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Study of Trend of Rainfall over Tamil Nadu

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Abstract:
Trend in the rainfall of the meteorological subdivisions of Tamil Nadu have been studied utilizing the data for the 140 years period from 1871 to 2011. It has been observed that the Mann Kendall trend analysis resulted in accepting the null hypothesis. Thus the absence of trend in the Tamil Nadu rainfall cannot be ignored. The decadal trend and the percentage contribution of the southwest monsoon rainfall and the northeast monsoon rainfall to the annual rainfall is calculated and the northeast monsoon contribution to the annual rainfall has increased from 1921 to 2011. The percentage contribution of the southwest monsoon rainfall has decreased over the years.

Keywords: *Trend, Mann Kendall trend, null hypothesis, percentage contribution*

1. Introduction

The study of weather and climate of a region is essential for the planning and substantial development of that region. The weather pattern varies from global scale to the regional scale. The analysis of long term trend that prevails in weather pattern helps in understanding the extreme weather event that can lead to drought, heat, flooding, etc., so that better adaptive methods can be devised. The long term trend analysis of the rainfall in a region is crucial for its economic development and hydrological planning. The long term trend rainfall has been investigated by several researchers on country scale, regional scale and individual station. The seasonal contribution of rainfall to the annual rainfall and its trend over India was studied by Parthasarathy and Dhar (1975), Rajeevan, Jyoti Bhate,and A. K. Jaswal (2008) also reported that the increasing trend in the extreme rainfall event in the last five decades is associated with increase in sea surface temperature which may lead to major flood risk over the central parts of India. Kumar et al (2010) showed that half of the Indian sub-divisions showed an increasing trend in annual rainfall, but for only three was this trend statistically significant. They state that "only one sub-division indicated a significant decreasing trend out of the 15 sub-divisions showing increasing trend in annual rainfall. Guhathakurta and Rajeevan (2007) have investigated the significant change in the monthly contribution of rainfall in the annual rainfall . At the regional level Sarma, Lakshmi Kumar and Koteswara Rao (2010) has studies the aspects of excess and deficit in summer monsoon rainfall through probability methods for Andhra Pradesh.

Tamil Nadu, located at an 11° 00' N latitude and 78° 00' E Longitude is the eleventh largest state in India. The southernmost tip of the Indian Peninsula is located in Tamil Nadu. Tamil Nadu is heavily dependent on monsoon rains, and thereby is prone to droughts when the monsoons fail. It has distinct periods of rainfall, which are the advancing monsoon period, South West monsoon (from June to September) with strong southwest winds, the North East monsoon (from October to December), with dominant northeast winds, and the Dry season (from January to May). The normal annual rainfall of the state is about 945 mm (37.2 in) of which 48% is through the North East monsoon, and 32% through the South West monsoon. Since the state is entirely dependent on rains for recharging its water resources, monsoon failures lead to acute water scarcity and severe drought.

2. Data And Methodology:

Trend is the long term change in the mean level and it is analyzed on a monthly, seasonal and annual scale for the state of Tamil Nadu. The rainfall data from 1871 to 2011 was procured IITM web site. In recent years forecasting has improved to a marked degree. Several techniques have been developed to find trend in the rainfall pattern. In the present paper we have employed the Mann Kendall Rank test to identify the turning point or the monotonic change the rainfall pattern of Tamil Nadu. From the monthly rainfall data the seasonal mean, standard deviation, coefficient of variation (CV) and percentage contribution to annual rainfall is estimated and presented in Table 1. The data was subjected to a 11 year running mean and a linear trend line was fitted to understand the trend in the rainfall pattern of Tamil Nadu. Figure 1 represents the linear trend analysis for the Annual, South west and Northeast monsoon rainfall of Tamil Nadu.

3. Seasonal Rainfall Pattern:

The Rainfall features are tabulated in Table 1. The annual rainfall of Tamil Nadu form1871 to 2011 is 930mm with a standard deviation of 148.5mm. The rainfall during the month of October and November contribute the maximum to the Annual rainfall of Tamil Nadu. October and November are the periods of the Northeast monsoon. Northeast Monsoon is the major Rain bearing season the state of Tamil Nadu. The Northeast monsoon contributes about 49 % to the Annual rainfall. The months January through April contribute on an average of about 3 % rainfall to the annual Rainfall. Also the coefficient of variation for the annual rainfall is 16 % and is Stable. The coefficient of variation is high during the months of January (142.5%) , February (172.0%) and March (125.7%). The coefficient of contribution is least during the heaviest monsoon season with 23.1% for south west monsoon and 30 % for northeast monsoon.

4. Mann Kendall Trend Analysis Of Tamil Nadu Rainfall

The Mann–Kendall is a nonparametric trend test, i.e., it does not require that the data follow a certain statistical distribution. Mann–Kendall test is chosen for the study as it is able to identify any trend in a time series without specifying whether the trend is linear or non-linear (Salas 1993; Lins and Slack 1999; Hisdal et al. 2001) Also, the Mann–Kendall test is rank order based, insensitive to missing values, and easy to calculate.

The computational procedure for the Mann Kendall test considers the time series of n data points and Ti and Tj as two subsets of data where i = 1,2,3,…, n-1 and j = i+1, i+2, i+3, …, n. The data values are evaluated as an ordered time series. Each data value is compared with all subsequent data values. If a data value from a later time period is higher than a data value from an earlier time period, the statistic *S* is incremented by 1. On the other hand, if the data value from a later time period is lower than a data value sampled earlier, *S* is decremented by 1. The net result of all such increments and decrements yields the final value of *S* (Drapela, K., Drapelova, I., 2011.)

The Mann-Kendall S Statistic is computed as follows:

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} sign(T_j - T_i)$$

$$Sign(T_j - T_i) = \begin{cases} 1 \; if \; (T_j - T_i) > 0 \\ 0 \; if \; (T_j - T_i) = 0 \\ -1 \; if \; (T_j - T_i) < 0 \end{cases}$$

Where T_j and T_i are the annual values in years j and i, j>I, respectively.[10]. At a certain probability level H_0 (no trend in time series) is rejected in favour of H_1 (possible trend in time series) if the absolute value of S equals or exceeds a specified value $S_{\alpha/2}$, where $S_{\alpha/2}$ is the smallest S which has the probability less than α/2 to appear in case of no trend. A positive (negative) value of S indicates an upward (downward) trend. For n = 10, the statistic *S* is approximately normally distributed with the mean and variance as follows:

E(S) = 0

The standard test statistics Z_s is calculated as follows

$$Z_s = \begin{cases} \frac{S-1}{\sigma} \; for \; S > 0 \\ 0 \; for \; S = 0 \\ \frac{S+1}{\sigma} \; for \; S < 0 \end{cases}$$

The test statistic Zs is used a measure of significance of trend. In fact, this test statistic is used to test the null hypothesis, H0.If | Zs| is greater than Z a/2, where a represents the chosen significance level (eg: 5% with Z0.025 = 1.96) then the null hypothesis is invalid implying that the trend is significant (Motiee H., McBean E., 2009)

The Test was run using Addinsoft's XLSAT 2012 software. The results obtained for Mann Kendall trend is tabulated in Table 2. If the p value is less than the significance level α =0.05, H0 is rejected. Rejecting H0 series, while accepting H0 indicates that there is a trend in the time indicates no trend was detected.

From Table 2 in it inferred that the p value is greater than α (0.05). Thus we fail to reject the null hypothesis H_0(no trend in the rainfall time series). This implies that the data are not sufficient to persuaded us for the alternative hypothesis H_1 (presence of significant trend in the rainfall) over the null hypothesis. Thus we have insufficient evidence to find any trend in the Tamil Nadu rainfall data. We can observe from Table 2 that the risk of rejecting the null hypothesis H_0, while it is true is 17.6 % for annual rainfall, 11.4% for North East monsoon rainfall and 48.7% for South West monsoon rainfall.

5. Decadal Trend Analysis Of Tamil Nadu Rainfall

Though there is no sufficient evidence for a trend in the Tamil Nadu rainfall, we analyse the decadal trend of the annual, northeast and southwest monsoon rainfall. We also analyse the percentage contribution of the southwest and northeast monsoon rainfall to the annual rainfall and it is tabulated in Table 3. Figure 2 show the trend line southwest monsoon and the northeast monsoon. The percentage contribution of the southwest monsoon to annual rainfall reduces through 1871 to2011. The northeast monsoon contribution to the annual rainfall is consistent with 50 %.

6. Conclusion

An important aspect of the present study is the significant decrease in southwest monsoon rainfall while increase in northeast rainfall on a decadal scale. The yearly analysis of the annual, southwest and northeast monsoon rainfall did not show any significant trend in its nature. The Mann Kendall test resulted in accepting the null hypothesis H_0 (no trend in the rainfall time series). Southwest monsoon rainfall contribution declines from 1921 to 2011 and increase in the northeast monsoon rainfall contribution is also from 1921 to 2011. The decreasing trend in southwest monsoon rainfall over Tamil Nadu is supported by other researchers (Balachandan et al.2006, Guhathakurta and Rajeevan, 2007. Rajalakshmi et al.2011). Thus more robust techniques are required to forecast the northeast monsoon of Tamil Nadu as it exhibits no trend in its yearly rainfall time series.

Month	Rainfall(mm)			
	Mean	Standard deviation	CV (%)	Percentage Contribution to annual rainfall
January	22.8	32.5	142.5	2.4
February	14.7	25.4	172.0	1.6
March	16.8	21.1	125.7	1.8
April	42.9	31.9	74.2	4.6
May	66.6	37.5	56.3	7.2
June	46.7	21.7	46.5	5.0
July	61.7	31.9	51.7	6.6
August	90.6	39.7	43.8	9.7
September	109.3	40.8	37.3	11.7
October	186.7	70.1	37.6	20.1
November	183.6	91.2	49.7	19.7
December	88.5	69.1	78.1	9.5
Annual	930.9	148.5	16.0	100.0
Southwest	308.3	71.3	23.1	33.1
Northeast	458.8	138.9	30.3	49.3

Table 1 : Monthly and Seasonal Means of rainfall (mm) over Tamil Nadu from 1871-2011

Rainfall	Mann Kendall Test				
	Mann Kendall statistics (S)	Var (S)	p- Value (two tailed test)	Alpha(α)	Test interpretation
ANNUAL	524	314739.3	0.176	0.05	Accept H_0
NORTHEAST	678	314736.7	0.114	0.05	Accept H_0
SOUTHWEST	19	314742.3	0.487	0.05	Accept H_0

Table 2: Mann Kendall results for Tamil Nadu annual, northeast and southwest monsoon

YEAR	ANNUAL	SOUTHWEST	NORTHEAST	percentage contribution to annual rainfall (%)	
				SW	NE
1871-1880	861.9	301.51	397.1	34.98	46.07
1881-1890	934.67	310.4	489.78	33.21	52.40
1891-1900	911.86	313.59	444	34.39	48.69
1901-1910	936.3	347.57	418.39	37.12	44.69
1911-1920	942.3	317.9	495.96	33.74	52.63
1921-1930	964.94	284.92	470.91	29.53	48.80
1931-1940	928.42	279.53	468.92	30.11	50.51
1941-1950	911.72	298.85	422.34	32.78	46.32
1951-1960	892.92	287.37	425.07	32.18	47.60
1961-1970	955.58	324.95	479.49	34.01	50.18
1971-1980	945.46	319.76	496.38	33.82	52.50
1981-1990	875.48	321.88	393.92	36.77	44.99
1991-2000	942.56	316.06	484.74	33.53	51.43
2001-2011	1019.41	293.42	528.84	28.78	51.88

Table 3: Percentage contribution of northeast and southwest monsoon rainfall to the annual rainfall of Tamil Nadu on an decadal scale

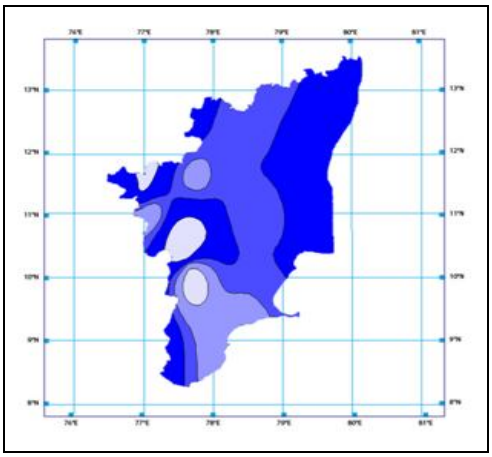

Figure 1: Location of Tamilnadu

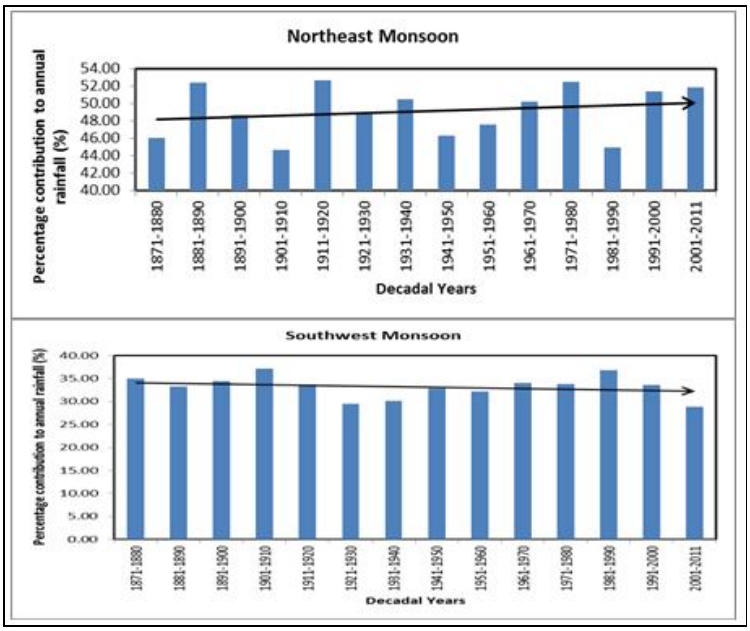

Figure 2: Percentage contribution of northeast and southwest monsoon rainfall to the Tamil Nadu annual rainfall.

7. References

1. B.parthasarathy and O.N.Dhar., 1975, Trend Analysis of Annual Rainfall, Hydological Sciences-bulletin, XX, 26.
2. M.Rajeevan,Joythi Bhate and A.K.Jaswal,2008, Analysis of Variability and trend of extreme rainfall events over India using 104 years of gridded daily rainfall data, Geophysical research letters,vol.35,L18707
3. Kumar, V., Jain, S.K. and Singh, Y. 2010. Analysis of long-term rainfall trends in India. *Hydrological Sciences Journal* **55**: 484-496
4. S Balachandran, R Asokan and S Sridharan, Global surface temperature in relation to northeast monsoon rainfall over Tamil Nadu, J. Earth Syst. Sci. 115, No. 3, June 2006, pp. 349–362.
5. P. Guhathakurta and M. Rajeevan, 2007, Trends in the rainfall pattern over India, Int. J. Climatol, DOI: 10.1002/joc.1640
6. Salas JD (1993) Analysis and modeling of hydrologic time series. In: Maidment DR (ed) Handbook of hydrology. McGraw-Hill, New York, pp 19.1–19.72.
7. Samuel Selvaraj. R and Raajalakshmi Aditya, 2011, Study on Correlation between Southwest and Northeast Monsoon Rainfall over Tamil Nadu, Universal Journal of Environmental Research and Technology, Volume 1, Issue 4: 578-581
8. Lins HF, Slack JR (1999) Streamflow trends in the United States. Geophys Res Lett 26(2):227–230
9. Hisdal H, Stahl K, Tallaksen LM, Demuth S (2001) Have streamflow droughts in Europe become more severe or frequent. Int J Climatol 21:317–333.
10. Drapela, K., Drapelova, I., 2011. Application of Mann-Kendall test and the Sen's slope estimates for trend detection in deposition data from Bílý Kríž (Beskydy Mts., the Czech Republic) 1997–2010. Beskdy Mendel University in Brno 4 (2), 133–146.
11. Motiee H., McBean E., 2009. An Assessment of Long Term Trends in Hydrologic Components and Implications for Water Levels in Lake Superior. Hydrology Research, 40.6, 564-579.
12. AALN Sarma,T.V.Laskhmi Kumar, and K Koteswara Rao, 2010,Extreme value analysis of summer monsoon rainfall over Andra Pedesh,Indian Journal of Radio and Spce Physics, Vol. 39,pp32-38