Department of Pesticide Regulation

Brian R. Leahy
Director

M E M O R A N D U M

Edmund G. Brown Jr.
Governor

TO: Randy Segawa
Environmental Program Manager I
Environmental Monitoring Branch

FROM: Jing Tao, Ph.D. Original Signed By
Environmental Scientist
Environmental Monitoring Branch
916-324-4201

DATE: December 9, 2013

SUBJECT: TIME SERIES ANALYSIS AND FORECASTING OF VENTURA COUNTY NONFUMIGANT PESTICIDE VOLATILE ORGANIC COMPOUND OZONE SEASON EMISSIONS–2013 UPDATE

INTRODUCTION

Time series modeling has been used to forecast annual nonfumigant Volatile Organic Compound (VOC_{NF}) emissions in Ventura County for five years (Tao, 2013). This method yielded better predictions than the original procedure, which used VOC_{NF} from two years prior as a forecast for the current year (Spurlock, 2009). The model parameters are updated every year with the most-recently available data. The Department of Pesticide Regulation (DPR) has finished calculating the VOC_{NF} emission of Ventura County in 2012. This memo summarizes the model components estimated with the updated data and the prediction of the 2013 and 2014 emissions. The modeling procedure was described in a previous memorandum (Tao, 2009). The model was developed with a classical decomposition algorithm (CDA) method using statistical software package R:

$$X_t = m_t + s_t + y_t \quad (1)$$

where X_t is the monthly VOC_{NF} over the time.
m_t is the trend estimated from the linear regression of deseasonalized VOC_{NF} on t.
s_t is the seasonal component, monthly in this study with $\sum_{j=1}^{12} s_j = 0$. The detrended VOC_{NF} were averaged for each month over the analyzed time and then centered to obtain the estimate.
y_t is residues fitted with an autoregressive integrated moving average (ARIMA) process.
t is the year as time index.

The notation used to denote a specific seasonal ARIMA model is

$$ARIMA(p,d,q) \times (P,D,Q)_L$$

Where p = 0, the order of nonseasonal autoregressive component;
d = 0, the order of nonseasonal differencing;
q = 2, the order of nonseasonal moving average process;
P = 0, the order of seasonal autoregressive component;
D = 1, the order of seasonal differencing;
Q = 1, the order of seasonal moving average process; and
L = 12, the seasonal length.

UPDATE TIME SERIES MODEL

Figure 1 presents the trend of VOC_{NF} over the past 22 years. The updated linear regression model $\{m_t\}$ is estimated as Eq.2:

$$m_t = 712381.54 - 343.53 \times t \quad (2)$$

R^2 of the model is 0.16. It suggests that the regression model accounts for 16% of the variation in the deseasonalized data. The negative slope indicates that the VOC_{NF} emissions is decreasing, which is consistent with the estimate of last three years.

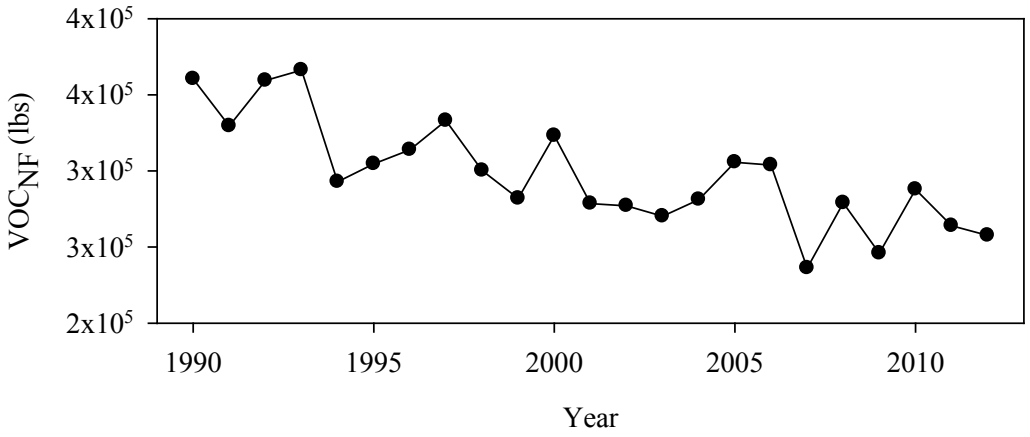

Figure 1. Yearly VOC_{NF} emissions in Ventura County from 1990 to 2012.

The seasonal component estimates show the same pattern with previous three years (Figure 2).

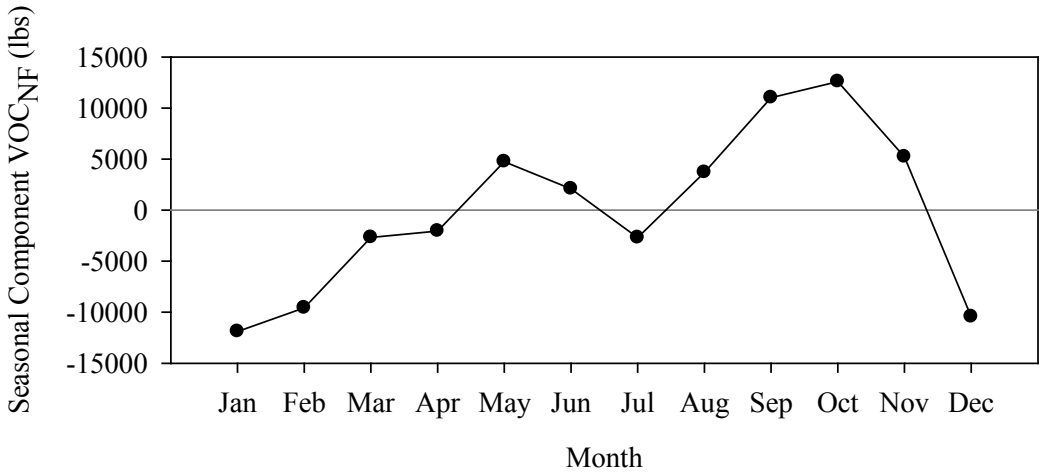

Figure 2. The estimates of seasonal component (lbs) in the VOC_{NF} series of 1990-2012.

ARIMA(0,0,2) × $(0,1,1)_{12}$ equation

$$y_t = \delta + w_t - \theta_1 w_{t-1} - \theta_2 w_{t-2} - \theta_{s,1} w_{t-12} - \theta_{s,1}\theta_1 w_{t-13} - \theta_{s,1}\theta_2 w_{t-14} \quad (3)$$

Where δ is a constant, $\theta_{S,1}$ is the seasonal moving average coefficient, estimated as -0.732; θ_1 and θ_2 are the nonseasonal moving average coefficient, estimated as 0.279 and 0.233; and w_t is a Gaussian white noise term with the distribution N(0, $\sigma_{wt}^2 = 25960584$). All of these numbers are very close to the previous estimates in Tao (2010, 2011, 2013).

PREDICTION FOR NONFUMIGANT VOLATILE ORGANIC COMPOUND EMISSIONS OF 2012-2013

The time series model X_t for the VOC_{NF} data is built by the combination of the seasonality s_t (Figure 2), the trend m_t (Eq. 2) and the ARIMA $(0,0,2) \times (0,1,1)_{12}$ (Eq. 3) for y_t as Eq.1. The model predicts the VOC_{NF} of two entire years in Ventura County: 256688 lbs for 2013 and 249723 lbs for 2014. The emission predictions during ozone season, May – October, are shown in Table 1.

Table 1. The prediction of VOC_{NF} monthly emissions (lbs) in 2013 and 2014 ozone season.

Month	**VOC_{NF} Prediction (lbs)**	
	2012	**2013**
May	23829	23485
June	26237	25893
July	20411	20067
August	22552	22208
September	29747	29403
October	30072	29728
Total	**152847**	**150786**
Tons/Day	**0.418**	**0.412**

REFERENCES

Spurlock, F. 2009. Time Series Analysis and Forecasting of Ventura County Nonfumigant Pesticide Volatile Organic Compound Emissions. July 16, 2009 Memorandum to Randy Segawa.

Tao, J. 2009. Time Series Analysis and Forecasting of Ventura County Nonfumigant Pesticide Volatile Organic Compound Emissions – 2009 Update. December 23, 2009 Memorandum to Randy Segawa.

Tao, J. 2010. Time Series Analysis and Forecasting of Ventura County Nonfumigant Pesticide Volatile Organic Compound Emissions – 2010 Update. December 2, 2010 Memorandum to Randy Segawa.

Tao, J. 2011. Time Series Analysis and Forecasting of Ventura County Nonfumigant Pesticide Volatile Organic Compound Emissions – 2011 Update. November 1, 2011 Memorandum to Randy Segawa.

Tao, J. 2013. Time Series Analysis and Forecasting of Ventura County Nonfumigant Pesticide Volatile Organic Compound Emissions – 2012 Update. January 28, 2013 Memorandum to Randy Segawa.