Figure 2: Semi Average Graph for 100 years

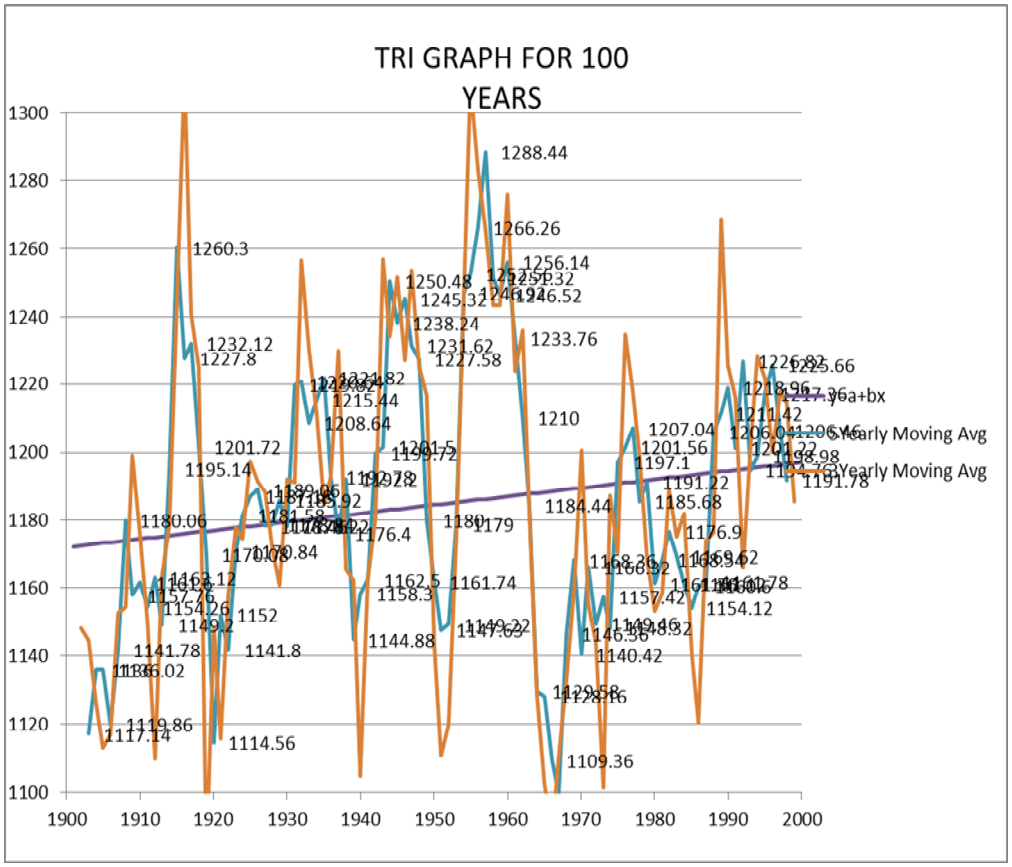

Figure 3: Graph by Least Square method and Moving Average of 3 and 5 years

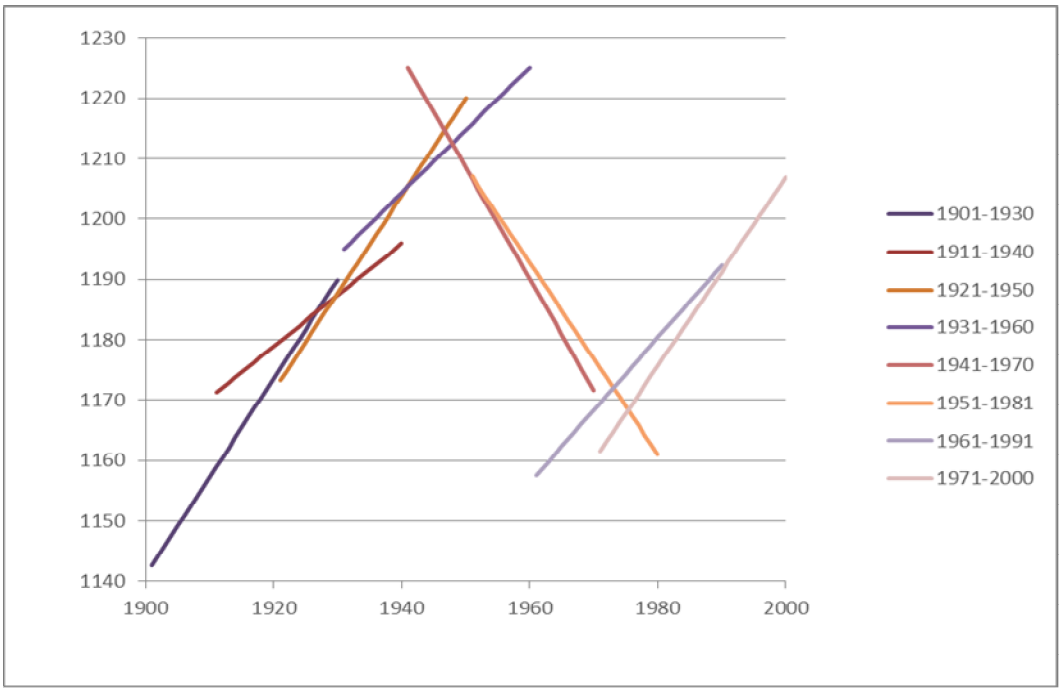

Figure 4: Graph by Least Square method for a window size of 30 years

Though the method is more accurate than the graphical method, fig(2) gives a straight line showing increasing trend, the epochal behavior of semi Average method is almost similar to that of least square method.

b) Window based approach:

An attempt has been made to modify the conventional approach of trend analysis by breaking the date into various windows. Each window is then taken as a separate data set and analyzed for the behavior of trend. These trends are then used for extrapolation / forecasting purposes. In the present study a window size of 30 yrs is used.

By breaking the data into 30 years packages there is a major difference in trend calculations. By linear trend (least squares) method and by Semi Average method, significant changes occur in the data. Ref. fig.(3)

The sequence of period of 1901-1930, 1914 – 1940, 1921 – 1950, 1931 – 1960 show an increasing trend (may be the wet period) and the sequence of periods 1941 – 1970 & 1951 – 1980 show decreasing trends. After that for the sequence of periods 1961 – 1990 & 1971 – 2000 again the trend is up. Whereas when we break the data of 100 yrs in 40's, the observation is slightly different. ie. For the first '3' 40 years period, it shows an increasing trend & next '3' 40 years decreasing and so on.

It is interesting to note that the results obtained by trend analysis using conventional methods are more accurate than obtained by other methods. Also it can be seen that the 'Window approach' used here brings out the negative trend behavior for two of the six date sets analyzed. This fact is does not reflect in the conventional trend analysis results. Work is now being continued to analysis the negative trend for its importance in understanding the behavior of Rainfall and if possible the causes for the same.

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Conclusion

We have analyzed various available of the trend analysis method for their use in analyzing of the rainfall data. It can be seen that the **"Least squares"** method gives accurate results in comparison to any other method for understanding rainfall pattern.

REFERENCES

Alvi SMA and Koteswaram P (1985). Time series analysis of annual rainfall over India. *Mausam* **36(**4) 479-490.

Burn, D.H. and M.A. Hag Elnur (2002). Detection of Hydrologic Trends and Variability. Journal of Hydrology **255**, 107-122.

de Beurs, K. M., Henebry, G. M. (2005). A statistical framework for the analysis of long image time series. International Journal of Remote Sensing **26** (8), 1551 – 1573

Goswami, B. N., V. Venugopal, D. Sengupta, M. S. Madhusoodanan, and P.K. Xavier (2006) Increasing trend of extreme rain events over India in a warming environment Research, 20: 127-136, Science, 314, 1442 – 1444

Makridakis, S., Wheelwright, S. C., Hyndman, R. J(1998). Forecasting: Methods and applications, 3rd Edition. John Wiley & Sons, New York

Krishnakumar, K.N., G.S.L.H.V.P. Rao and C.S. Gopakumar (2009). Rainfall trends in twentieth century over Kerala, India. Atmospheric Environment, **43** 1940-1944.

Kumar, V. and S.K. Jain (2010). Trends in seasonal and annual rainfall and rainy days in Kashmir Valley in the last century. Quaternary Int., **212** 64 – 69

Rakhecha, P.R. & pisharoty, P.R, (1996) Heavy rainfall during monsoon season: Point and spatial distribution current science,. **71** 177-186.

Sahai AK, Grimn AM, Satyan V, Pant GB (2003) Long lead prediction of Indian summer monsoon rainfall from global SST Evolution.- Climate Dynamics **20** 855-863

Van Belle, G. and J. P. Hughes (1984). Nonparametric tests for trend in water quality. Water Resource

WMO 2000. Detecting trends and other changes in hydrological data. WCDMP 45, WMO TD 1013 , 157 p.