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RESEARCH ARTICLE

REGRESSION ANALYSIS AND FORECASTING HOURLY CONCENTRATION OF SURFACE OZONE IN CHENNAI, TAMIL NADU

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ABSTRACT

Observed Ozone Concentrations are valuable indicators of possible health and environmental impacts. They are also used to monitor changes and trends in the source of Ozone and its precursors. The influence of meteorological variables is a confounding factor. The paper examines Ozone concentration and meteorology in Chennai at Koyambedu which is a major big Bus terminus. We were the first researchers measuring Ozone and meteorological parameters in this site. We have made an effort to understand seasonal variation of Surface Ozone and meteorological parameters. This will be very useful for further research and future researchers. A non-linear regression model has been designed to forecast hourly average ground level Ozone concentration on the next day in Chennai using meteorological data. For this purpose, a number of regression models were considered. The selection of final model was based on extensive analysis and literature. One day hourly forecast of Ozone Concentration was made by the meteorological parameters which are very closely correlated to ozone.

INTRODUCTION

Ozone manifests itself its effect on organisms as poisonous gas. It results in irritation of the respiratory system and show effects on the health especially of children. (C.Comrie.,1997). Process in the formation of Ozone O3 is highly multifaceted in nature. Ozone is a secondary pollutant and it is not usually emanated straight forwardly from stacks. The ozone precursors are generally divided into two groups, namely oxides of nitrogen (NOX) and Volatile Organic Components (VOC) like evaporative solvents and other hydrocarbons. In suitable ambient meteorological condition (e.g. warm, sunny, clear day) ultra violet radiation (UV) causes the precursors to interact photo chemically in a set of reactions that result in the formation of ozone. (G.Bandyodhyay.*et al*,2007).
The process of ozone formation can be expressed as,

$$N\,O_2 + UV \rightarrow NO + O$$
$$O + O_2 + M \rightarrow O_3 + M.$$

Where, M is a third body molecule that remains unchanged in reaction. Ozone produced this way gets simultaneously destroyed as.

$$O_3 + D \rightarrow DO + O_2$$

Where, D implies additional reactant that destroys the ozone via oxidation. (T.H.Slini,2002, Andrew, C.Commrie,1997). Photochemical process leading to Ozone formations in the atmosphere are complex and non-linear. (MacDonald *et al*.,2001). Ozone levels tend to be higher under hot sunny conditions favorable for photochemical ozone production in the presence of precursors. At the same time higher temperatures cause convection to develop, which in turn can enchance vertical ozone transport. Conversely, wet rainy whether with high relative humidity is typically associated with the low ozone levels provided by less intensive photochemical production and possibly, by ozone deposition on water droplets. In particular, strong wind reflects the increased intensity of the vertical transport. If the boundary layer acts as a source of ozone due to chemical generation, the growth of the wind speed leads to the decrease of ozone concentration becacuse of vertical mixing.. (O.A. Tarasova.,2003., G.Bandyodhyay.*et al*)

The Non linear Regression equation predicts O_3 better than a linear equation does, because several of the relationship between O_3 and predictor variable are non linear. Furthermore some of these relation are interactive, for example O_3 versus temperature segregated by wind speed, it reveal that non linear. O_3 versus temperature relationship attenuated at high wind speed. The non linear equation captures this feature in a way that a linear equation cannot. (Geoffrey Cobourn.2000, T.H.Slini,.2002.). Average behaviour of selected parameters and their structure can be divided into three broad categories. Linear regression, regression trees and non-linear regression. it shoud be noted that regression models are generally site dependent, highlighted that there is no guarantee as to the reliability of the model once it is extrapolated beyond the range of the input data used to obtain it. (T.H.Slini,.2002.) In the past few decades world has seen manifold increase in energy consumption which has led to rise in CO_2 emission and air pollutants such as SO2, NOx and VOCs. With this, the levels

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of secondary air pollutants like ozone (O_3) have also risen. In order to provide adequate early warning, it is important to have accurate and reliable forecast of future high ozone levels. Many of these use statistical approaches, such as correlation and regression analysis. (K.Elampari., 2011).

Table 1: Comparison between the overall regression models

Test parameter	MAE	RMSE	MAPE
power	1.39	1.39	9.19
exponential	1.36	1.36	10.129
linear	1.9	1.9	15.8
logarithmic	2.18	2.18	16.39

DATA AND METHODOLOGY

There are various forecasting methods available in the literature. Non linear regressive method is used in this study. Regression analysis which is widely used for prediction and forecasting is also used to understand which among the independent variables are related to the dependent variable and explore the form of these relationships. NLREG is a powerful statistical analysis program that performs linear and nonlinear regression analysis, surface and curve fitting. NLREG determines the values of parameters for an equation, whose form you specify, that cause the equation to best fit a set of data values. NLREG can handle linear, polynomial, exponential, logistic, periodic, and general nonlinear functions. Unlike many "non-linear" regression programs that can only handle a limited set of function forms, NLREG can handle essentially any function whose form you can specify algebraically.

This statistical models can give reliable results, when they built with good continuous sets of data. The reliability of the result is not guaranted when the data are extrapolated out of the range of values used in the adjustment of the model.(2,J.L.Bravo). This study intends to assess the ground level ozone concentration in Chennai at Koyambedu where there is big Moffssel bus terminus. There is a heavy influx of vehicles to this terminus throughout the day. So we have choose this as out ideal location since it is a highly polluted area. Measurements were carried out from 5th August ,2011 to 14th August, 20011 i.e. for 10 days. Ozone and Other meteorological parameters have been measured between 8.00 am in the morning to 5.00 pm in the evening during this study. We have measured and obtained 10 hourly data set. We have calculated correlation coefficient for Ozone and other meteorological parameters such as temperature (0.25), wind speed (0.15), relative humidity(-0.25) and UV radiation (0.54).

From the results obtained, we were able to identify that the meteorological parameter namely UV radiation has correlated better than other parameters. So we have made the regression equation using UV Radiation as the independent variable. To determine the ground – level ozone concentration a portable Aeroqual series 200 Ozone monitor has been used. Many researcher developed day-wise regression equation to estimate the surface ozone. Even though surface ozone changes every day is depends on Temperature and other meteorological parameters .If we would develop regression equations for hourly , that will improve the performance of the model. So we analyzing hour- wise data of Chennai, the following regression equations are suggested to estimate daily hourly surface ozone concentration at Chennai.

$O_3 = 5.3415\ln(X) = 2.959$ ---------- (1)

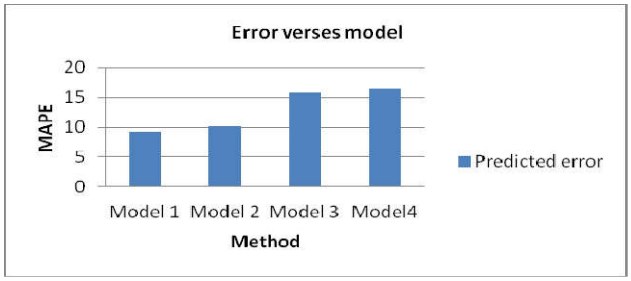
$O_3 = 10.247e^{0.0224X}$ ---------- (2)

$O_3 = 4.974x^{0.452}$ ---------- (3)

$O_3 = -0.007X^2+0.642X+8.9448$ ---------- (4)

RESULT AND DISCUSSION

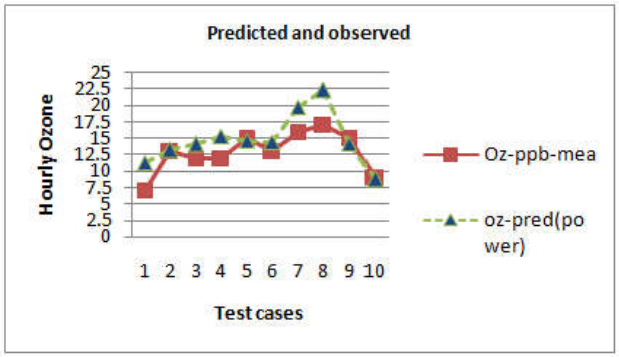
Of all meteorological variables examined, UV has correlated good positive correlation with hourly ozone concentration, with temperature too follow, Finally all variable except humidity are positively correlated. Wet, rainy weather with high relative humidity is typically associated with low ozone levels provide by less intensive photochemical production(OA. Tarasova., 2003).



Fig(1).

Fig 1. It illustrate comparison of Mean absolute error of all model

From the standard statistical table1. & Fig.1. we found that Model 1 and the value of MAPE and RMSE lies within the acceptable value. But the Model in 3 & 4 the value of MAPE lies outside the acceptable value. So the low value of MAPE suggests that proposed Model estimate the surface Ozone concentration in Chennai with good accuracy. MAPE is the most natural measure of average error magnitude, and unlike RMSE, it is an unambiguous measure of average error magnitude. (J. Willmott., Kenji Matsuura.,2005).



Fig(2).

Fig 2. Illustrate the excellent agreement the measured value and the values estimated from the hourly regression model.

Conclusion

The result of this study indicate that the RMSE value and MAPE value are lesser for the proposed power model (Model –I) than the existing logarithmic, exponential and linear model does not show any further significant betterment in the results. Further, the hour wise regression models proposed in this study estimate surface ozone at Chennai with good accuracy. Hence the proposed model can be recommended to predict the hourly ozone for next day at Chennai.

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