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Ozone Trend Analysis at Pedregal Station in the Metropolitan Area of Mexico City

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Abstract. Pedregal Station is located in a residential area in the southwest portion of Mexico City, where the worst ozone episodes are registered. Three models for forecasting ozone are analyzed based on the 19 mean semester maximum values of daily ozone registered at Pedregal Station. The logarithm model seems to fit best the available data. Its use suggests that near 10 years have to elapse fom July 2005, before air quality is recovered. Additional control measures are suggested, such as, doubling concentration of MTBE, reducing gasoline Reid Vapor Pressure from 7.5 to 7 psia and increasing efficiency and cover of the public transport system, but reinforcing the present control policies.
Key words. Forecasting ozone, Pedregal Station, MTBE, Reid Vapor Pressure.

Resumen. En la estación de Pedregal, localizada en la zona residencial de la región suroeste de la Ciudad de México, se registran los peores episodios de ozono. Se analizan tres modelos para pronosticar ozono sobre la base de los 19 datos del valor medio semestral de la máxima concentración diaria de ozono registrados en la estación de Pedregal. El modelo logarítmico es el que se ajusta mejor a los datos disponibles. Su uso sugiere que se requieren cerca de 10 años a partir de julio 2005, para recuperar la calidad del aire respecto al ozono. Se sugieren medidas adicionales de control, tales como doblar la concentración de MTBE, reducir la presión de vapor de la gasolina Reid de 7.5 a 7.0 psia e incrementar la eficiencia y cobertura del transporte público, pero reforzando las medidas actuales.
Palabras clave. Predicción de ozono, Estación de Pedregal, MTBE, Presión de Vapor Reid.

Introduction

Ozone measurement on the Metropolitan Area of Mexico City has been performed on 19 sites since 1986. The worst episodes are registered at the Pedregal Station located in a residential area in the southwest portion of Mexico City. Although programs to control ozone have been enforced since 1963, ozone has overreached the maximum allowable concentration of 0.11 ppm, many times a year. It is therefore convenient to analyze the trend and to determine the time taken to satisfy the maximum allowable concentration, and to recommend other control measures to be taken to speed up recovery of air quality.

The whole set of data were not always available, the missing data were linearly interpolated when it was only one, two or up to 3 consecutive points, but in some instances the missing data were several consecutive points, then an autoregressive method to forecast or predict the missing values was applied; also a method of delays (as used in chaotic time series) or a mixture of both methods was used to recover as well as possible the missing data [1].

The trend for the mean semester values for the daily maximum of ozone from 1996 to 2004 shows a decrease as can be appreciated in the following table, except for the first semester of 2005, which is even higher than the second semester of 2003:

The second semester values are smaller that the first semester ones, which may be due to the rainy season that occurs mainly during the second semester and it lasts until October, each year, with the exception of 1997.

Plot of data in table 1, where "s" is the semester, starting from 1996, is shown in the graph 1.

There is no doubt that ozone maxima has been diminishing, with the exception of the first semester of 2005.An standard deviation of 0.0394 ppm. was registered in 2004. As the trend is not a smooth one, not amenable of extrapolation with certainty, it is therefore necessary to forecast certain horizons to estimate the semester in which the standard will be reached. In forecasting, we shall base our estimation on the available data of the 19 semesters, this is, the first leg of the curve must satisfy the available data.

Table 1. Mean semester ozone values from 1996 to 2004

Año	Mean of daily Maximum of ozone, first semester (ppm)	Mean of daily maximum ozone, second semester (ppm)
1996	0.160407	0.154152
1997	0.142077	0.148413
1998	0.148116	0.139636
1999	0.160685	0.13137
2000	0.145604	0.135482
2001	0.11633	0.097912
2002	0.135435	0.129587
2003	0.117027	0.104162
2004	0.0976136	0.0942907-
2005	0.116629	

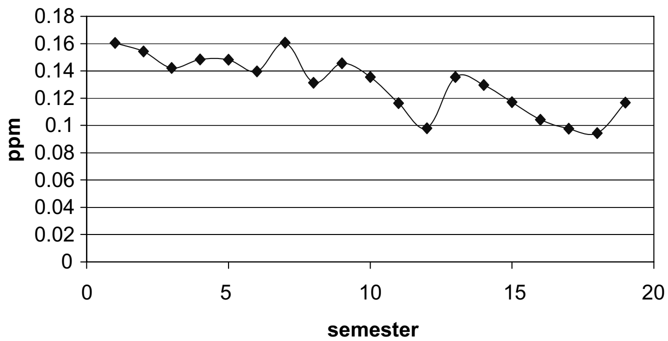

Fig. 1. Ozone trend at the pedregal station.

Forecasting models.-It will be assumed that ozone may decrease in accordance with three horizons given by an exponential, logarithm or potential law. To determine the analytical relation governing these processes, Excel software program was used. The analytical expressions found to suite best the initial 18 semester data are:

Logarithm expression:
O_3 = -0.0204 Ln (s) + 0.1725 $R^2 = 0.5952$

Exponential expression:
O_3 = 0.1653 exp [-0.0252(s)] $R^2 = 0.6829$

Potential expression:
$O_3 = 0.1785\ (s)^{[-0.1588]}$ $R^2 = 0.5592$

Where "s" is the semester, starting from 1996.

If three times the standard deviation is substracted to the standard of 0.11 ppm, then the value of 0.09818 ppm. should be the maximum mean ozone daily level to be reached when rare episodes are expected at Pedregal Station, with a probability less than 0.003%.

In the figure 2, mean semester of daily ozone values predicted by the three models are shown, to select the semester in which the maximum allowable mean ozone level would be reached:

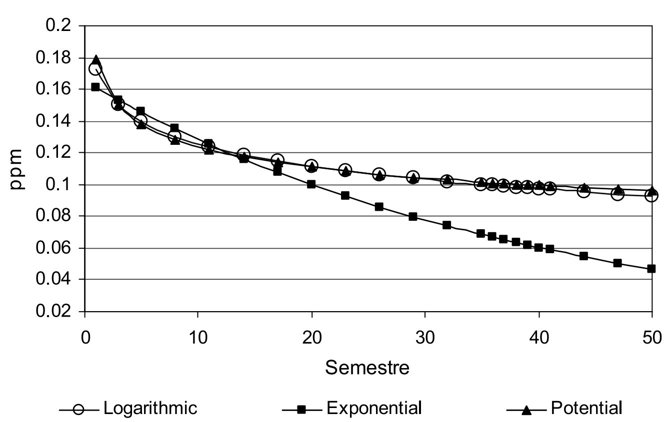

Fig. 2. Ozone levels in accordance to extrapolating horizon

Conclusion

In accordance with the above figure, air quality level would be attainable after 38 semesters if a logarithm law is followed or 41 semesters if a potential one is obeyed. For an exponential law only 20 semesters will be required. However, in practice, when control measures are implemented there is a sudden decrease of concentration of a contaminant followed by a less pronounced decrease. Therefore, it will be assumed that the exponential model does not represent adequately the ozone trend and logarithm or potential models represent better the fate of ozone concentration at Pedregal station.

In the logarithm scenery, 19 semesters have to elapsed from July 2005, to reach air quality. For a potential scenery 22 semesters have to pass from July 2005, to recover air quality. Therefore, from 9.5 to 11 years have to elapse from July 2005, to meet the standard, unless additional control measures are implemented. It is evident that additional control measures should be taken if it is desired to reach air quality soon.

It is here suggested that besides maintaining and reinforcing the present control policies described in detail elsewhere [2, 3], additional control measures should be implemented, such as, doubling the level of gasoline oxygenation by MTBE, to decrease the level of hydrocarbons in the exhaust gases, as well as decreasing gasoline Reid Vapor Pressure to 7 psia [4] to reduce concentration of light olefins, the establishment of a fast and efficient public transport system, maintaining and strengthening the vehicular inspection program and taking off from circulation the heavy contaminating vehicles.

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