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International Journal Of Engineering And Computer Science ISSN:2319-7242
Volume 2 Issue 8 August, 2013 Page No. 2521-2526

Modeling and Predicting Total Ozone Column and Rainfall in Kodaikanal, Tamilnadu By Arima Process

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ABSTRACT:
Amongst all weather happenings, ozone plays the very important role in human life as well as climate change. The understanding of Total Ozone Column (TOC) and rainfall variability helps the agricultural management in planning and decision- making process. The important aspect of this research is to find a suitable time series seasonal model for the prediction of total ozone column and annual-rainfall in Kodaikanal,Tamilnadu. In this study, Box-Jenkins model is used to build an ARIMA model for predicting the monthly total ozone column and rainfall in Kodaikanal, Tamilnadu with a total of 12 years data.
Keywords: ARIMA, Rainfall, Seasonality, Total Ozone Column

Introduction:

Ozone is a minor constituent of the atmosphere. It is mainly distributed in the stratosphere. Ozone is mainly found in two regions of the Earth's atmosphere. Most ozone (about 90%) resides in a layer between approximately 10 and 50 km above the Earth's surface, in the region of the atmosphere called the stratosphere. The remaining ozone is in the lower region of the atmosphere, the troposphere. The total column ozone indicates both the troposphere as well as stratospheric ozone over a specified region. It absorbs dangerous solar UV rays and plays an important role to control the chemical kinetics of lower and upper atmospheric constituents. WMO Bulletin confirms that O_3 is depleted everywhere with smaller amounts but dramatic decreases of O_3 concentration takes place only over Antarctica during spring time. It is well established that stratospheric ozone controls different environmental parameters and a definite correlation exists between weather conditions in the troposphere and ozone content in the stratosphere. Dobson et al.reported that a fall in ozone content in the stratosphere takes place over England before the arrival of warm fronts at the ground surface. They also reported that the rise in ozone content in the stratosphere takes place when cold fronts reach near the ground level. Mitra et al. reported the close relationship between barometric height, tropospheric weather, and ionospheric parameters of the upper atmosphere. It was observed that minimum height of F region and average E ionization tend to follow the variation of barometric height. Mitra et al.also mentioned that correlation was observed between lowest virtual height of E region and ground temperature at Stanford, California, USA. Midya et al. also showed that Rain occurs only when ozone concentration lies in a certain concentration level. Major agricultural operations are normally undertaken during Southwest and North east Monsoon season. Rain is an important parameter of our environment. The purpose of this paper is to investigate the correlation between Total ozone concentration and annual-rainfall over Kodaikanal of Tamilnadu. It has been noted that the Total ozone and rainfall shows a strong variation during this period.

Data and Methodology

We have used the total ozone concentration (TOC) from the period of 1994 to 2005 and rainfall data from the period 2001 to 2012 of Kodaikanal, Tamilnadu. The above data is obtained from the India Meteorological Department, New Delhi and Regional Meteorological Centre, Chennai. Ozone is a secondary pollutant resulting from photochemical reaction of a variety of natural and anthropogenic precursors (mainly volatile organic compounds (VOCs) and oxides of nitrogen (NO_x). Despite massive and costly control efforts, countries in Europe and North America still experience severe ozone problems (Wu and Chan, 2001). People in Asia cannot escape from ozone pollution. In some large Asian cities, elevated ozone levels have been reported (Chan and Chan, 2000). Development and use of statistical and other quantitative methods in the environmental sciences have been a major communication between environmental scientists and statisticians (Hertzberg and Frew, 2003). In recent years, many statistical analyses have been used to study air pollution as a common problem in urban areas (Lee, 2002). Many investigators have used probability models to explain temporal distribution of air pollutants (Bencala and Seinfield, 1979;Yee and Chen, 1997). Time-series analysis is a useful tool for better understanding of cause and effect relationships in environmental pollution (Kyriakidis and Journal, 2001). The main aim of time-series analysis is to describe movement history of a particular variable in time. Many authors have tried to detect changing behaviour of air pollution through time using different techniques (Kocak et al, 2000; Hies et al, 2003). Many others have tried to relate air pollution to human health through time-series analysis (Roberts, 2003; Touloumi et al, 2004).Therefore, this study aims at extending time-series analysis to give both qualitative and quantitative information about total ozone concentrations and rainfall prediction of kodaikanal , Tamilnadu

Material and Methods:

Arima Model

As the aim of the study was to forecast total ozone concentrations and rainfall of Kodaikanal, various forecasting techniques were considered for use. ARIMA model, introduced by Box and Jenkins (1970), was frequently used for discovering the pattern and predicting the future values of the time series data. Akaike (1970) discussed the stationary time series by an AR(p), where p is finite and bounded by the same integer. Moving Average (MA) models were used by Slutzky (1973). Hannan and Quinn (1979) suggested obtaining the order of a time series model by minimizing the errors for pure AR models, and Hannan (1980) for ARMA models. A second order determination method could be considered as a variance of Schwarz's Bayesian Criterion (SBC) which gives a consistent estimate of the order of an ARMA model. Hosking (1981) introduced a family of models, called fractionally differenced autoregressive integrated moving average models ,by generalizing the ‘d’ fraction in ARIMA (p, d, q) model. Stochastic time-series ARIMA models were widely used in time series data having the characteristics (Alan Pankratz, 1983) of parsimonious, stationary, invertible, significant estimated coefficients and statistically independent and normally distributed residuals. When a time series is non-stationary, it can often be made stationary by taking first differences of the series i.e., creating a new time series of successive differences ($Y_t - Y_{t-1}$). If first differences do not convert the series to stationary form, then second differences can be created. This is called second-order differencing. A distinction is made between a second-order differences ($Y_t - Y_{t-2}$). While Mendelssohn (1981) used Box-Jenkins models to forecast fishery dynamics, Prajneshu and Venugopalan (1996) discussed various statistical modeling techniques viz., polynomial, ARIMA time series methodology and nonlinear mechanistic growth modelling approach for describing marine, inland as well as total fish production in India during the period 1950-51 to 1994-95. Many authors developed ARIMA model to predict ground level ozone (Marzuki Ismail 2011).The time series when differenced follows both AR and MA models and is known as autoregressive integrated moving averages(ARIMA) model. Hence, ARIMA model was used in this study, which required a sufficiently large data set and involved four steps: ***identification, estimation, diagnostic checking and forecasting***. Model parameters were estimated using the Statistical Package for Social Sciences (SPSS) package and to fit the ARIMA models.Autoregressive process of order (p) is,

$$Y_t = \mu + \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \ldots\ldots\ldots\ldots\ldots\ldots\ldots \phi_p Y_{t-p} + \varepsilon_t$$

; Moving Average process of order (q) is

$$Y_t = \mu - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \ldots\ldots\ldots\ldots\ldots\ldots\ldots\theta_q \varepsilon_{t-q} + \varepsilon_t$$

; and the general form of ARIMA model of order (p, d, q) is

$$Y_t = \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \ldots\ldots\ldots\ldots\ldots\ldots\ldots \phi_p Y_{t-p} + \mu - \theta_1\varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \ldots\ldots\ldots\ldots\ldots\ldots\ldots\theta_q \varepsilon_{t-q} + \varepsilon_t$$

where Yt is total ozone column and rainfall to be predict,ε_t's are independently and normally distributed with zero-mean and constant variance σ^2 for t = 1,2,..., n; d is the fraction differenced while interpreting AR and MA and φs and θs are coefficients to be estimated.

Trend fitting

The Box-Ljung Q statistics was used to transform the non-stationary data in to stationary data and to check the adequacy for the residuals. For evaluating the adequacy of AR, MA and ARIMA processes, various reliability statistics like R^2, Stationary R^2, Root Mean Square Error (RMSE), Mean Absolute Percentage Error (MAPE), and Bayesian Information Criterion (BIC) [as suggested by Schwartz, 1978] were used. The reliability statistics viz. RMSE, MAPE, BIC and Q statistics were computed as below:

$$RMSE = \left[1/n \sum_{i=1}^{n} \left(Y_{i\ actual} - Y_{i\ forecasted} \right)^2 \right]^{1/2}$$

$$MAPE = 1/n \sum_{i=1}^{n} \left| \frac{\left(Y_{i\ actual} - Y_{i\ forecasted} \right)}{Y_{i\ actual}} \right|$$

$$BIC(p,q) = \ln v^*(p,q) + (p+q) [\ln (n) / n]$$

where p and q are the order of AR and MA processes respectively and n is the number of observations in the time series and v* is the estimate of white noise variance σ^2.

$$Q = \frac{n(n+2) \sum_{i=1}^{k} rk^2}{(n-k)}$$

where n is the number of residuals and rk is the residuals autocorrelation at lag k. In this study, the data on total ozone column and monthly rainfall in kodaikanal were collected from Indian Meteorological Department, New Delhi and Regional Meteorological Centre, Chennai.

Model identification

ARIMA model was designed after assessing that transforming the variable under forecasting was a stationary series. The stationary series was the set of values that varied over time around a constant mean and constant variance. The most common method to check the stationarity is to explain the data through graph and hence is done in Figure 1a and 1b reveals that the data used were non-stationary. Again, non-stationary in mean was corrected through first differencing of the data. The newly constructed variable Yt could now be examined for stationarity. Since, Yt was stationary in mean, the next step was to identify the values of p and q. For this, the autocorrelation and partial autocorrelation coefficients (ACF and PACF) of various orders of Yt were computed and presented in Table 1a, 1b ,1c and 1d and Figure 2a, 2b,2c and 2d.

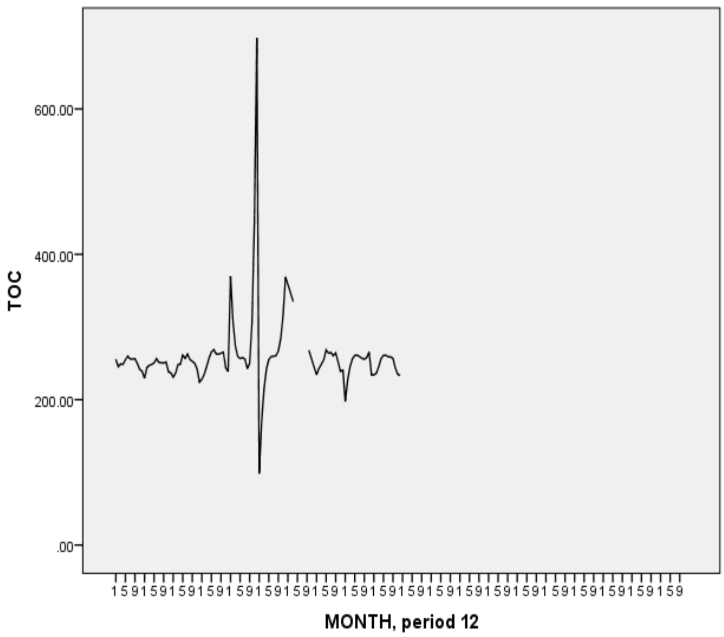


Figure 1a: Time Series Graph for TOC

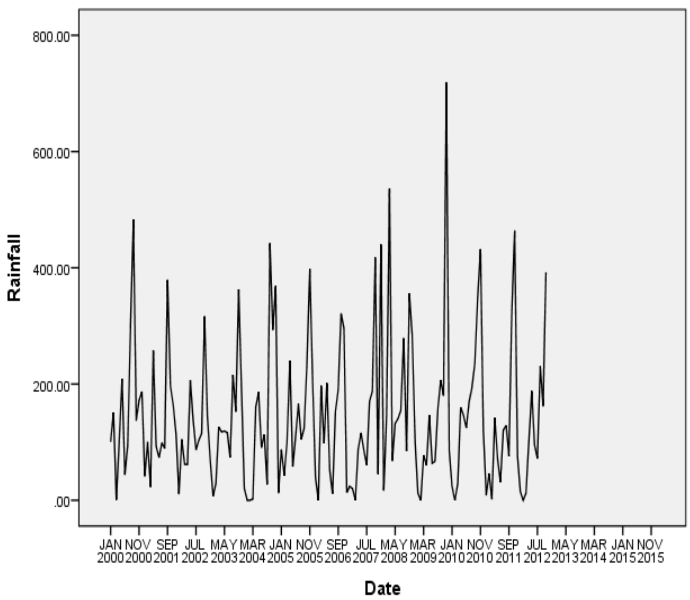


Figure 1b: Time Series Graph for Rainfall

Table 1a Autocorrelations Series: TOC

Lag	Autocorrelation	Std. Error[a]	Box-Ljung Statistic		
			Value	df	Sig.[b]
1	0.211	0.094	4.982	1	0.026
2	-0.094	0.094	5.989	2	0.05
3	-0.133	0.093	8.045	3	0.045
4	-0.073	0.092	8.687	4	0.069
5	-0.015	0.091	8.714	5	0.121
6	-0.005	0.09	8.716	6	0.19
7	-0.006	0.089	8.72	7	0.273
8	0.009	0.088	8.731	8	0.366
9	0.058	0.087	9.167	9	0.422
10	0.127	0.086	11.353	10	0.331
11	0.177	0.085	15.658	11	0.154
12	0.104	0.084	17.176	12	0.143

Table 1b Autocorrelations Series: Rainfall

Lag	Autocorrelation	Std. Error[a]	Box-Ljung Statistic		
			Value	df	Sig.[b]
1	.184	.080	5.313	1	.021
2	.004	.080	5.316	2	.070
3	-.145	.079	8.644	3	.034
4	-.226	.079	16.829	4	.002
5	-.013	.079	16.857	5	.005
6	-.089	.078	18.148	6	.006
7	-.079	.078	19.156	7	.008
8	-.189	.078	25.030	8	.002
9	-.233	.078	34.050	9	.000
10	-.034	.077	34.245	10	.000
11	.226	.077	42.851	11	.000
12	.426	.077	73.536	12	.000

13	0.028	0.084	17.292	13	0.186
14	0.019	0.083	17.342	14	0.238
15	-0.003	0.083	17.344	15	0.299
16	-0.003	0.082	17.345	16	0.364

13	.280	.077	86.925	13	.000
14	-.032	.076	87.105	14	.000
15	-.181	.076	92.771	15	.000
16	-.231	.076	102.041	16	.000

Table 1c. Partial Autocorrelations: TOC

Lag	Partial Autocorrelation	Std. Error
1	0.211	0.096
2	-0.145	0.096
3	-0.085	0.096
4	-0.04	0.096
5	-0.015	0.096
6	-0.023	0.096
7	-0.015	0.096
8	0.006	0.096
9	0.052	0.096
10	0.109	0.096
11	0.15	0.096
12	0.082	0.096
13	0.065	0.096
14	0.08	0.096
15	0.036	0.096
16	0.033	0.096

Table 1d. Partial Autocorrelations: Rainfall

Lag	Partial Autocorrelation	Std. Error
1	.184	.081
2	-.031	.081
3	-.145	.081
4	-.183	.081
5	.062	.081
6	-.124	.081
7	-.108	.081
8	-.219	.081
9	-.223	.081
10	-.070	.081
11	.160	.081
12	.286	.081
13	.150	.081
14	-.085	.081
15	-.134	.081
16	-.174	.081

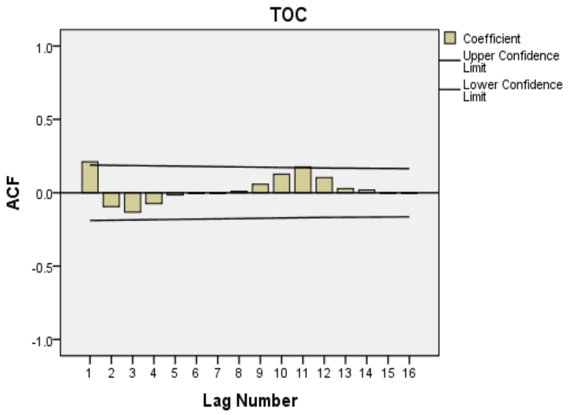


Figure 2a:ACF series for TOC

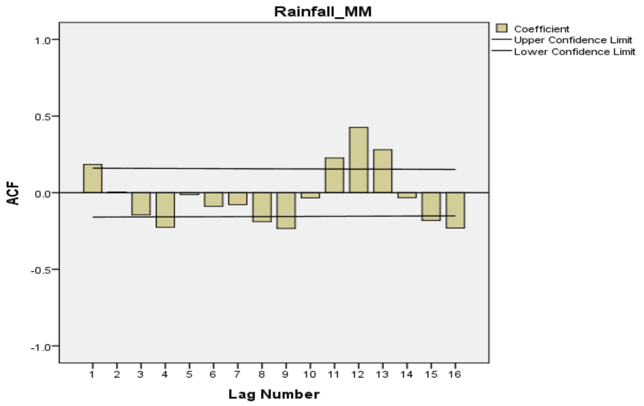
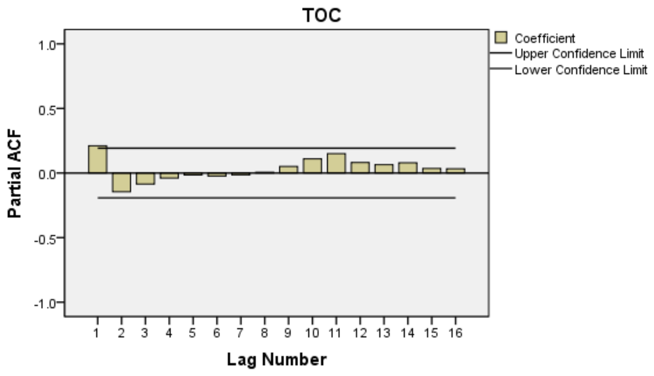


Figure 2b:ACF series for Rainfall



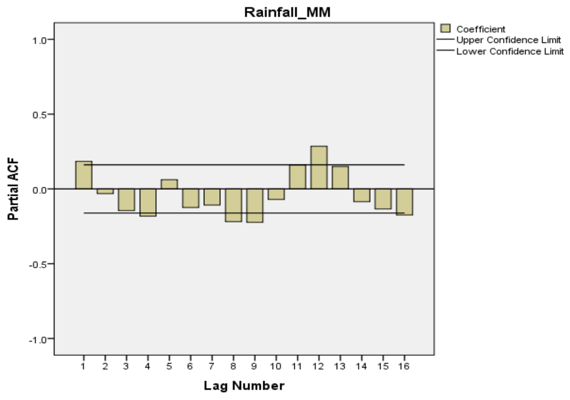


Figure 2c: PACF series for TOC

Figure 2d: PACF series for Rainfall

The value of normalized BIC of TOC was 4.869; the value of normalized BIC of Rainfall was 9.32.

Model estimation

Model parameters were estimated using SPSS package and the results of estimation are presented in Tables 2a and 2b. R^2 value for total ozone column was 0.983 and R^2 value for annual rainfall of kodaikanal was 0.463. Hence, the most suitable model for Total Ozone Prediction was ARIMA (1, 0, 0),$(1,1,0)^{12}$ and the most suitable model for monthly rainfall was ARIMA(0,0,12) as this model had the lowest normalized BIC value, good R^2 and better model fit statics (RMSE and MAPE).Estimated ARIMA model fit statistics shown in Table 2a and 2b.

Table 2a: Estimated ARIMA Model Fit Statistics for total ozone column of kodaikanal

Fit Statistic	Mean	Minimum	Maximum	Percentile						
				5	10	25	50	75	90	95
Stationary R-squared	.992	.992	.992	.992	.992	.992	.992	.992	.992	.992
R-squared	.983	.983	.983	.983	.983	.983	.983	.983	.983	.983
RMSE	8.182	8.182	8.182	8.182	8.182	8.182	8.182	8.182	8.182	8.182
MAPE	2.270	2.270	2.270	2.270	2.270	2.270	2.270	2.270	2.270	2.270
MaxAPE	11.342	11.342	11.342	11.342	11.342	11.342	11.342	11.342	11.342	11.342
MAE	5.678	5.678	5.678	5.678	5.678	5.678	5.678	5.678	5.678	5.678
MaxAE	26.050	26.050	26.050	26.050	26.050	26.050	26.050	26.050	26.050	26.050
Normalized BIC	4.869	4.869	4.869	4.869	4.869	4.869	4.869	4.869	4.869	4.869

Table 2b: Estimated ARIMA Model Fit Statistics for monthly rainfall of kodaikanal

Fit Statistic	Mean	SE	Minimum	Maximum	Percentile						
					5	10	25	50	75	90	95
Stationary R-squared	.46		.46	.46	.46	.46	.46	.46	.46	.46	.46

R-squared	.46		.46	.46	.46	.46	.46	.46	.46	.46	.46
RMSE	94.21		94.21	94.21	94.21	94.21	94.21	94.21	94.21	94.21	94.21
MAPE	665.56		665.56	665.56	665.56	665.56	665.56	665.56	665.56	665.56	665.56
MaxAPE	55935.35		55935.35	55935.35	55935.35	55935.35	55935.35	55935.35	55935.35	55935.35	55935.35
MAE	72.16		72.16	72.16	72.16	72.16	72.16	72.16	72.16	72.16	72.16
MaxAE	340.77		340.77	340.77	340.77	340.77	340.77	340.77	340.77	340.77	340.77
Normalized BIC	9.32		9.32	9.32	9.32	9.32	9.32	9.32	9.32	9.32	9.32

Diagnostic checking

The model verification is concerned with checking the residuals of the model to see if they contained any systematic pattern which still could be removed to improve the chosen ARIMA, which has been done through examining the autocorrelations and partial autocorrelations of the residuals of various orders. The Figure 3a and 3b shows the model fitting graph. Figure 4 a, 4b shows residual ACF and PACF .This proved at the selected ARIMA (1, 0, and 0) (1, 1, and 0)^{12} model was an appropriate model for forecasting Total ozone column and ARIMA(0,0,12) model was an appropriate model for forecasting monthly rainfall in kodaikanal, Tamilnadu.

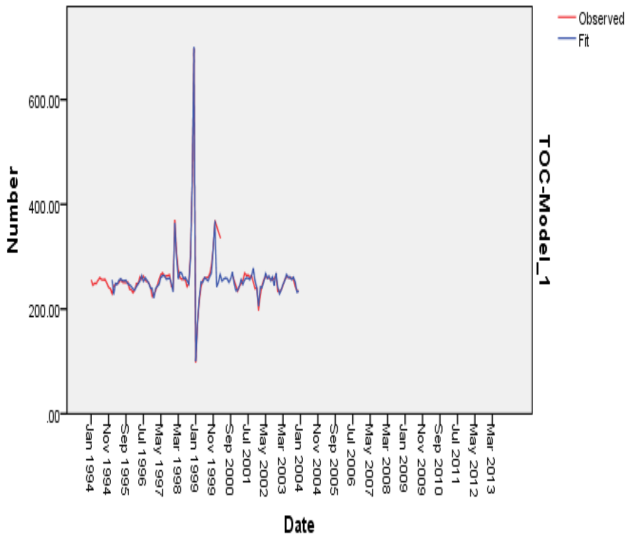


Fig 3a. Model fitting graph for total ozone column of kodaikanal

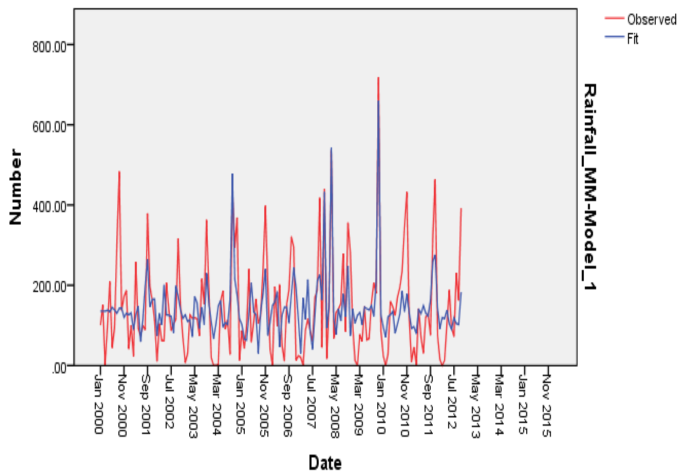
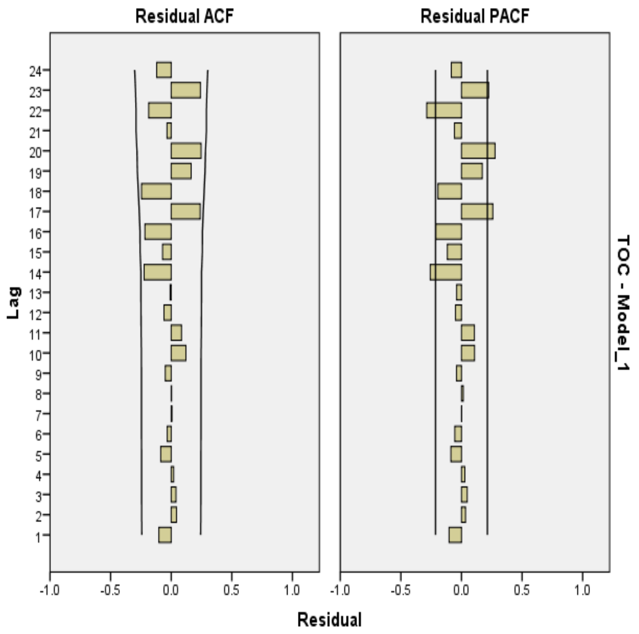


Fig 3b. Model fitting graph for monthly rainfall of kodaikanal



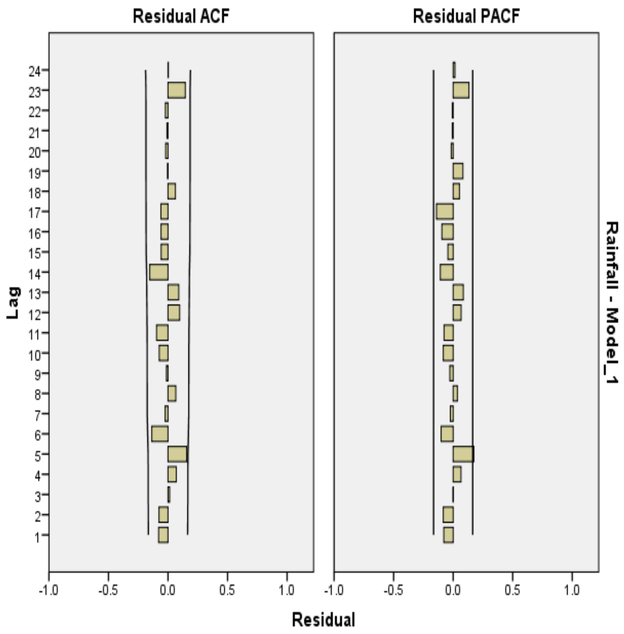


Fig 4a: Residual ACF& PACF For TOC

Fig4b. Residual ACF& PACF For Rainfall

Forecasting

Based on the model fitted, forecasted Total Ozone column (in Dobson unit) for the year 2013. The actual and forecasted value of Total Ozone Prediction (with 95% confidence limit, including some missing data's)) in kodaikanal, Tamilnadu was in shown Table 3a.

Table 3a : Forecast of Total Ozone Column of Kodikanal,Tamilnadu

Year	Month	TOC(DU)Actual	Predicted_TOC_Model_1_	LCL_TOC_Model_1_A	UCL_TOC_Model_1_A
1994	JANUARY	255.72			
1994	FEBRUARY	245.47			
1994	MARCH	249.29			
1994	APRIL	248.64			
1994	MAY	255			
1994	JUNE	259.88			
1994	JULY	256			
1994	AUGUST	255.88			
1994	SEPTEMBER	256.57			
1994	OCTOBER	249.6			
1994	NOVEMBER	241.57			

1994	DECEMBER	239.08			
1995	JANUARY	229.67	255.72	233.05	278.39
1995	FEBRUARY	244.47	228.3	211.25	245.34
1995	MARCH	247.3	248.76	231.72	265.81
1995	APRIL	248.5	247.53	230.48	264.57
1995	MAY	250.71	255.22	238.18	272.26
1995	JUNE	256.38	257.51	240.47	274.54
1995	JULY	251.25	254.39	237.36	271.42
1995	AUGUST	250.92	253.81	236.79	270.83
1995	SEPTEMBER	250.46	254.92	237.94	271.9
1995	OCTOBER	251.9	248.07	231.16	264.98
1995	NOVEMBER	238.31	246.8	230.07	263.53
1995	DECEMBER	236.95	242.99	226.69	259.29
1996	JANUARY	231.04	238.27	223.14	253.39
1996	FEBRUARY	236.6	236.11	222.1	250.11
1996	MARCH	248.41	242.84	228.84	256.84
1996	APRIL	248.74	248.56	234.56	262.57
1996	MAY	261.38	253.26	239.26	267.27
1996	JUNE	256.92	263.83	249.82	277.83
1996	JULY	262.83	252.99	238.99	267
1996	AUGUST	255.25	259.63	245.62	273.63
1996	SEPTEMBER	252.75	254.94	240.93	268.94
1996	OCTOBER	250.17	249.8	235.79	263.8
1996	NOVEMBER	242.33	239.89	225.89	253.89
1996	DECEMBER	224.08	239.6	225.59	253.6
1997	JANUARY	228	220.92	206.92	234.93
1997	FEBRUARY	234.94	239.59	225.58	253.59
1997	MARCH	245.67	243.7	229.7	257.71
1997	APRIL	257	247.21	233.2	261.21
1997	MAY	265.78	260.86	246.86	274.87
1997	JUNE	268.83	263.56	249.55	277.56
1997	JULY	263	264.33	250.32	278.33
1997	AUGUST	262.57	257.27	243.27	271.27
1997	SEPTEMBER	264	257.93	243.93	271.94
1997	OCTOBER	265.4	259.48	245.47	273.48
1997	NOVEMBER	243.57	249.48	235.48	263.48
1997	DECEMBER	239	233.76	219.75	247.76
1998	JANUARY	369.88	363.57	349.57	377.58
1998	FEBRUARY	308.5	299.28	285.28	313.28
1998	MARCH	274.25	258.32	244.32	272.33
1998	APRIL	259.5	270.2	256.2	284.2
1998	MAY	256.63	268.05	254.05	282.05
1998	JUNE	258	257.64	243.64	271.64
1998	JULY	256	260.22	246.22	274.23
1998	AUGUST	243	253.82	239.82	267.83
1998	SEPTEMBER	249.83	247.38	233.38	261.39
1998	OCTOBER	307.33	299.62	285.62	313.62
1998	NOVEMBER	446.33	447.57	433.57	461.58
1998	DECEMBER	697.67	699.76	685.75	713.76
1999	JANUARY	98.43	100.24	86.24	114.24
1999	FEBRUARY	168.28	170.48	156.48	184.49
1999	MARCH	214.43	221.27	207.27	235.28
1999	APRIL	241.76	251.7	237.7	265.71
1999	MAY	255.16	251.03	237.03	265.04
1999	JUNE	259.5	259.74	245.74	273.75

1999	JULY	259.67	256.89	242.89	270.9
1999	AUGUST	260.54	253.94	239.94	267.95
1999	SEPTEMBER	267	262.14	248.13	276.14
1999	OCTOBER	283.93	268.8	254.79	282.8
1999	NOVEMBER	316.21	316.14	302.14	330.15
1999	DECEMBER	368.71	368.24	354.24	382.24
2000	JANUARY	-	243.08	229.07	257.08
2000	FEBRUARY	-	250.8	233.99	267.6
2000	MARCH	-	265.97	248.07	283.86
2000	APRIL	-	253.76	235.41	272.11
2000	MAY	-	257.25	238.7	275.8
2000	JUNE	-	259.48	240.84	278.11
2000	JULY	-	258.13	239.46	276.8
2000	AUGUST	-	250.91	232.22	269.6
2000	SEPTEMBER	-	257.46	238.76	276.15
2000	OCTOBER	-	270.05	251.35	288.75
2010	MAY	-	260.64	226.35	294.94
2010	JUNE	-	260.98	226.66	295.3
2010	JULY	-	258.96	224.63	293.29
2010	AUGUST	-	258.09	223.76	292.42
2010	SEPTEMBER	-	256.27	221.94	290.6
2010	OCTOBER	-	248.7	214.37	283.03
2010	NOVEMBER	-	236.95	202.62	271.29
2010	DECEMBER	-	233.66	199.33	268
2011	JANUARY	-	230.92	195.46	266.39
2011	FEBRUARY	-	231.72	195.77	267.67
2011	MARCH	-	244.47	208.31	280.63
2011	APRIL	-	255.86	219.61	292.11
2011	MAY	-	260.65	224.36	296.95
2011	JUNE	-	260.99	224.67	297.3
2011	JULY	-	258.96	222.64	295.28
2011	AUGUST	-	258.12	221.8	294.44
2011	SEPTEMBER	-	256.28	219.96	292.61
2011	OCTOBER	-	248.54	212.22	284.87
2011	NOVEMBER	-	236.89	200.56	273.21
2011	DECEMBER	-	233.66	197.33	269.99
2012	JANUARY	-	230.87	193.44	268.3
2012	FEBRUARY	-	231.64	193.73	269.55
2012	MARCH	-	244.46	206.34	282.58
2012	APRIL	-	255.85	217.64	294.06
2012	MAY	-	260.65	222.4	298.89
2012	JUNE	-	260.98	222.72	299.25
2012	JULY	-	258.96	220.69	297.23
2012	AUGUST	-	258.1	219.83	296.38
2012	SEPTEMBER	-	256.28	218	294.56
2012	OCTOBER	-	248.63	210.35	286.91
2012	NOVEMBER	-	236.93	198.65	275.2
2012	DECEMBER	-	233.66	195.38	271.94
2013	JANUARY	-	230.9	191.59	270.21
2013	FEBRUARY	-	231.69	191.93	271.44
2013	MARCH	-	244.47	204.52	284.42
2013	APRIL	-	255.86	215.82	295.89
2013	MAY	-	260.65	220.58	300.72
2013	JUNE	-	260.98	220.89	301.07
2013	JULY	-	258.96	218.86	299.06

2013	AUGUST	-	258.11	218.01	298.21
2013	SEPTEMBER	-	256.28	216.18	296.38
2013	OCTOBER	-	248.58	208.48	288.68
2013	NOVEMBER	-	236.9	196.8	277.01
2013	DECEMBER	-	233.66	193.56	273.76

Table3b: Forecasting Monthly Rainfall of Kodaikanal

Year	Month	RAIN FALL(MM)	Predicted Rainfall_Model_1	LCL_rainfall_Model_1	UCL_rainfall_Model_1
2000	JANUARY	100.5	135.44	-72.63	343.5
2000	FEBRUARY	151.3	135.44	-72.63	343.5
2000	MARCH	1	135.44	-72.63	343.5
2000	APRIL	98.1	137.95	-69.58	345.48
2000	MAY	209.3	134.3	-73.23	341.83
2000	JUNE	44	145.09	-62.44	352.62
2000	JULY	94.2	138.31	-69.21	345.84
2000	AUGUST	300.2	130.03	-77.5	337.55
2000	SEPTEMBER	483.5	142.73	-64.79	350.26
2000	OCTOBER	137.3	143.92	-61.55	349.39
2000	NOVEMBER	171.9	120.07	-85.4	325.54
2000	DECEMBER	187.1	130.34	-75.13	335.81
2001	JANUARY	41.4	126.48	-63.03	316
2001	FEBRUARY	100.4	131.05	-58.47	320.56
2001	MARCH	23.1	89.52	-99.99	279.04
2001	APRIL	257.7	127.4	-61.96	316.76
2001	MAY	92.6	147.28	-42.08	336.64
2001	JUNE	73.5	59.25	-130.11	248.61
2001	JULY	98.7	114.05	-75.29	303.39
2001	AUGUST	89.2	199.3	9.96	388.64
2001	SEPTEMBER	379.2	264.43	75.09	453.78
2001	OCTOBER	196.9	146.31	-41.7	334.32
2001	NOVEMBER	163.9	165.16	-22.85	353.18
2001	DECEMBER	112.4	165.34	-22.67	353.35
2002	JANUARY	10.7	74.47	-110.56	259.5
2002	FEBRUARY	105.1	129.72	-55.31	314.75
2002	MARCH	62	101.43	-83.6	286.46
2002	APRIL	61.8	201.06	16.08	386.03
2002	MAY	206.3	126.35	-58.63	311.32
2002	JUNE	138.4	125.62	-59.36	310.6

2002	JULY	86.7	122.27	-62.65	307.19
2002	AUGUST	103.5	81.62	-103.3	266.55
2002	SEPTEMBER	115.2	198.42	13.5	383.34
2010	JANUARY	23.7	95.08	-87.51	277.68
2010	FEBRUARY	0	70.76	-111.83	253.36
2010	MARCH	28.4	121.36	-61.24	303.96
2010	APRIL	159.9	126.7	-55.89	309.3
2010	MAY	146.5	134.91	-47.68	317.51
2010	JUNE	124.7	80.27	-102.33	262.87
2010	JULY	170.2	103.82	-78.77	286.42
2010	AUGUST	194.4	128.5	-54.09	311.1
2010	SEPTEMBER	236	185.5	2.9	368.09
2010	OCTOBER	347.8	134.04	-48.55	316.64
2010	NOVEMBER	432.3	178.34	-4.25	360.94
2010	DECEMBER	119.2	131.91	-50.69	314.5
2011	JANUARY	8.5	92.64	-89.96	275.23
2011	FEBRUARY	45.9	96.86	-85.73	279.46
2011	MARCH	1.8	79.48	-103.11	262.08
2011	APRIL	142.2	140.55	-42.05	323.14
2011	MAY	71.4	129.49	-53.1	312.09
2011	JUNE	30.9	149.21	-33.39	331.8
2011	JULY	120.9	131	-51.6	313.59
2011	AUGUST	128.8	123.48	-59.12	306.07
2011	SEPTEMBER	75.8	163.77	-18.82	346.37
2011	OCTOBER	325.5	260.84	78.25	443.44
2011	NOVEMBER	463.9	275.57	92.97	458.16
2011	DECEMBER	75.8	142.94	-39.66	325.53
2012	JANUARY	14.5	91.77	-90.83	274.36
2012	FEBRUARY	0	119.67	-62.92	302.27
2012	MARCH	12.4	116.79	-65.8	299.38
2012	APRIL	103	138.12	-44.48	320.71
2012	MAY	188.1	104.53	-78.07	287.12
2012	JUNE	94.8	90.36	-92.23	272.96
2012	JULY	72.3	118.54	-64.05	301.13
2012	AUGUST	230.4	104.12	-78.47	286.71
2012	SEPTEMBER	161.9	102.23	-80.36	284.83
2012	OCTOBER	392.4	182.74	0.15	365.34
2012	NOVEMBER	-	254.17	71.57	436.76
2012	DECEMBER	-	119.71	-62.89	302.3
2013	JANUARY	-	101.96	-80.64	284.55
2013	FEBRUARY	-	58.63	-123.96	241.23
2013	MARCH	-	80.82	-101.77	263.42
2013	APRIL	-	125.7	-56.9	308.29
2013	MAY	-	155.68	-26.91	338.27
2013	JUNE	-	126.93	-55.66	309.53
2013	JULY	-	73.68	-108.91	256.28
2013	AUGUST	-	200.54	14.98	386.09
2013	SEPTEMBER	-	166.2	-19.36	351.75
2013	OCTOBER	-	243.52	57.96	429.07
2013	NOVEMBER	-	135.44	-72.63	343.5
2013	DECEMBER	-	135.44	-72.63	343.5

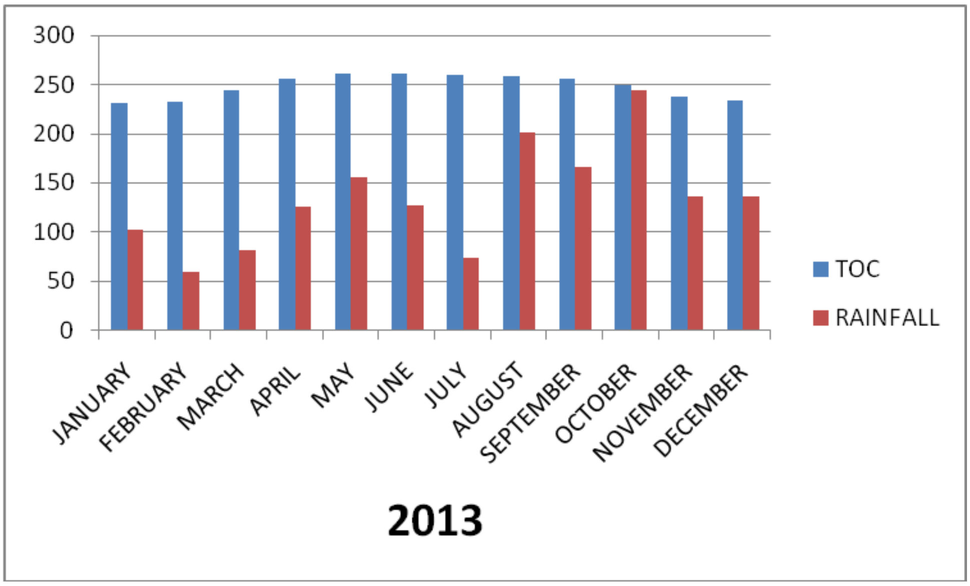


Fig 5. Comparison of Total ozone column and Rainfall of kodaikanal based forecasting value

Conclusion

Time-series analysis is an important tool in modelling and forecasting air pollutants. Although, this piece of information was not appropriate to predict the exact total ozone concentration and rainfall, ARIMA (1,0,0) $(1,1,0)^{12}$ and ARIMA (0,0,12) model give us information that can help the decision makers establish strategies, priorities and proper use of rainfall in kodaikanal. Based on both forecasting value of Total ozone column and rainfall of kodaikanal, plot the graph(Fig 5) it clearly indicates August, September and October we will get good rainfall especially, October we can get more than 200 mm rainfall .One direct effect of increasing total ozone column is expected to be increasing rainfall.

Acknowledgement

The researcher would like to thank India Meteorological Department, New Delhi and Regional Meteorological Centre, Chennai. Authors are also grateful to authors/editors/publishers of those articles, journals and books from where the literature of this article has been reviewed and discussed

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