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An Unbiased Time Series Modelling of Annual Rainfall Measurement of Assam and Meghalaya Province of the Eastern Himalayan Region

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***Abstract*: Time Series analysis is very widely used for the forecasting purpose. This paper maneuvers this technique to build a contemporary autoregressive model of order 6, which can predict the annual rainfall measurement of different provinces in North Eastern region of Indian continent. The data that will be used for modeling is the annual rainfall measurement data of this region for the period 1901 to 2017.**

***Keywords*: Time series analysis, rainfall model, Monsoon in Assam, Meghalaya rainfall, Autoregressive (AR) model.**

1. Introduction

Geographically, the largely inhabitant plain-valley in the North-East India is Assam which comprises of two plain-valleys, the Brahmaputra and the Barak, surrounded by many hills and also, the hilly province Meghalaya, famous for its subtropical forests and biodiversity, more precisely, for receiving the highest average rainfall in Monsoon at Mawsynram area. Assam is most affected in the North-Eastern region of India due to rainfall related disasters. The North-East India, especially Assam and Meghalaya have been witnessing tremendous amount of rainfall compared to the other provinces of India throughout the year for Centuries as per data suggest. Nonetheless, the average monsoon rainfall has been observed to be decreasing significantly since fourth quarter of the 19th century. In this article, we perform a comparative analysis of the trends of rainfall in these two states from 1901 to 2017.

2. Literature and Preliminaries

In this section, we provide some basic geography of Assam and Meghalaya and some literature review on the works in rainfall data of the two states.

1) Rainfall data of Assam

The Assam valley is situated between the Himalayas in the northern side and the hills of Arunachal Pradesh in the east and Naga, Khasi and Jayantiya hills in the southern side. Assam has mostly plain areas which are of infact low elevation. A large number of rivers and hills meet the main river of the valley (Brahmaputra). All the rivers in Assam are likely to be the source of flood in the valley, mainly because they receive heavy rainfall within a short span in the valley and its neighbourhood such as Arunachal hill, Naga hill, Khasi-jayantia hill, North cachar hill. Being a low elevation region, the rain water in the hills runs very fast in to Assam and become the main cause of flood and soil erosion. For a brief review, see [1-10, 12-14]. Here, we mention some of the work done in the rainfall data of these two valleys. Sarmah [6,7,9] had contributed much in this field through his works on the distribution, seasonal variation and trends of rainfall in the Brahmaputra valley. Das and Joshi [4] studied the erratic rainfall pattern and its consequences in the Barak valley.

2) Rainfall data of Meghalaya

The topography of the Khasi and the Jayantiya hills (which cover most of Meghalaya) can be characterize into three parts: Northern hills, Central upland zone and the Southern plateau. Beside the alignment of the two hills, the main reason for high rainfall in Meghalaya is the warm moist winds that blow from the Bay of Bengal during the Monsoon. These warm moist winds cover a large area of Meghalaya and concentrate over the Khasi hills. As a result, substantial amount of moisture is concentrated over the hills. Meghalaya gets maximum rain fall in the month of July (31% of SW Monsoon rainfall). Marak, Sarma and Bhattacharyya (2020) [11] used innovative trend analysis method with MK test to study the trends in rainfall for some regions in Meghalaya. Unlike a flood like situation in Assam, people of Meghalaya are also adversely affected by heavy rainfall over the hills. Many researchers have studied the rainfall data of the North-East collectively and several others also focused on studying the rainfall data for each state individually. For example, a good number of research articles feature a significant study on the seasonal and temporal variations of the rainfall at the Brahmaputra and the Barak valleys of Assam. Several attempts have been made so far for analytical study of various meteorological parameters in the Brahmaputra- Barak valley region, especially rainfall/precipitation and temperature.

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3. Aim of the Study and Data Source

Meghalaya experiences the highest rainfall in the world. Mawsynram and Cherrapunji which are considered the wettest places on Earth are in Meghalaya. Assam is a neighboring state of Meghalaya which is facing flood and related issues for a very long time. Additionally, the economy of this whole region is dependent on the agricultural production and annual rainfall plays a crucial role in it. Hence the rainfall in this region necessitates a statistical modeling so that that statistics on rainfall can be predicted and necessary actions can be taken within the proper time. In our literature review we noticed some gap in the study in this regard and this is what motivated us for this study.

For the modeling purpose, we have taken data from Open Government Data (OGD) Platform India: https://data.gov.in/. The data we have collected is a time series data of annual rainfall in Assam and Meghalaya from January, 1901 to December, 2017.

4. Study Methodology

A time series is a series of data points indexed in time order. Conventionally, it is a sequence taken at successive equally spaced points in time. Time series analysis comprises of methods for analyzing time series data in order to extract the statistical and computational characteristics of the data sets. Methods of time series analysis may be divided into linear and non-linear, univariate and multivariate categories.

1) Stationary time series

In mathematics and statistics, stationary process or time series is a stochastic process whose probability distribution does not change with time. Subsequently, several central parameters and variation parameters do not change over time. So, while analyzing a time series we may recall that a trend-stationary process is a stochastic process from which an underline trend can be deleted, leaving a stationary process. Mathematically, Y (process) is called trend-stationary if

Y¬¬t= f (t) + et,

Where t is time, f is a real function and {e} is a stationary process. The value f (t) is called the trend value of the process at time t.

2) Unit root test

A unit root (Unit root process or a difference stationary process) is a stochastic trend in the time series and sometimes it is called a "random work with drift". Further if a time series has a unit root it shows a systematic pattern that is unpredictable. We called a test is unit root test if it tests or study the stationary' in a time series. In a stationary time, series, a shift in time doesn't cause a change in the shape of the distribution. Several tests are known for having low statistical power and some test exist, in part, because none stand out as having the most power, for example Dickey fuller test, Elliot-Rothenberg Stock test etc.

3) AR(P) Model

Autoregressive model of order p is,

$$y_t = c+\phi_1 y_{t-1}+\phi_2 y_{t-2}+\dots+\phi_p y_{t-p}+\varepsilon_t,$$

where $\phi_1, \dots, \phi_p$ are the parameters of the model and *c is a constant and* ε_t are white noise.

5. Analysis of Data

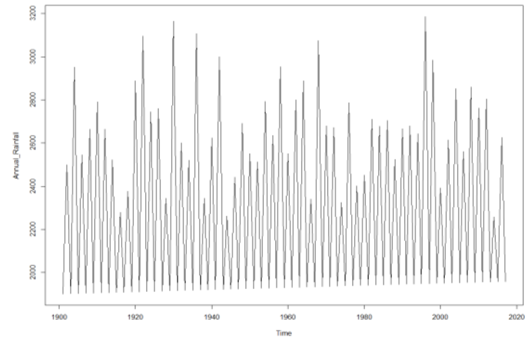

Fig. 1. Yearly Annual Rainfall (in mm) in Assam and Meghalaya

Observation: In the figure, we do not notice any trend or seasonality for the time series data.

1) Augmented Dickey-Fuller (ADF) Test results

To check if the time series is stationary, we performed ADF test and get the following result:

Dickey-Fuller = -35.401, Lag order = 0, p-value = 0.01 And alternative hypothesis: stationary

Result: ADF test suggests that the data is stationary.

2) Correlogram analysis

Let us now check the autocorrelation function (ACF) and partial autocorrelation function (PACF) plots below:

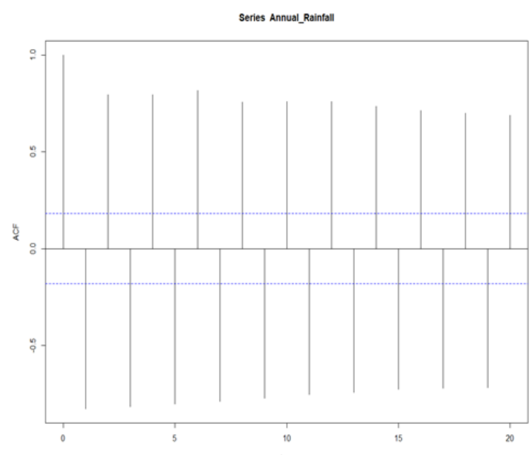

Fig. 2. Above figure demonstrating the ACF plot

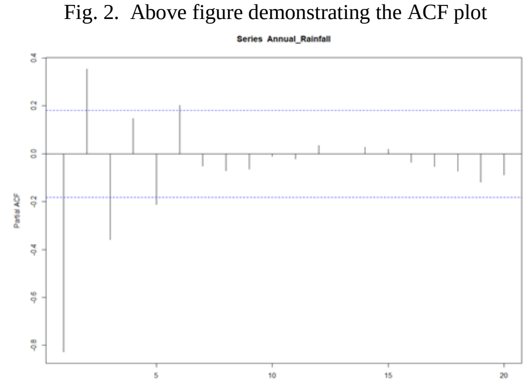

Fig. 3. Above figure demonstrating the PACF Plot

The plots of ACF and PACF suggests that we can fit Autoregressive model of order 6 i.e. AR (6).

3) Empirical result

We estimate the parameters of AR (6) model as follows:

Table 1
3) Empirical results

Parameters	**Estimate**	**Standard Error**	**z value**	**Pr(>|z|)**
ar1	-0.196079	0.088548	-2.2144	0.026803
ar2	0.015246	0.088446	0.1724	0.863143
ar3	-0.202347	0.087352	-2.3164	0.020534
ar4	0.076619	0.090349	0.848	0.396421
ar5	-0.196594	0.090152	-2.1807	0.029206
ar6	0.282878	0.090364	3.1304	0.001746
Intercept	2299.154834	13.150314	174.8365	< 2.2e-16

4) Box-Ljung test on the residuals:

We performed the Box-Ljung test on the residuals and get the following results:

X-squared = 4.8778, df = 6, p-value = 0.5596.

Result: Box-Ljung test suggests no evidence of lack of fit in our model. The same is also evident from the following residual plots.

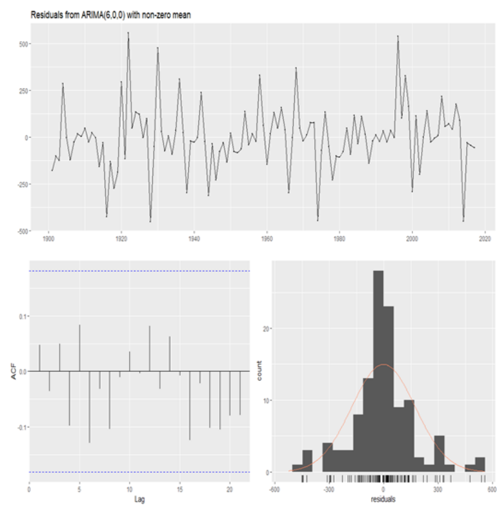

Fig. 4. Residual's plot

6. Conclusion

It may be concluded that the annual rainfall in Assam and Meghalaya region in India follows AR (6) model. It may be used as the basis for forecasting, planning and management of the rainfall in this region.

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