Variation of Total Ozone Concentration and Rainfall by Decomposition Analysis

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Abstract- This paper presents the significant relationship between Total Ozone Concentration and annual rainfall over Kodaikanal of Tamilnadu. Analysis shows that rainfall decreases with decrease of Total Ozone concentration. Stratospheric ozone controls different environmental parameters. Analysis of the total ozone concentration is vital for the purpose of forecasting. It enables one to identify the changes and impacts that are very crucial for an agro-based economy like the state of Tamil Nadu. This paper summarises the decomposition method of analysis of 12 year data of Total Ozone concentration and annual rainfall of Kodaikanal. The objective of this study is to analyse variation of Total ozone concentration and annual rainfall of Kodaikanal of Tamilnadu using decomposition method. The Decomposition techniques are used to identify salient features of a time series such as trend, seasonality and cyclical patterns. The variation of seasonal behaviour of Total ozone concentration and annual rainfall in Kodaikanal is analysed in the paper.

Index Terms— Annual Rainfall, Decomposition method, Moving average, Total ozone Concentration, Kodaikannal

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1 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 tropospheric 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 (1992) confirms that O3 is depleted everywhere with smaller amounts but dramatic decreases of O3 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. [2] reported that a fall in ozone content in the stratosphere takes place over England before the arrival of warmfronts 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. [3] reported the close relationship between barometric height, tropospheric weather, and ionospheric parameters of the upper atmosphere. It were observed that minimum height of F region and average E ionization tend to follow the variation of barometric height. Mitra et al. [4] also mentioned that correlation was observed between lowest virtual height of E region and ground temperature at Stanford, California, USA.

Midya et al. [5] also showed that Rain occurs only when ozone concentration lies in a certain concentration level. Major agricultural operations are normally undertaken during South-west 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 arainfall over Kodaikanal of Tamilnadu. It has been noted that the Total ozone and annual rainfall shows a strong variation during this period.

2 DATA AND METHODOLOGY

We have used the total ozone concentration and rainfall data of Kodaikanal, Tamilnadu from the period 2001 to 2012. The above data is obtained from the India Meteorological Department, New Delhi and Regional Meteorological Centre, Chennai.

3 DECOMPOSITION METHODS

Parametric classical decomposition method is one of the most widely used techniques to analyse time series data. It is used to decompose a series into non-observable components that can be associated to different types of temporal variation. Classical decomposition is used to isolate trend, seasonal, and other variability components from a time series model (Shim, Jae,200). This decomposition method goes back to Persons (1919). According to this decomposition method, time series has four components

a) Trend component, (T_t) -is the component that models a steady upward growth or downward decline

b) Seasonal component,(S_t) - is the component that mod els a systematic and related movements, generally annual (i.e. a similar patterns of behaviour are observed at particular times of the year)

c) Cyclic component,(C_t) -is the component that represent a regular uctuations at cyclical periods rather than at particular times of the year and
d) Random component, (ε_t) is the component that models the unexpected events which arising suddenly.

The idea is to create separate models for these four components and then combine them, either additively or multiplicatively,(DeLurgio,et.al,1991) as follows:

$$Y_t = T_t + S_t + C_t + \varepsilon_t$$
$$Y_t = T_t \cdot S_t \cdot C_t \cdot \varepsilon_t$$

Where Y_t is the observed value of the time series in time period t.

3.1 STEPS TO CALCULATE CLASSICAL DECOMPOSITION

A) Determine seasonal indexes using the ratio to moving average method.
B) Deseasonalize the data.
C) Develop the trend-cyclical regression equation using deseasonalized data.
D) Multiply the forecasted trend values by their seasonal indexes to create a more accurate forecast

(i) Determination of seasonal indexes

Start with multiplicative model
$Y = TCSe$
$Se = (Y/TC)$
To find seasonal indexes, first estimate trend-cyclical components use centered moving average and for quarterly data, use four-quarter moving average.
The seasonal-error components are found by dividing original data by trend-cyclicalcomponents
$Se = (Y/TC)$
Where, Se is the Seasonal-error components,Y is the Original data value and TC is Trend-cyclical components .
Unadjusted seasonal indexes (USI) are found by averaging seasonal-error components by period. We develop adjusting factor (AF) so USIs are adjusted so their sum equals the number of quarters (4).
The Adjusted seasonal indexes (ASI) are derived by multiplying the unadjusted seasonal index by the adjusting factor. It is given as follows,
ASI = USI x AF
ASI = Adjusted seasonal index
USI = Unadjusted seasonal index
AF = Adjusting factor

(ii) Deseasonalisation of the data.

The deseasonalized data is produced by dividing the original data values by their seasonal Indexes
(Y/S) = TCe
Y/S = Deseasonalized data
TCe = Trend-cyclical-error component

(iii) The trend-cyclical regression equation

Develop the trend-cyclical regression equation using deseasonalized data
$T_t = a + bt$
T_t = Trend value at period t
a = Intercept value
b = Slope of trend line

(iv) Forecast data

Finally the Total ozone concentration and rainfall data is forecasted by multiplying the trend data values by their seasonal indexes. In our method we have used the data from 2001 to 2012. The seasons are divided into four. They are winter, Pre-monsoon, Southwest monsoon, Post monsoon.

Table 1 gives the calculation of the classical decomposition of the annual rainfall data of kodaikanal.

Table 2 gives the calculation of the classical decomposition of the Total ozone concentration kodaikanal.

The first three columns represent the year, the corresponding season and the time period. The fourth column represents the total ozone and annual rainfall for the seasons recorded for the respective years. The fifth and the sixth column represent Seasonal index and deseasonalised ozone data. The trend is calculated in the seventh column

Table 1:
Classical decomposition of the rainfall data of Kodaikanal

Year	Quarter	Period(t)	Measured value(mm) Y	Adjusted Seasonal Index S	Deseasonalized Data Tce=Y/S	Trend equvation Tt = a + bt	Forecated Value
2001	**1(JAN, FEB) Winter**	5	70.90	0.2561	276.8302	163.8360	41.9606
	2(MAR,APR,MAY) Pre Monsoon	6	124.47	0.9514	130.8298	162.7305	154.8158
	3(JUNE,JULY,AUG,SEP) SW Mon	7	160.15	1.0812	148.1209	161.6250	174.7507
	4(OCT,NOV,DEC) Post M soon	8	157.73	1.7113	92.1717	160.5195	274.6968
2002	**1(JAN, FEB) Winter**	9	57.90	0.2561	226.0715	159.4140	40.8281
	2(MAR,APR,MAY) Pre Monsoon	10	110.03	0.9514	115.6586	158.3085	150.6089
	3(JUNE,JULY,AUG,SEP) SW Mon	11	110.95	1.0812	102.6164	157.2030	169.9696
	4(OCT,NOV,DEC) Post M soon	12	177.50	1.7113	103.7224	156.0975	267.1294
2003	**1(JAN, FEB) Winter**	13	18.00	0.2561	70.2813	154.9920	39.6956
	2(MAR,APR,MAY) Pre Monsoon	14	120.93	0.9514	127.1159	153.8865	146.4019
	3(JUNE,JULY,AUG,SEP) SW Mon	15	139.78	1.0812	129.2763	152.7810	165.1885
	4(OCT,NOV,DEC) Post M soon	16	190.93	1.7113	111.5722	151.6755	259.5620
2004	**1(JAN, FEB) Winter**	17	1.00	0.2561	3.9045	150.5700	38.5630
	2(MAR,APR,MAY) Pre Monsoon	18	116.13	0.9514	122.0705	149.4645	142.1950
	3(JUNE,JULY,AUG,SEP) SW Mon	19	168.48	1.0812	155.8206	148.3590	160.4074
	4(OCT,NOV,DEC) Post M soon	20	224.90	1.7113	131.4207	147.2535	251.9947
2005	**1(JAN, FEB) Winter**	21	64.70	0.2561	252.6222	146.1480	37.4305
	2(MAR,APR,MAY) Pre Monsoon	22	133.27	0.9514	140.0797	145.0425	137.9881
	3(JUNE,JULY,AUG,SEP) SW Mon	23	125.85	1.0812	116.3973	143.9370	155.6263
	4(OCT,NOV,DEC) Post M soon	24	279.40	1.7113	163.2679	142.8315	244.4273
2006	**1(JAN, FEB) Winter**	25	19.35	0.2561	75.5524	141.7260	36.2980
	2(MAR,APR,MAY) Pre Monsoon	26	165.43	0.9514	173.8908	140.6205	133.7812
	3(JUNE,JULY,AUG,SEP) SW Mon	27	101.35	1.0812	93.7375	139.5150	150.8452
	4(OCT,NOV,DEC) Post M soon	28	210.13	1.7113	122.7918	138.4095	236.8599
2007	**1(JAN, FEB) Winter**	29	22.25	0.2561	86.8755	137.3040	35.1654
	2(MAR,APR,MAY) Pre Monsoon	30	68.23	0.9514	71.7217	136.1985	129.5742
	3(JUNE,JULY,AUG,SEP) SW Mon	31	126.53	1.0812	117.0216	135.0930	146.0640
	4(OCT,NOV,DEC) Post M soon	32	301.10	1.7113	175.9483	133.9875	229.2926
2008	**1(JAN, FEB) Winter**	33	82.05	0.2561	320.3656	132.8820	34.0329
	2(MAR,APR,MAY) Pre Monsoon	34	245.40	0.9514	257.9457	131.7765	125.3673
	3(JUNE,JULY,AUG,SEP) SW Mon	35	164.68	1.0812	152.3061	130.6710	141.2829
	4(OCT,NOV,DEC) Post M soon	36	247.03	1.7113	144.3543	129.5655	221.7252
2009	**1(JAN, FEB) Winter**	37	6.05	0.2561	23.6223	128.4600	32.9004
	2(MAR,APR,MAY) Pre Monsoon	38	94.83	0.9514	99.6815	127.3545	121.1604
	3(JUNE,JULY,AUG,SEP) SW Mon	39	123.58	1.0812	114.2931	126.2490	136.5018
	4(OCT,NOV,DEC) Post M soon	40	328.03	1.7113	191.6868	125.1435	214.1579
2010	**1(JAN, FEB) Winter**	41	11.85	0.2561	46.2685	124.0380	31.7678
	2(MAR,APR,MAY) Pre Monsoon	42	111.60	0.9514	117.3054	122.9325	116.9534
	3(JUNE,JULY,AUG,SEP) SW Mon	43	181.33	1.0812	167.7055	121.8270	131.7207
	4(OCT,NOV,DEC) Post M soon	44	299.77	1.7113	175.1691	120.7215	206.5905
2011	**1(JAN, FEB) Winter**	45	27.20	0.2561	106.2029	119.6160	30.6353
	2(MAR,APR,MAY) Pre Monsoon	46	71.80	0.9514	75.4707	118.5105	112.7465
	3(JUNE,JULY,AUG,SEP) SW Mon	47	89.10	1.0812	82.4076	117.4050	126.9396
	4(OCT,NOV,DEC) Post M soon	48	288.40	1.7113	168.5270	116.2995	199.0231
2012	**1(JAN, FEB) Winter**	49	7.25	0.2561	28.3077	115.1940	29.5028
	2(MAR,APR,MAY) Pre Monsoon	50	101.17	0.9514	106.3387	114.0885	108.5396
	3(JUNE,JULY,AUG,SEP) SW Mon	51	139.85	1.0812	129.3457	112.9830	122.1585
	4(OCT,NOV,DEC) Post M soon	52	392.40	1.7113	229.2996	111.8775	191.4558

Table 2:
Classical decomposition of the Total Ozone column data of Kodaikanal

Year	Quarter	Trend equvation Tt = a + bt	Forecated Value(Dobson unit)
2001	1(JAN, FEB) Winter	249.213	227.7872062
	2(MAR,APR,MAY) Pre Monsoon	248.9585	257.9261683
	3(JUNE,JULY,AUG,SEP) SW M soon	248.704	262.565426
	4(OCT,NOV,DEC) Post M soon	248.4495	247.0116944
2002	1(JAN, FEB) Winter	248.195	226.8567276
	2(MAR,APR,MAY) Pre Monsoon	247.9405	256.8714992
	3(JUNE,JULY,AUG,SEP) SW M soon	247.686	261.4906881
	4(OCT,NOV,DEC) Post M soon	247.4315	245.9995857
2003	1(JAN, FEB) Winter	247.177	225.9262489
	2(MAR,APR,MAY) Pre Monsoon	246.9225	255.8168301
	3(JUNE,JULY,AUG,SEP) SW M soon	246.668	260.4159503
	4(OCT,NOV,DEC) Post M soon	246.4135	244.9874769
2004	1(JAN, FEB) Winter	246.159	224.9957703
	2(MAR,APR,MAY) Pre Monsoon	245.9045	254.762161
	3(JUNE,JULY,AUG,SEP) SW M soon	245.65	259.3412124
	4(OCT,NOV,DEC) Post M soon	245.3955	243.9753682
2005	1(JAN, FEB) Winter	245.141	224.0652916
	2(MAR,APR,MAY) Pre Monsoon	244.8865	253.7074919
	3(JUNE,JULY,AUG,SEP) SW M soon	244.632	258.2664746
	4(OCT,NOV,DEC) Post M soon	244.3775	242.9632595
2006	1(JAN, FEB) Winter	244.123	223.134813
	2(MAR,APR,MAY) Pre Monsoon	243.8685	252.6528228
	3(JUNE,JULY,AUG,SEP) SW M soon	243.614	257.1917367
	4(OCT,NOV,DEC) Post M soon	243.3595	241.9511508
2007	1(JAN, FEB) Winter	243.105	222.2043343
	2(MAR,APR,MAY) Pre Monsoon	242.8505	251.5981537
	3(JUNE,JULY,AUG,SEP) SW M soon	242.596	256.1169989
	4(OCT,NOV,DEC) Post M soon	242.3415	240.9390421
2008	1(JAN, FEB) Winter	242.087	221.2738557
	2(MAR,APR,MAY) Pre Monsoon	241.8325	250.5434846
	3(JUNE,JULY,AUG,SEP) SW M soon	241.578	255.042261
	4(OCT,NOV,DEC) Post M soon	241.3235	239.9269333
2009	1(JAN, FEB) Winter	241.069	220.343377
	2(MAR,APR,MAY) Pre Monsoon	240.8145	249.4888155
	3(JUNE,JULY,AUG,SEP) SW M soon	240.56	253.9675232
	4(OCT,NOV,DEC) Post M soon	240.3055	238.9148246
2010	1(JAN, FEB) Winter	240.051	219.4128984
	2(MAR,APR,MAY) Pre Monsoon	239.7965	248.4341464
	3(JUNE,JULY,AUG,SEP) SW M soon	239.542	252.8927853
	4(OCT,NOV,DEC) Post M soon	239.2875	237.9027159
2011	1(JAN, FEB) Winter	239.033	218.4824197
	2(MAR,APR,MAY) Pre Monsoon	238.7785	247.3794773
	3(JUNE,JULY,AUG,SEP) SW M soon	238.524	251.8180474
	4(OCT,NOV,DEC) Post M soon	238.2695	236.8906072
2012	1(JAN, FEB) Winter	238.015	217.5519411
	2(MAR,APR,MAY) Pre Monsoon	237.7605	246.3248081
	3(JUNE,JULY,AUG,SEP) SW M soon	237.506	250.7433096
	4(OCT,NOV,DEC) Post M soon	237.2515	235.8784985

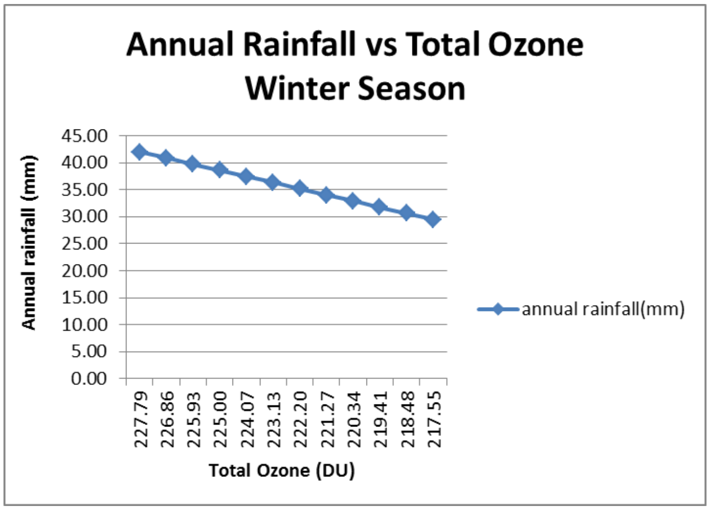

Figure1: Annual Rainfall vs Total Ozone-Winter season

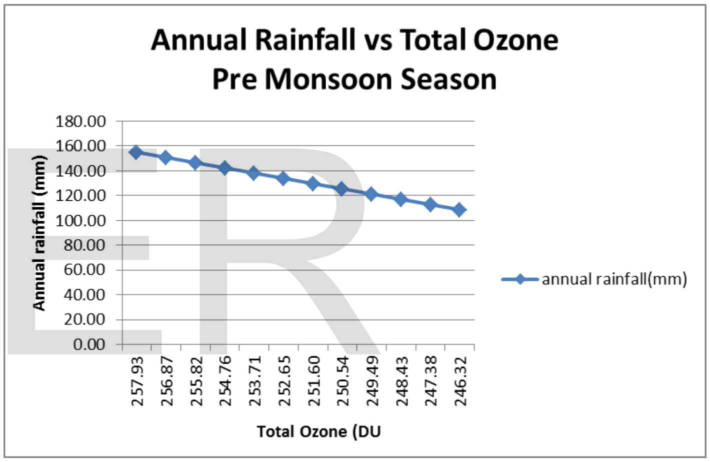

Figure2: Annual Rainfall vs Total Ozone-Pre monsoon

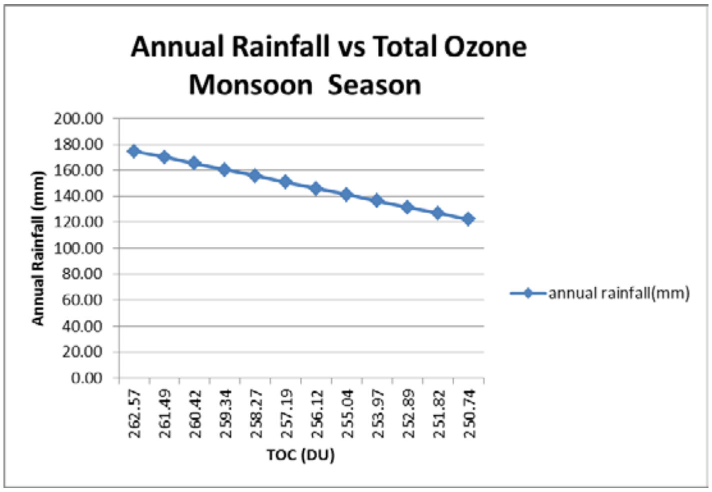

Figure3: Annual Rainfall vs Total Ozone-Monsoon season

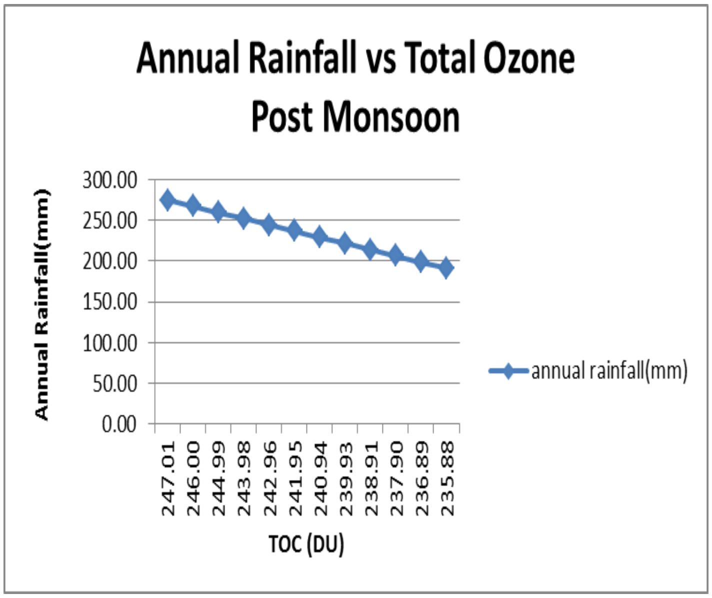

Figure4: Annual Rainfall vs Total Ozone-Post monsoon

4.0 RESULTS AND DISCUSSION

A graph is plotted for seasonal Total Ozone column and Rainfall. It clearly indicates that total ozone column reduces rainfall also reduces.

5.0 CONCLUSION

Time-series analysis is an important tool in modelling and forecasting air pollutants. The Classical Decomposition model give us information that can help the decision makers establish strategies, priorities for rainfall. This is very important because Total ozone (TOC) is increased rainfall also increase. In summary, concentrations of Total ozone and annual rainfall in Kodaikanal have been measured, and, as Total ozone is increasing rainfall is expected to be increase.

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