Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.6265

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **6 (2):** 1372-1375 (2018)

Research Article

International Journal of Pure & Applied Bioscience

OPEN ACCESS

Seasonal Arima Model to Forecast Rainfall for Three Mandalas of Telangana State

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Received: 5.02.2018 | Revised: 14.03.2018 | Accepted: 20.03.2018

ABSTRACT

The prediction of rainfall on monthly and seasonal timescale is not only scientifically challenging but is also implement for planning and devising original strategies. Various research groups attempt to predict rainfall on a seasonal time scale using different techniques. This paper describes the Box-Jenkins time series Seasonal ARIMA (Auto Regressive Integrated Moving Average) approach for prediction of rainfall on monthly scale. Seasonal ARIMA(0,0,0)(1,1,0) for rainfall (m.m) was identified the best model to forecast rainfall for Aswaraopet and Vemsoor mandals and Seasonal ARIMA(0,0,0)(0,0,1) was identified for Sathupally mandal for next one year with confidence level of 95 percent by analyzing 27 years data(1990-2017).Previous data is used to formulate the seasonal ARIMA model and in determination of model parameters. The preference evaluation of the adopted models are carried out on the basis of correlation coefficient (R^2) and Mean absolute percentage error. The study conducted at three mandals Aswaraopet, Sathupally and Vemsoor of Telangana State (India).The result indicate that the Seasonal ARIMA model provide consistent and satisfactory prediction for rainfall parameters on monthly scale.

Key words: *ARIMA, Rainfall, Auto correlation function (ACF), Partial autocorrelation function (PACF), Mean Absolute Percentage Error (MAPE)*

INTRODUCTION

Climate is a driving force for almost every natural resource management issues. Climate change will have for reaching impacts on many ecological and resource degrading process. The agricultural practices and crop yield of India are heavily dependent on the climatic factors like rainfall. Out of 142 million hectare cultivated land in India 92 million hectare (i.e.about 65%) area under the influence of rain fed agriculture.

Cite this article: Prakash, K.K., Umar, S.K.N., Ramesh, G., Jyothi, S.H. and Venkataramulu, M., Seasonal Arima Model to Forecast Rainfall for Three Mandalas of Telangana State, *Int. J. Pure App. Biosci.* **6(2):** 1372-1375 (2018). doi: http://dx.doi.org/10.18782/2320-7051.6265

The monsoon is the principal rain bearing season and in fact a substantial part of the annual rainfall over a large part of the country occurs in this season. Small variation in the timing and the quantity of monsoon rainfall have the potential to impact on agriculture output, Rainfall is the most important climatic element that influences agriculture. Monthly rainfall forecasting plays an important role in the planning and management of agricultural scheme and water resource management. Our study is focused on fitting the best model to the rainfall data collected in three mandals of Telangana State, India. For this purpose daily rainfall data was collected for the past 27 years from 1990 to 2017 of three mandals from mandal records. Aswaraopet located 17.24Latitutude, 81.104 Longitude, Sathupally located 17.20 and 80.49 and Vemsoor 17.1302 respectively. The climate of three mandals are typical humid subtropical, have from October to February and is followed by the summer which continues till about the middle of June, South west monsoons influences from June to September and North east monsoon from October to November. The major rainfall receives these three mandals from North East monsoon only. The main objective of this paper is to examine rainfall patterns over time from 1990-2017) in three mandals of Telangana State, India. Also the study seeks to forecast rainfall figure. Rainfall is a seasonal phenomenon with 12 months period. Seasonal time series are often modeled by SARIMA technique. Recently a few researchers modeled monthly rainfall using SARIMA methods. Nirmala *et al*[7]. fitted a SARIMA (0,1,1) x$(0,1,1)_{12}$ model to monthly rainfall in Tamil Nadu. A.R. Abdul-Aziz *et al*.[4] fitted a SARIMA (0,0,0)x$(2,1,0)_{12}$ to the rainfall data in Ashanti region of Ghana. Etuk *et al*.[6] fitted a SARIMA (0,0,0)$(0,1,0)_{12}$ model to monthly rainfall in Gadaref, Sudhan. Anosh Graham *et al.*[2] fitted SARIMA(0,0,0)x$(0,1,0)_{12}$ model to monthly rainfall in identified best model and forecasted rainfall for next 5 years for Allahabad region, Uttar Pradesh (India).

MATERIAL AND METHODS

Time series is defined as a set of observations arranged chronologically. i.e. a sequence of observations usually ordered in time. Seasonality in a time series is a regular pattern of changes that repeats over S time periods where S defines the number of time period until the pattern repeats again. Seasonal ARIMA model incorporates both non seasonal and seasonal factors in a multiplicative model.

ARIMA (p,d,q)x(P,D,Q) S

p is non seasonal AR order	P is seasonal AR model
d is non seasonal difference	D is seasonal differencing
q is non seasonal MA order	Q is seasonal MA order

S is time span of repeating seasonal pattern.

a. Model Identification: Identification of model consists of specifying the appropriate structure (AR,MA,ARIMA) and order of model. Model can also be identified by looking at plots of Auto correlation function (ACF) and Partial Auto correlation function (PACF), Thus making sure that the variables are stationary, identifying seasonality in the dependent series and using plots of the ACF and PACF of the dependent time series to decide which auto regressive or moving average component should be used in the model[1].

b. Estimation of the parameters of the model: Coefficients of the model can be estimated by maximum likely hood estimator or non-linear least square estimation method. Estimation of parameters of MA and ARMA models usually require a more complicated iteration procedure[1,5].

c. Model checking and Forecasting: Two important elements of checking are to ensure that the residuals of the model are random and to ensure that the estimated parameters are statistically significant. Usually the fitting process is guided by the principal of parsimony, by which the best model is the simplest possible model .Plotting the mean and variance of residual over time and performing Ljung-Box test or plotting Auto correlation and Partial Auto correlation of the residual are also helpful to identify misspecification[3].

Consider the function Z_t represents forecasted rainfall at time't' month, Y_t is series of observed data of rainfall. If series is stationary then ARIMA process can be represented as

$\nabla^p Z_t = \nabla^q Y_t$ ………(1)

Where ∇ is a back shift operator.

If series Y_t is not a stationary then it can be reduced to a stationary series by differencing a finite number of times.

$\nabla^p Z_t = \nabla^q (1-B)^d Y_t$ …….(2)

Where d is a positive integer and B is backshift operator on the index of time series so that

$BY_t = Y_{t-1}$; $B^2 Y_t = Y_{t-2}$ and so on.

Thus further, equation (2) can be simplified into following equation

$(1-\emptyset_1 B - \emptyset_2 B^2 - \ldots - \emptyset_p B^p)\, Z_t = \theta_0 + (1 - \theta_1 B - \theta_2 B^2 - \ldots - \theta_q B^q) a_t$ ……….(3)

Where a_t's a sequence of identically distributed uncorrelated deviates, referred to as 'white noise'

Combining equation (2) and (3) yields the basic Box-Jenkins models for non-stationary time series.

$(1-\emptyset_1 B - \emptyset_2 B^2 - \ldots - \emptyset_p B^p)\,(1-B)^d\, Y_t = \emptyset_0 + (1 - \theta_1 B - \theta_2 B^2 - \ldots - \theta_q B^q) a_t$ ……(4)

Equation (4) represents an ARIMA process order (p,d,q)

Seasonal ARIMA model represented as follows for a stationary series i.e. differencing parameters (d and d_s = 0) equal to zero, used for forecasting rainfall.

$\nabla^{ps}\, \nabla^p\, Z_t = \nabla^{qs}\, \nabla^q\, Y_t$ ………(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 (a) identification (b) estimation (c) model identification forecasting.

At the identification stage tentative values of p,d,q and p_s d_s q_s were chosen. Coefficient of variables used in model were estimated. Finally diagnostic check were made to determine, where 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, estimation and application was repeated until a satisfactory model was obtained. Data was analyzed using **SPSS** software to find the best fit of a time series to past values of this time series in order to make forecast.

RESULTS AND DISCUSSION

The model that seems to represent the behavior of the series is searched, by the means of the Autocorrelation function (ACF) and Partial autocorrelation function (PACF),for further investigation and parameter estimation. The behavior of ACF and PACF is to see whether the series is stationary of not. For modelling by ACF and PACF methods, examination of values relative to auto regression and moving average were made. Many models were examined differently for three taluks according to ACF and PACF of the data. An appropriate model for estimation of monthly rainfall for three mandals were found. The model that gives the minimum Bayesian Information Criterion(BIC), maximum R^2 value and Minimum Mean Absolute Percentage Error(MAPE) is selected as best fit model as shown in table.1.Obviously model SARIMA(0,0,0)(1,1,0) has the maximumR^2, minimum MAPE and smallest value of BIC, Observed for Aswaraopet and Vemsoor mandals and SARIMA(0,0,0)(0,0,1) model has the maximumR^2, minimum MAPE and smallest value of BIC for Sathupally mandal predicted values of next one year are determined for three mandals.

Table: 1 Various ARIMA models of three mandals

ARIMA Model	ASWARAOPET			SATHUPALLY			VEMSOOR		
	R-Square	MAPE	BIC	R-Square	MAPE	BIC	R-Square	MAPE	BIC
(000)(110)	**0.98**	**204.56**	**6.49**	0.82	72.76	8.44	**0.97**	**28.3**	**6.82**
(000)(111)	0.79	203.93	8.05	0.81	75.47	8.4	0.87	66.34	7.61
(000)(010)	0.75	215.04	8.18	0.79	130.93	8.44	0.79	75.74	7.96
(000)(011)	0.79	203.811	8.03	0.821	82.19	8.34	0.87	68.71	7.636
(000)(001)	0.8	204.22	8.07	**0.821**	**71.39**	**8.43**	0.85	64.8	7.723

Table 2: shows forecasted values of three mandals from January to December2018.Three mandals receives major rainfall from North East monsoon which occurred from June to October

Month	Aswaraopet	Sathupally	Vemsoor
Jan-18	0	0	0
Feb-18	0	0	0
Mar-18	0	0	0
Apr-18	0	0	0
May-18	22.21	72.25	41.4
Jun-18	77.89	302.25	300.1
Jul-18	265.59	200.12	231.33
Aug-18	103.88	282.45	228.7
Sep-18	149.23	193.32	166.18
Oct-18	90.07	119.9	72.09
Nov-18	0	8.6928	0
Dec-18	14.6355	0	0

CONCLUSION

The Box-Jenkins ARIMA methodology was used to develop monthly rainfall of three mandals of Telangana state. The monthly rainfall is panning over the period of 1990-2017 at three mandals. The performance of resulting ARIMA model was evaluated by using the data from the year 1990-2017.The study reveals that Box-Jenkins methodology can be used as an appropriate tool to forecast rainfall in the three mandals for next one year. The accuracy of predictions made for rainfall by Seasonal ARIMA model is less because data is abrupt and contains many missing values, which increases white noise in the system, because no value assigned to missing value and are assumed zero. Accuracy of these predictions can be increased in future by using these predicted values for missing values.

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