RESEARCH ARTICLE

TIME SERIES ANALYSIS MODEL TO FORECAST RAINFALL FOR JAGDALPUR REGION (CHHATTISGARH)

Avinash Yadu*, Anosh Graham and Jyotish Kumar Sahu

Department of Environmental Sciences and NRM, College of Forestry, Sam Higginbottom University of Agriculture, Technology & Sciences Allahabad-211007,Uttar Pradesh, India.
Email:anoshgraham@gmail.com

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Abstract: The prediction of Rainfall on monthly and seasonal time scales is not only scientifically Challenging but is also important for planning and devising agricultural strategies. Various research groups attempted to predict rainfall on a seasonal time scales using different techniques. This paper describes the Box-Jenkins time series seasonal ARIMA (Auto Regression Integrated Moving Average) approach for prediction of rainfall on monthly scales. ARIMA model (0, 0, 0) (0, 1, 1) for rainfall was identified the best model to forecast rainfall for next 4years with confidence level of 95 percent by analyzing last 27 year's data (1990-20016). Previous years data is used to formulate the seasonal ARIMA model and in determination of model parameters. The performance evaluations of the adopted models are carried out on the basis of correlation coefficient (R^2) and root mean square error (RMSE). The study conducted at Jagdalpur, Chhattisgarh (India). The results indicate that the ARIMA model provide consistent and satisfactory predictions for rainfall parameters on monthly scale.

Keywords: Rainfall,ARIMA, Correlation Coefficient (R^2), Root Mean Square Error (RMSE).

INTRODUCTION

Agriculture is the backbone of Indian economy. Irrigation facility is still not so good in India and most of agriculture depends upon the rain. A good rainfall result in the occurrence of a dry period for a long time or heavy rain both affect the crop yield as well as the economy of country, so due to that early prediction of rainfall is very crucial . A wide range of rainfall forecast methods are employed in weather prediction at regional and national levels.

Prediction of rainfall is tough due to its non-linear pattern and a large variation in intensity. Till today, numerous techniques have been used to predict rainfall. Among them, Autoregressive Integrated Moving Average (ARIMA) modeling, introduced by Box and Jenkins is an effective method. The Box-Jenkins Seasonal ARIMA (SARIMA) model has several advantages over other models, particularly over exponential smoothing and neural network, due to its forecasting capability and richer information on time-related changes. ARIMA model consider the serial correlation which is the most important characteristic of time series data. ARIMA model also provides a systematic option to identify a better model. Another advantage of ARIMA model is that the model uses less parameter to describe a time series.

MATERIALS AND METHODS

Study area

The study was conducted around Jagdalpur city of Bastar district Chhattisgarh during March 2017. This is one of the tribal districts of the state. Location of city is between 19.107 degree north latitudes and 81.953 degree east longitude. The district is located in southern part of Chhattisgarh situated at the height of 2000 m above plateau MSL various small scale industries situated in this town. Rainfall ranges from 1200mm to 1600mm per annum. Agroclimatically, according to the national agricultural research project (NARP) of ICAR. this region is termed as bastar plateau.

Data Collection

Daily rainfall data for the past 27 years from 1990 to 2016 was collected from department of agro meteorological IGKV Raipur, for forecasting.

Software used

SPSS Auto Regressive Integrated Moving Average (ARIMA) models were selected using SPSS software to find the best fit of a time series to past values of this time series in order to make forecasts.

A time series is defined as a set of observations arranged chronologically i.e. a sequence of observations usually ordered in time. The principal aim of a time series analysis is to describe the history of movements in time of some variable at a particular site. The objective is to generate data having properties of the observed historical record. To compute properties of a historical record, the historical record or time series is broken into separate components and analyzed individually to understand the casual mechanism of different components. Once properties of these components are understood, these can be generated with similar properties and combined together to give a generated future time series. Analysis of a continuously recorded rainfall and temperature data time series is performed by transforming the continuous series into a discrete time series of finite time interval. Mathematical modeling of rainfall data is a stochastic process.

*Corresponding Author

Several mathematical models based on the probability concept are available. These models help in knowing the probable weekly, monthly or annually rainfall. Over the past decade or so, a number of models have been developed to generate rainfall and runoff. Monthly rainfall and temperatures were analyzed using time series analysis. Time series models have been extensively studied by Box and Jenkins (1976) and as their names have frequently been used with synonymously with general ARIMA process applied to time series analysis and forecasting. Box and Jenkins (1976) have effectively put together in a comprehensive manner, the relevant information required to understand and use time series ARIMA models. A detailed strategy for the construction of linear stochastic equation describing the behavior of time series was examined. Consider the function Z_t represents forecasted rainfall and temperature at time t month. Y_t is series of observed data of rainfall and temperature at time t. If series is stationary, then a ARIMA process can be represented as

$$\nabla pZ_t = \nabla qY_t \quad \text{....(1)}$$

Where ∇ is a back shift operator. If series Y is not stationary then it can be reduced to a stationary series by differencing a finite number of times.

$$\nabla pZ_t = \nabla q\ (1\text{-}B)\ d\ Y_t \quad \text{....(2)}$$

Where d is a positive integer, and B is back shift operator on the index of time series so that BY_t= Y_t-1; B2Y_t = Y_t-2 and so on. Thus further equation (2) can be simplified into following equation.

(1-Φ1B-Φ2B2-…….-ΦpBp) Z_t = θ0+ (1-θ1B-θ2B2-………- θqBq) at ….. (3)

Where a_t's a sequence of identically distributed uncorrelated deviates, referred to as "white noise". Combining equations (2) and (3) yields the basic Box-Jenkins models for non stationary time series (1-Φ1B-Φ2B2-…….-ΦpBp) (1-B)d Yt =θ0+ (1-θ1B-θ2B2- ………-θqBq) at ….(4) Equation (4) represents an ARIMA process of order (p,d,q). Seasonal ARIMA model represented as follows for a stationary series i.e. differencing parameters (d &d_s = 0) equal to Zero, used for forecasting rainfall.

$$\nabla ps\ \nabla pZ_t = \nabla\ qs\ \nabla q\ Y_t \quad \text{....(5)}$$

Where p_s and q_s are the seasonal parameters corresponding to AR and MA process. Model of type of equation (5) was fitted to given set of data using an approach consists of mainly three steps (a) identification (b) estimation (c) application (forecasting) or diagnostic checking. At the identification stage tentative values of p,d,q and p_s,d_s,q_s were chosen. Coefficients of variables used in model were estimated. Finally diagnostic checks were made to determine, whether the model fitted adequately describes the given time series. Any inadequacies discovered might suggest an alternative form of the model, and whole iterative cycle of identification, estimation and application was repeated until a satisfactory model was obtained.

RESULTS AND DISCUSSION

The model that seems to represent the behavior of the series is searched, by the means of autocorrelation function (ACF) and partial auto correlation function (PACF), for further investigation and parameter estimation. The behavior of ACF and PACF is to see whether the series is stationary or not. For modelling by ACF and PACF methods, examination of values relative to auto regression and moving average were made. An appropriate model for estimation of monthly rainfall for jagdalpur station was finally found. Many models for jagdalpur station, according to the ACF and PACF of the data, were examined to determine the best model. The model that gives the minimum Bayer's Information Criterion (BIC) is selected as best fit model, as shown in Table 1. Obviously, model ARIMA (0, 0, 0) (0, 1, 1) has the smallest values of BIC. Observed and predicted values of next four years are determined and plotted as shown in figure: 4.

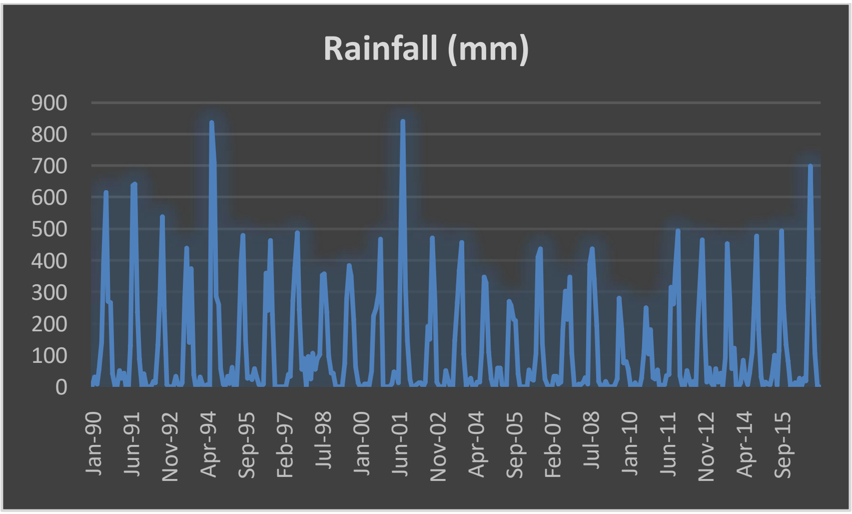

Fig 1: Observed rainfall in jadalpur (Jan. 1990-Dec. 2016)

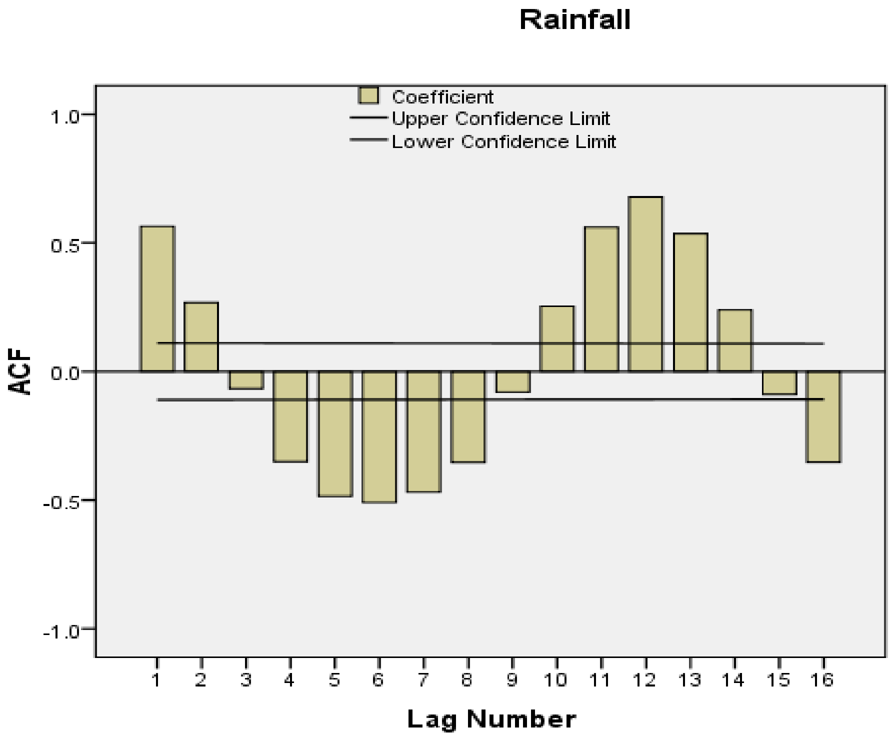

Fig 2: Autocorrelation function of rainfall

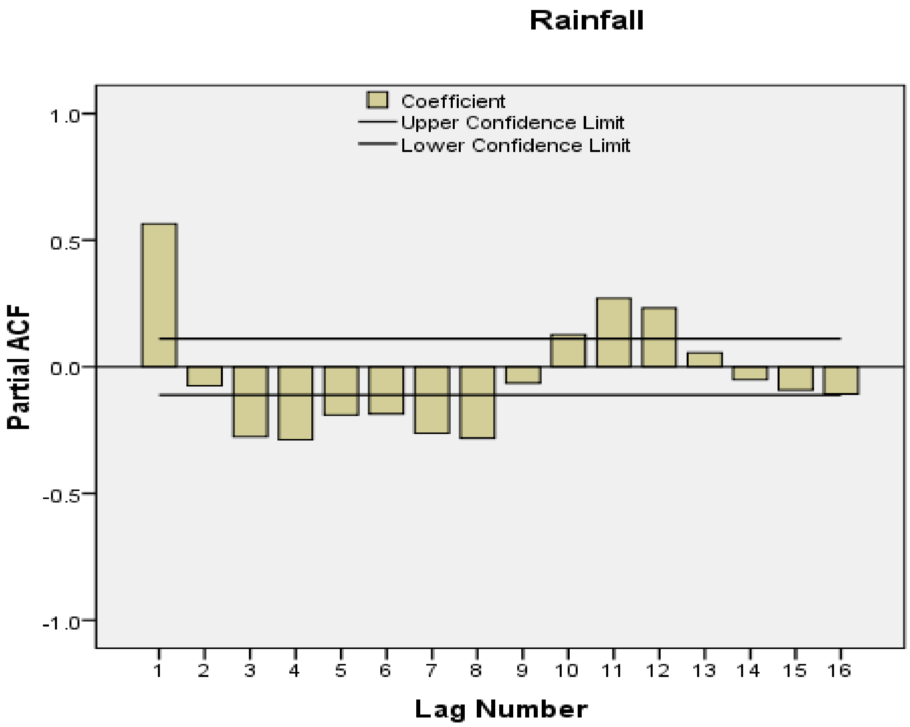

Fig 3: Autocorrelation function of rainfall.

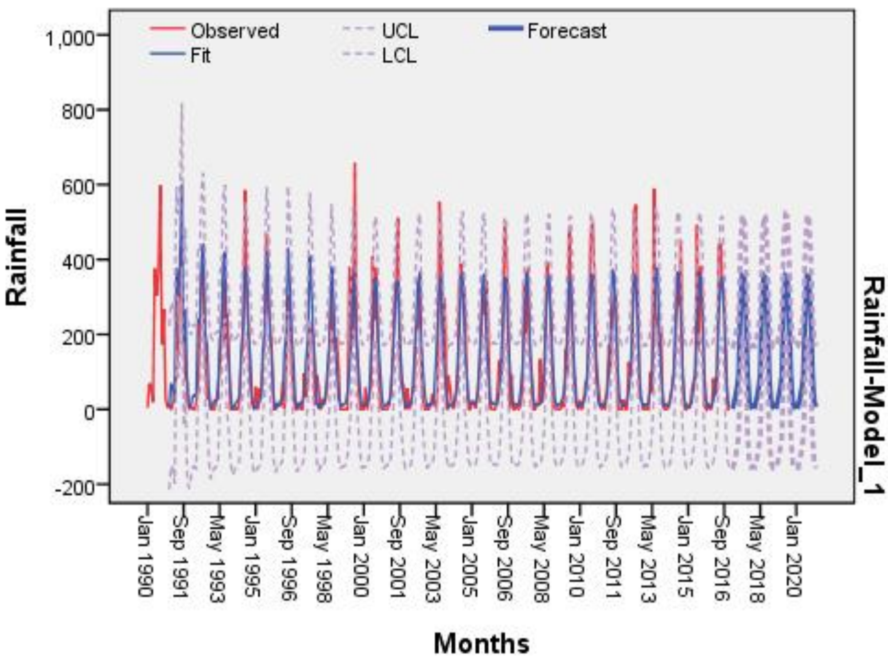

Fig 4: Observed and fitted values of rainfall series.

Table 1.

Parameters	Rainfall model ARIMA (0,0,0)(0,1,1)
R^2	.667
RMSE	85.597

CONCLUSION

The Box-Jenkins ARIMA methodology was used to develop monthly rainfall of Jagdalpur. The monthly rainfall is panning over the period of 1990-2016 at jagdalpur. The performance of resulting ARIMA model was evaluated by using the data from the year 1990-2016 through graphical comparison between the forecasted and observed data. In ARIMA model the forecasted and observed data of rainfall showed good results. The study reveals that Box-Jenkins methodology can be used as an appropriate tool to forecast rainfall in Jagdalpurfor upcoming years.

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