

Assessment of Long-Term Rainfall Correlation Trends in Eastern Peninsular India

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Introduction

The work presented here uses Markov Chain analysis to provide a thorough understanding of the rainfall over Eastern Peninsula region of India (EPI). The Indian summer monsoon rainfall (ISMR), which has been seen through normal distribution fitting, has a greater influence on the overall pattern of annual rainfall over eastern peninsula India than the post-monsoon season. The rainfall time series, discretized to a binary time series, has been demonstrated to be serially independent via a Markovian analysis. For all the time series being taken into consideration, a rescaled-range analysis is carried out. It has been noted that the Hurst exponent is smaller than 0.5 in each of the three examples. The time series, it has been found that, do not exhibit significant long-term auto-correlation. Rather, there is a long-term fluctuation between high and low rainfall values.

Methods

Data

The Indian Institute of Tropical Meteorology's (IITM) website was used to collect observational data on rainfall across Eastern Peninsular India (EPI) from 1848 to 2005.

Markov chain analysis

The annual rainfall model, which is based on the Markov Chain model, has a number of benefits. The time series of rainfall under discussion contains a continuous random variable. In order to use Markov Chain models, a discrete random variable that would be obtained from this continuous random variable by defining a new random variable in the manner described below is required:

$X_t = 0$ if the observation at time point t is less than the mean of the data set

$X_t = 1$ if the observation at time point t is equal or greater than the mean of the data set.

The transition probabilities are basically conditional probabilities in the FOTS Markov Chain model, where the event of interest is the state of the system at a specific time point and the conditioning event is the immediately previous state of it.

$$P[X_t = 1 | X_{t-1} = 0] = P_{01}$$

$$P[X_t = 1 | X_{t-1} = 1] = P_{11}$$

$$P[X_t = 0 | X_{t-1} = 0] = P_{00}$$

$$P[X_t = 0 | X_{t-1} = 1] = P_{10}$$

Here, suffix t denotes the system's state at time point t , while suffix $(t-1)$ denotes the system's state at the previous time point.

Rescaled range analysis

There are numerous methods for calculating Hurst exponents. Rescaled range analysis is employed among all these techniques. According to Hurst, for shorter time series, the distance covered by any random particle would increase with the square root of the time.

It can be written as follows

$$R = \sqrt{T} = T^{0.5}$$

Here, R = Distance covered (Range) T = Time Index

When we divide R by the Standard deviation S of the time series it becomes dimensionless.

Results and Discussions

We consider the null hypothesis H_0 that the data are normally distributed. The alternative H_1 is that they are not normally distributed. For both JJAS and ANNUAL case the computed value of chi-square is more than the tabular value and hence the null hypothesis is rejected. So, from these we can say that the behaviour of the annual rainfall is being influenced by the behaviour of the JJAS pattern not by the OND pattern.

Season	Value of Hurst exponent	Conclusion
JJAS	H=0.32	long-term switching between high and low values.
OND	H=0.36	long-term switching between high and low values.
Annual	H=0.24	long-term switching between high and low values.

Table -Outcomes of Rescaled-Range analysis of rainfall over eastern peninsula region

For Markov chain, null hypothesis H_0 is that the data are serially independent. This is being tested against the alternative hypothesis H_1 proposing Markovian dependence. For JJAS and Annual the computed chi-square values are 2.379 and 0.304 respectively with 3 degrees of freedom. The tabular value is $\chi^2_{0.05,3} = 7.815$. Since the tabular value is greater than the computed value in both the cases, the null hypothesis proposing serial independence is rejected for JJAS as well as Annual rainfall over the study zone. Hence, it can be interpreted that both the time series are characterized by FOTS Markov chain process.

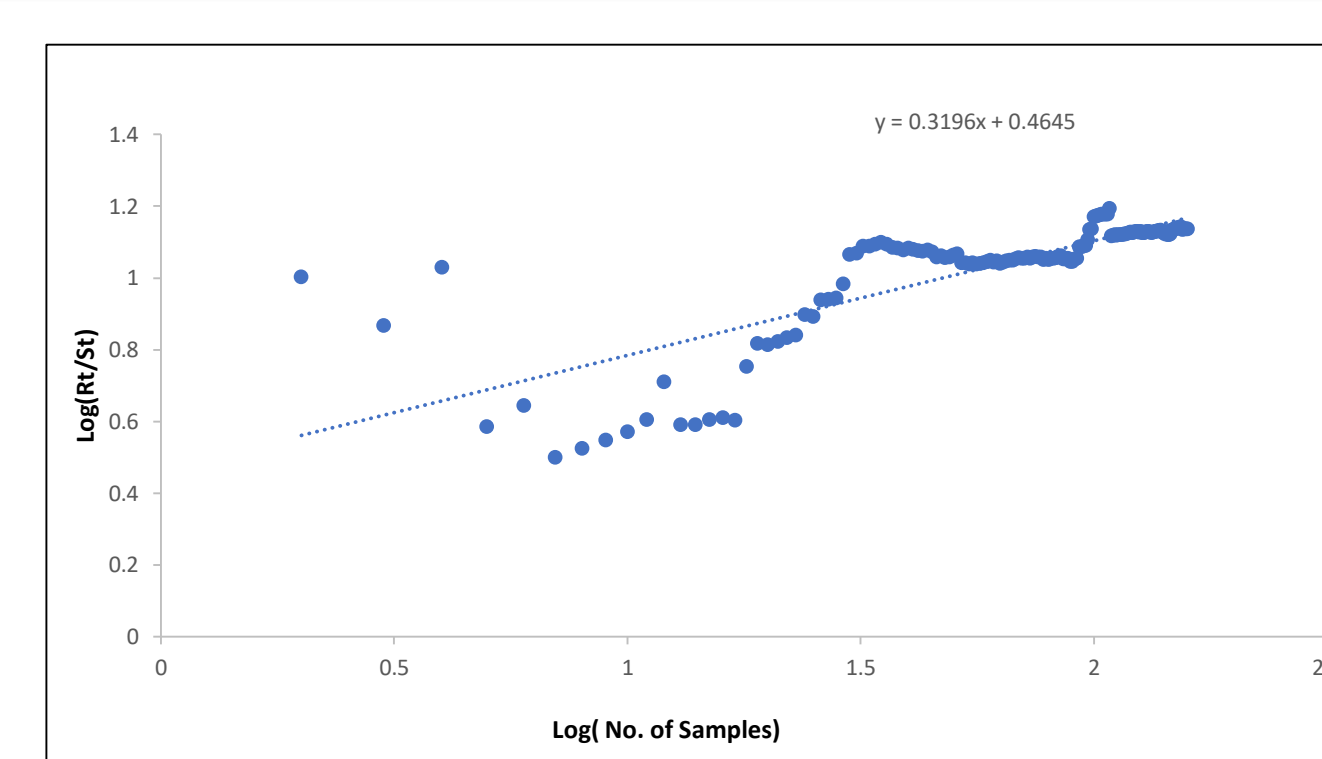


Fig.1

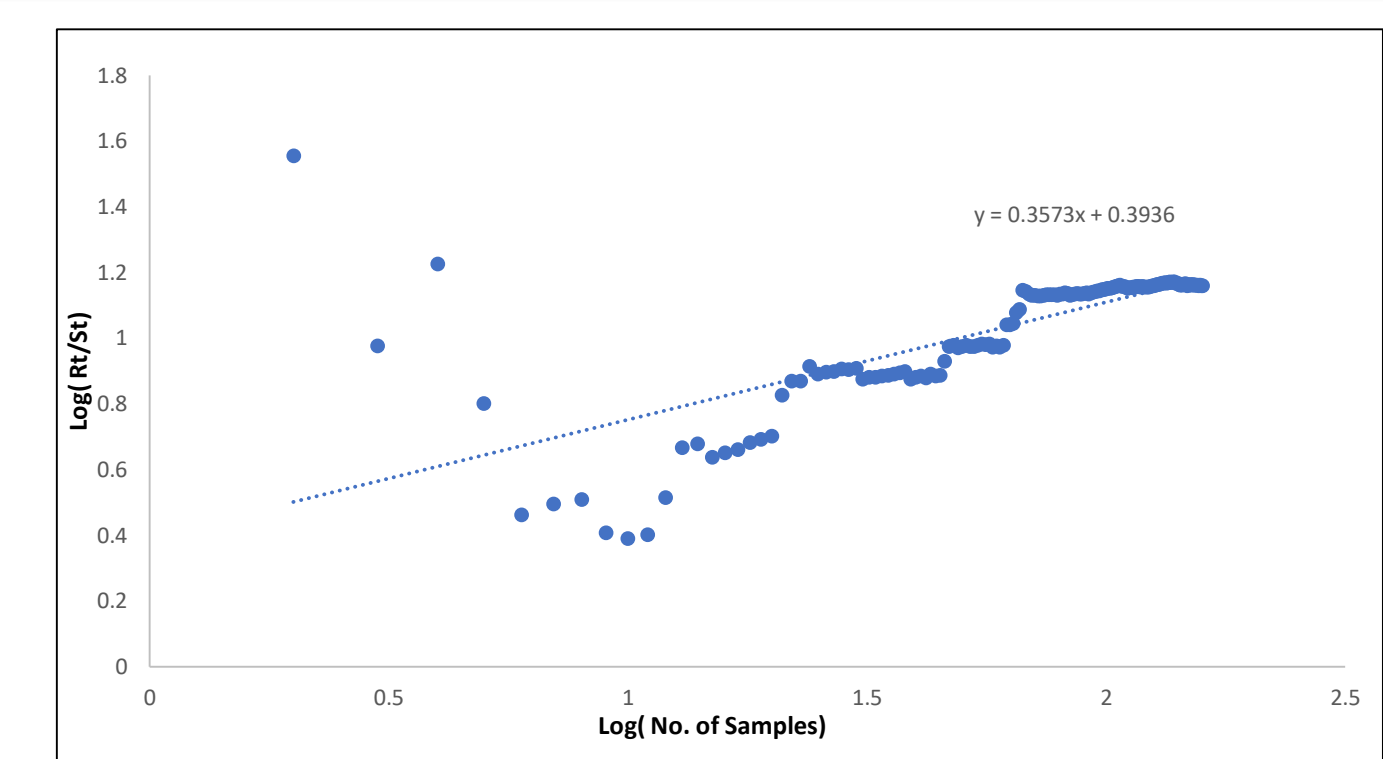


Fig.2

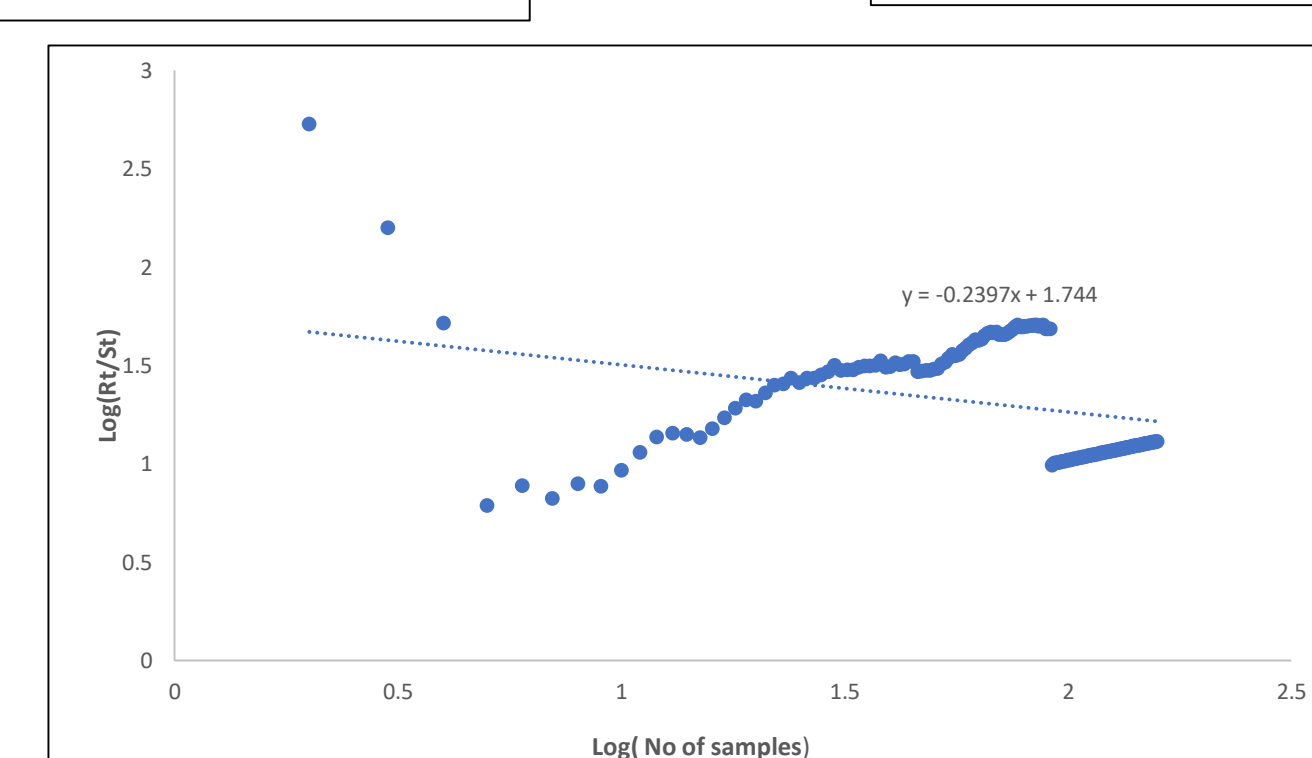


Fig.3

Fig.1,2,3 represents Rescaled range analysis for JJAS, OND, ANNUAL rainfall respectively

Conclusions

- ❑ We have demonstrated detailed analysis of the rainfall over the eastern peninsula region of India using Normal distribution and Markov Chain analysis and observed that normal distribution has fitted well in OND and failed to fit in JJAS.
- ❑ We have observed that in FOTS Markov Chain Model the tabular value is greater than the computed value in both the cases. So, the null hypothesis proposing serial independence is rejected for JJAS as well as Annual rainfall over the study zone.
- ❑ We have carried out rescaled-range analysis of all the time series under consideration and observed that the Hurst exponent is less than 0.5. Therefore, the time series are not characterized by strong long term auto-correlation.
- ❑ There exist long-term switching between high and low values of rainfall. So as a concluding remark it may be noted that the time series under consideration have been explored for their long-term behaviour.

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