RESEARCH ARTICLE

FORECASTING MONTHLY PRECIPITATION MODEL FOR DANTEWADA, JAGDALPUR AND SUKMA REGION (CHHATTISGARH) USING ARIMA MODEL

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Received-05.04.2020, Revised-27.04.2020

Abstract: Earlier forecasting was based on observing weather patterns. Latter-days weather forecasting involves a combination of computer models, observations and knowledge of tends and patterns. 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 of Dantewada (0, 0, 1) (0, 1, 1), Jagdalpur (0, 0, 0) (1, 1, 1), Sukma (0, 0, 1) (1, 1, 1) for rainfall was identified the best model to forecast rainfall for next 5 years with confidence level of 95 percent by analyzing last 30 year's data (1989-20018). 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 three cities Dantewada, Jagdalpur & Sukma, 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

Rainfall is a stochastic process which depends on so many parameters and these properties make forecasting of rainfall a formidable challenge. Information about rainfall is really essential for the planning and management of water resources. Forecasting of rainfall is vital as it is very much important for flood warning. Rainfall mostly occurs during a season called Monsoon and major part of the annual rainfall occurs in this monsoon.

A wide range of rainfall forecast methods are employed in weather prediction at regional and national levels. According to Somvanshi *et al.* (2006), rainfall is natural climatic occurrences and its prediction remains a difficult challenge as a result of climatic variability. The forecast of precipitation is particularly relevant to agriculture, growth of plants and development, which profoundly contribute to the economy of Africa. In the statement of the above authors, attempts have been made to predict behavioral pattern of rainfall using autoregressive integrated moving average (ARIMA) technique. In agricultural planning the understanding of rainfall variability and its prediction has great significance in the agricultural management and helps in decision making process. Rainfall information is an important input in the hydrological modeling, predicting extreme precipitation events such as droughts and floods, for planning and management of irrigation projects and agricultural production is very important [Nirmala 2015]. Etuk and Mohamed (2014) fitted a SARIMA (0, 0, 0) x (0, 1, 1)12 model to monthly rainfall in Gadaref, Sudan. 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

Dantewada - The Dantewada lies on 370m above sea level. The climate here is tropical. When compared with winter, the summers have much more rainfall. This location is classified as Aw by Köppen and Geiger. The temperature here averages 26.2 °C | 79.1 °F. The annual rainfall is 1391 mm | 54.8 inch. The driest month is December, with 3 mm | 0.1 inch of rain. In August, the precipitation reaches its peak, with an average of 405 mm | 15.9 inch.

Sukma - The Sukma lies on 216m above sea level. Sukma has a tropical climate. The summers are much rainier than the winters in Sukma. The Köppen-Geiger climate classification is Aw. The temperature

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here averages 27.0 °C | 80.6 °F. The rainfall here is around 1477 mm | 58.1 inch per year. The driest month is February, with 3 mm | 0.1 inch of rainfall. The greatest amount of precipitation occurs in July, with an average of 416 mm | 16.4 inch.

Jagdalpur - The Jagdalpur lies on 558m above sea level .The climate here is tropical. When compared with winter, the summers have much more rainfall. The climate here is classified as Aw by the Köppen-Geiger system. The average annual temperature is 25.0 °C | 77.0 °F in Jagdalpur. The annual rainfall is 1451 mm | 57.1 inch. The driest month is January, with 7 mm | 0.3 inch of rain. In August, the precipitation reaches its peak, with an average of 371 mm | 14.6 inch.

Data Collection

Daily rainfall data (mm) for the past 30 years from 1989 to 2018 was collected from Department of Agrometeorology 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.

METHODOLOGY

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 Zt represents forecasted rainfall and temperature at time t month. Yt is series of observed data of rainfall and temperature at time t. If series is stationary, then an 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

$B\ Y_t = Y_t\text{-}1$; $B2Y_t = Y_t\text{-}2$ and so on. Thus further equation (2) can be simplified into following equation.

$(1\text{-}\Phi 1B\text{-}\Phi 2B2\text{-}\ldots\ldots\text{-}\Phi pBp)\ Z_t = \theta 0 + (1\text{-}\theta 1B\text{-}\theta 2B2\text{-}\ldots\ldots\ldots\text{-}\ \theta qBq)\ at$ ..... (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 $(1\text{-}\Phi 1B\text{-}\Phi 2B2\text{-}\ldots\ldots\text{-}\Phi pBp)\ (1\text{-}B)d\ Yt = \theta 0 + (1\text{-}\theta 1B\text{-}\theta 2B2\text{-}\ \ldots\ldots\ldots\text{-}\theta qBq)$ 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 &ds = 0) equal to Zero, used for forecasting rainfall.

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

Where ps and qs 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 ps, ds, qs 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 modeling 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 Dantewada, Jagdalpur, Sukma was finally found. Many models for Dantewada, Jagdalpur, Sukma, 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 Dantewada (0, 0, 1) (0, 1, 1), Jagdalpur (0, 0, 0) (1, 1, 1), Sukma (0, 0, 1) (1, 1, 1) has the smallest values of BIC. Observed and predicted values of next five years are determined and plotted as shown in figure: 8,9,10.

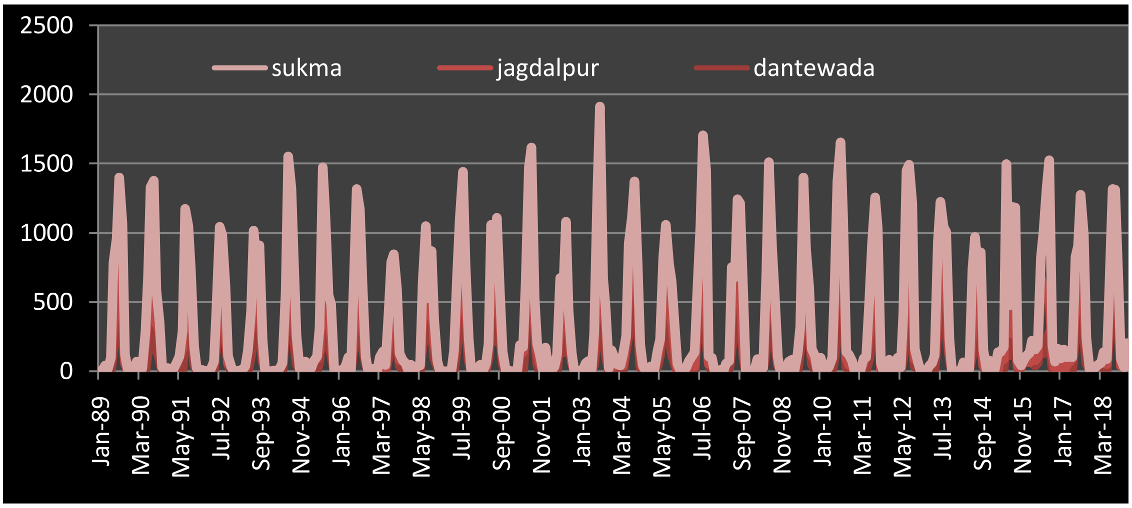

Fig. 1. Observed rainfall of Sukma, Jagdalpur & Dantewada district (Jan1989-Dec2018)

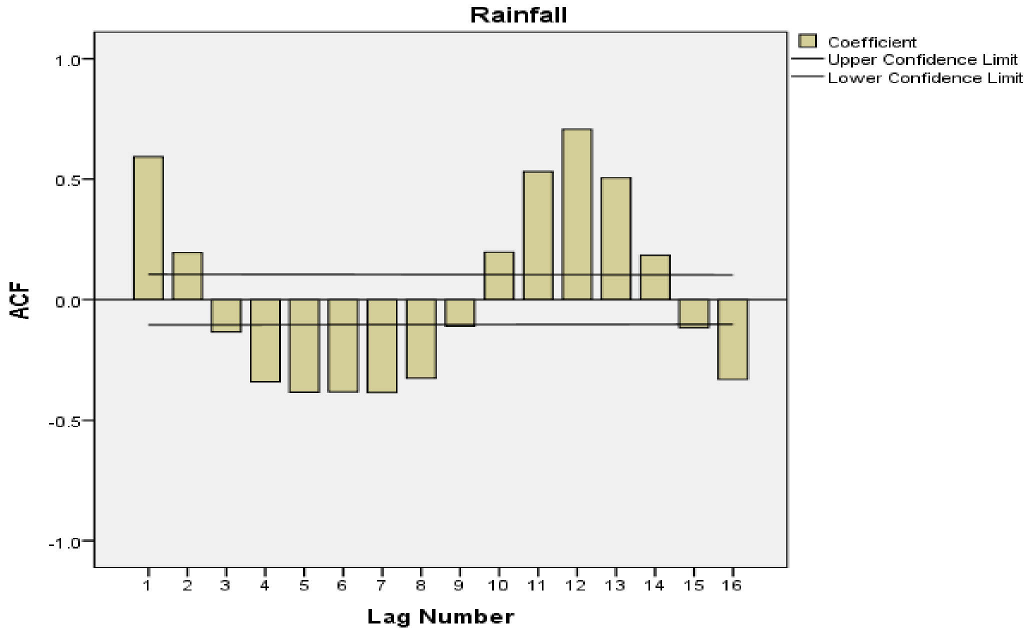

Fig. 2. Autocorrelation function of rainfall Sukma.

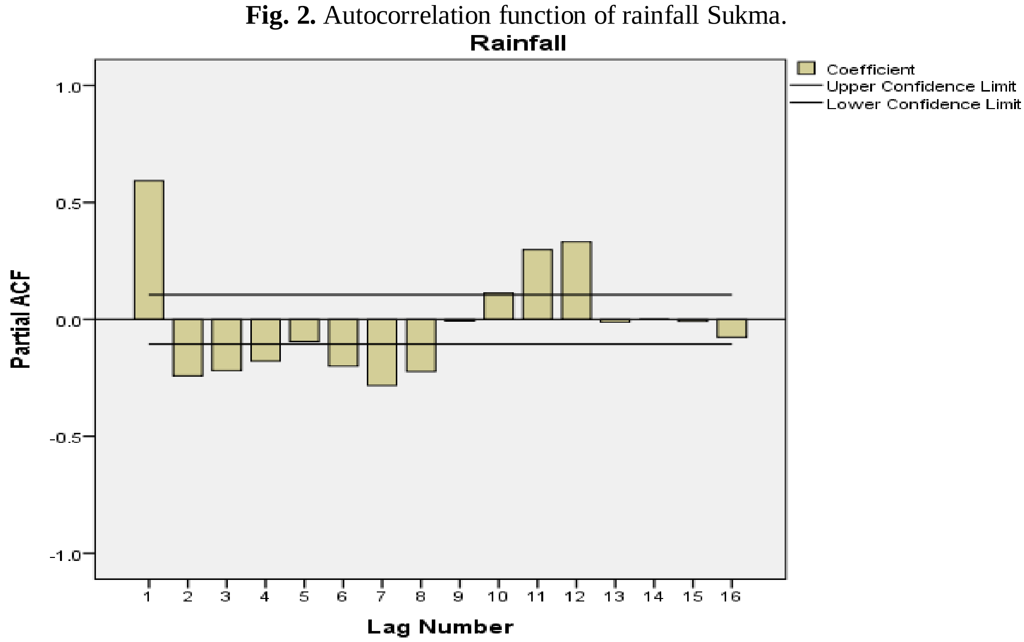

Fig. 3. Partial Autocorrelation function of rainfall Sukma.

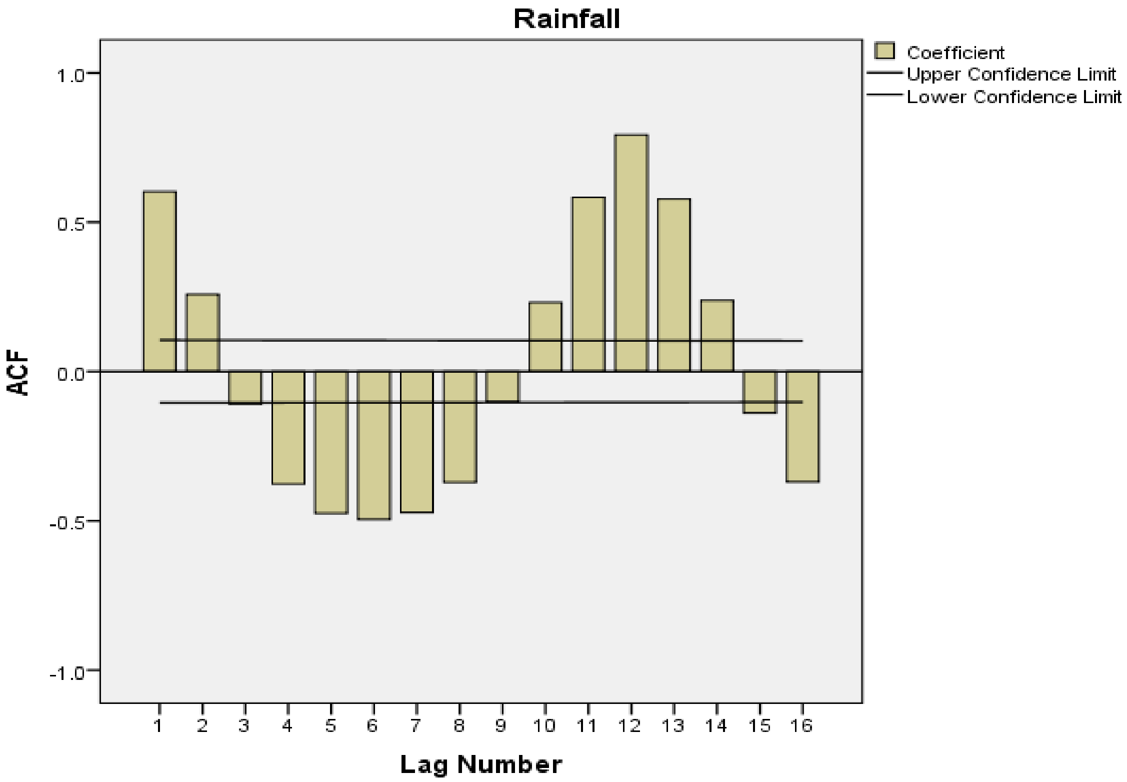

Fig. 4. Autocorrelation function of rainfall Jagdalpur.

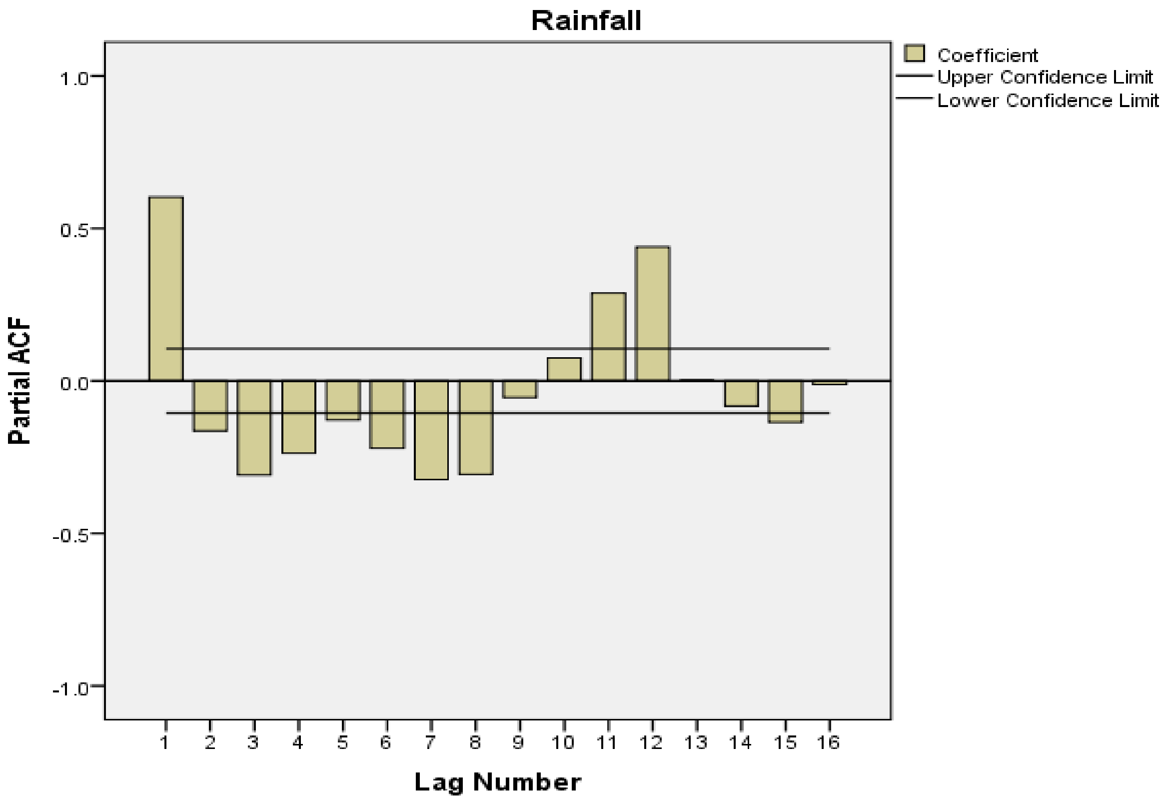

Fig. 5. Partial Autocorrelation function of rainfall Jagdalpur.

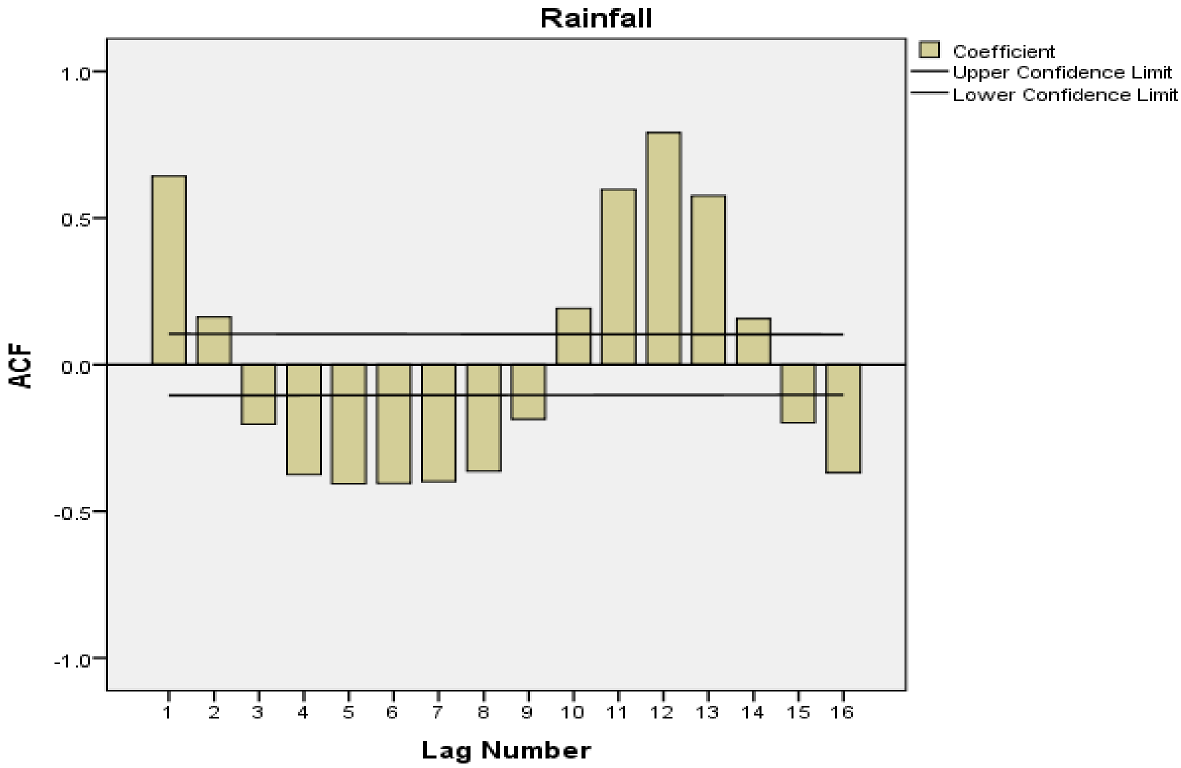

Fig. 6. Autocorrelation function of rainfall Dantewada.

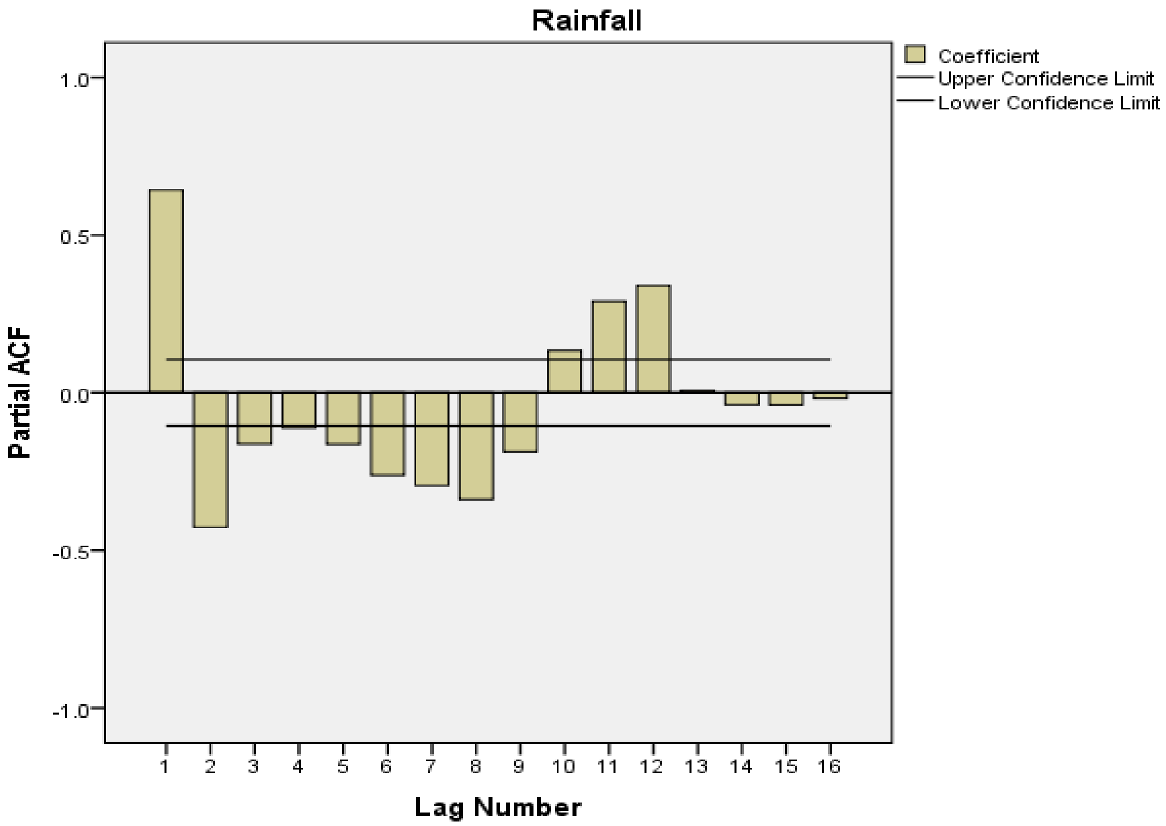

Fig. 7. Partial Autocorrelation function of rainfall Dantewada.

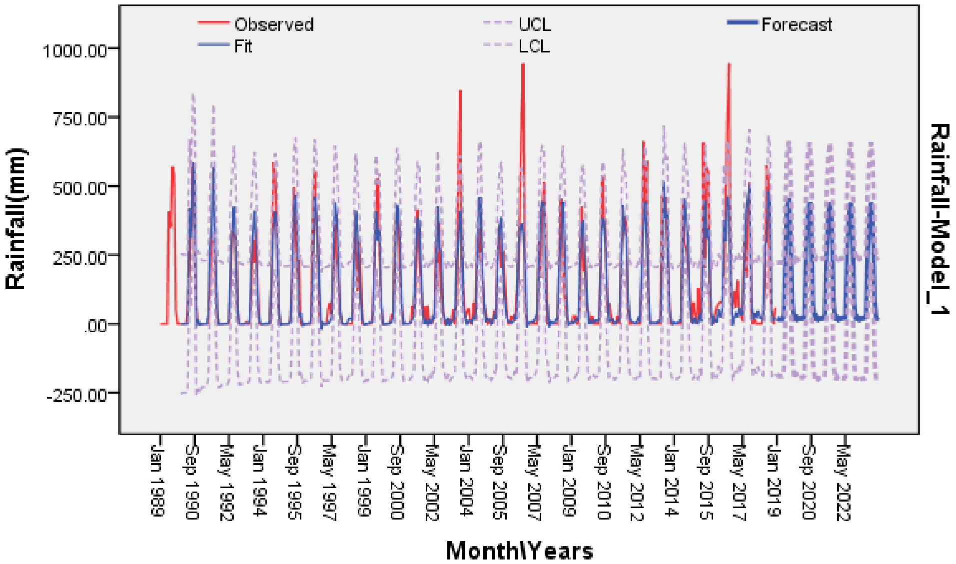

Fig. 8. Observed and fitted values of rainfall for Sukma.

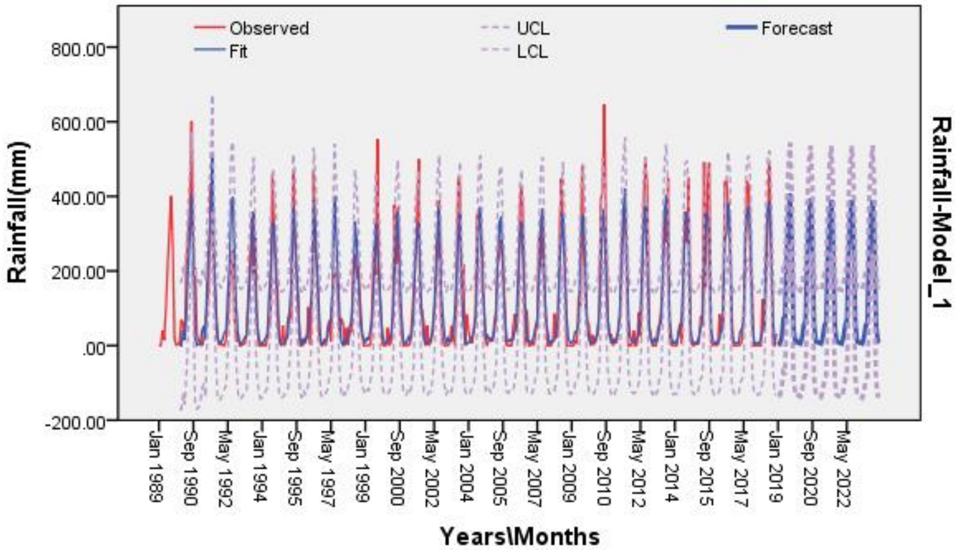

Fig. 9. Observed and fitted values of rainfall for Jagdalpur.

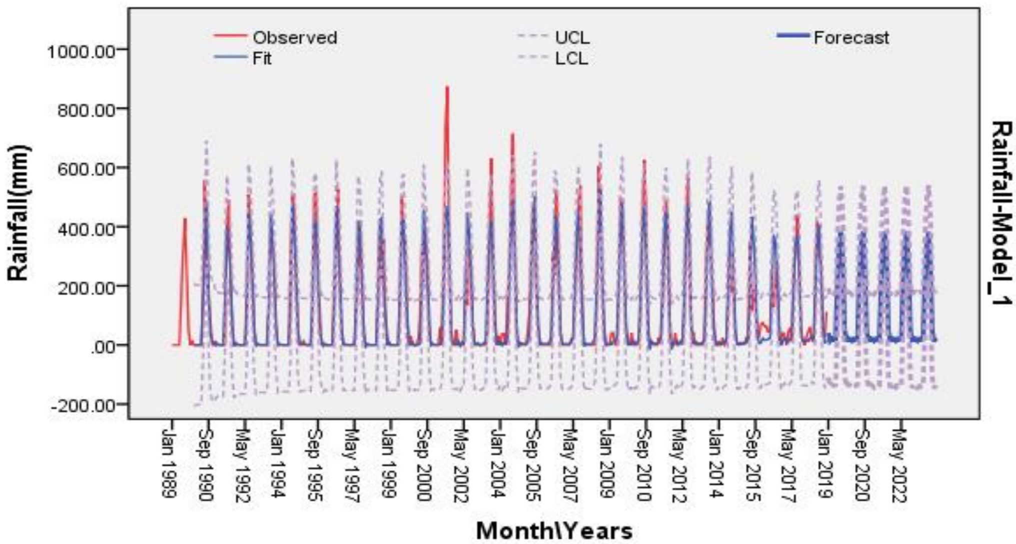

Fig. 10. Observed and fitted values of rainfall for Dantewada

Table 1.

	Dantewada	Jagdalpur	Sukma
Rainfall model	(0, 0, 1) (0, 1, 1),	(0, 0, 0) (1, 1, 1),	(0, 0, 1) (1, 1, 1)
R^2	0.788	0.76	0.68
RMSE	78.678	71.713	104.698

CONCLUSION

The Box-Jenkins ARIMA methodology was used to develop monthly rainfall of Dantewada, Jagdalpur, Sukma. The monthly rainfall is panning over the period of 1989-2018 at Dantewada and the results are good for this region. In Jagdalpur region the observed and forecasted data are fitted and showed good results, In Sukma region the results were not so good. The performance of resulting ARIMA model was evaluated by using the data from the year 1989-2018 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 Dantewada, Jagdalpur, Sukma for upcoming years.

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