M E M O R A N D U M

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SUBJECT: TIME SERIES ANALYSIS AND FORECASTING OF VENTURA COUNTY NONFUMIGANT PESTICIDE VOLATILE ORGANIC COMPOUND OZONE SEASON EMISSIONS–2011 UPDATE

INTRODUCTION

Time series modeling has been used to forecast annual nonfumigant Volatile Organic Compound (VOC_{NF}) emissions in Ventura County (Spurlock, 2009; Tao, 2009; Tao, 2010). This method yielded better predictions than the original procedure of using VOC_{NF} from two years prior as a forecast for the current year (Spurlock, 2009). The model parameters are updated every year by modeling the most recently available VOC data. The Department of Pesticide Regulation (DPR) finished calculating the actual VOC_{NF} emission in 2010, which is used to update the time series model components and predict the 2011 and 2012 emissions in Ventura County. 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

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

where:

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

UPDATE TIME SERIES MODEL

The updated linear regression model $\{m_t\}$ is estimated as:

$$m_t = 753084.9 - 363.9 \times t \quad (2)$$

R^2 of the model is 0.15, which suggests that the regression model accounts for 15% of the variation in the deseasonalized data, similar to 16% of last year's estimate. The negative slope indicates that the VOC_{NF} emissions decreased over the past 20 years. The absolute value of the slope is lower than the number estimated last year (399.0) but higher than the number estimated in 2009 (337.1), which is consistent with the variation of VOC_{NF} emissions during the past three years (Figure 1).

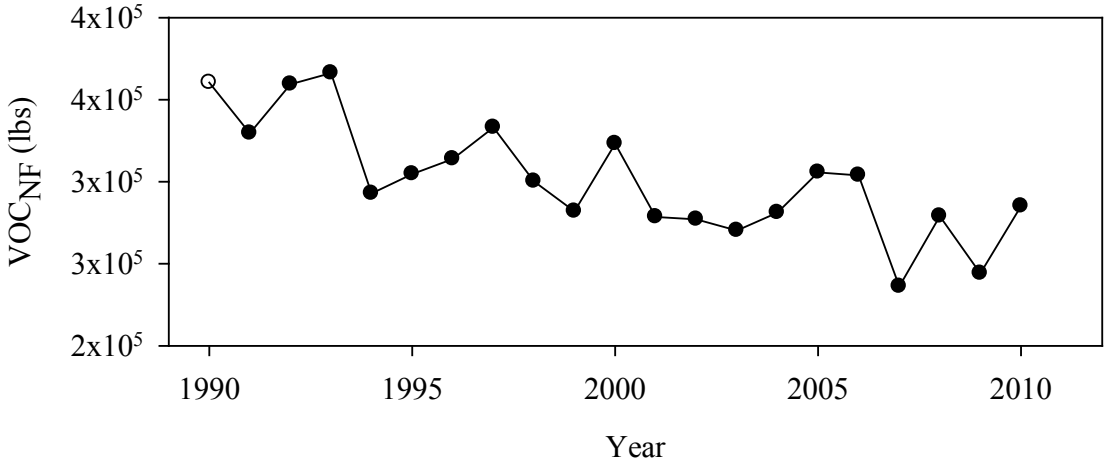

Figure 1. Yearly VOC_{NF} emissions in Ventura County from 1990 to 2010.

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

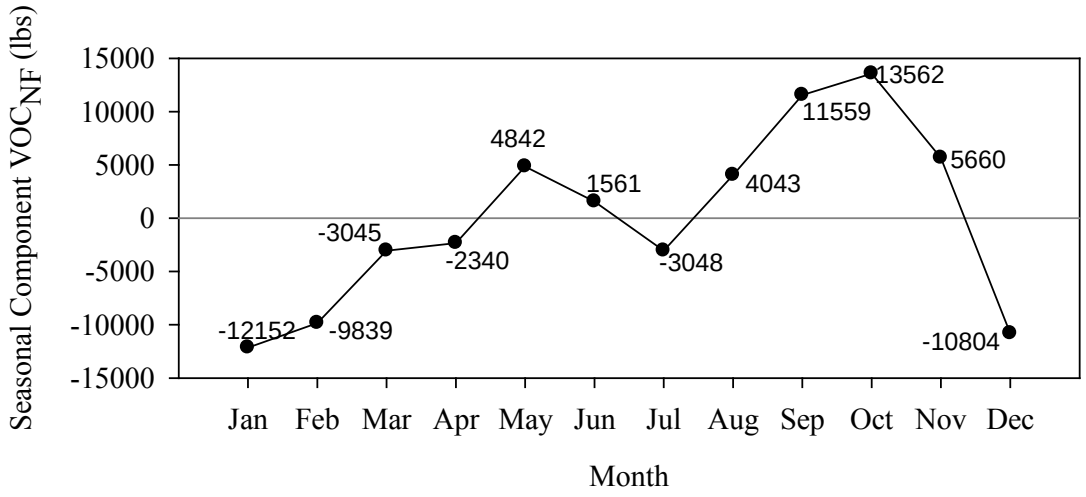

Figure 2. The estimates of seasonal component (lbs) in the VOC_{NF} series of1990-2010.

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 -0.754, θ_1 and θ_2 are the nonseasonal moving average coefficient, estimated as 0.259 and 0.217, and w_t is a Gaussian white noise term assumed $N(0, \sigma_{wt}^2 = 26371769)$. All of these numbers are close to previous estimates in Tao (2010).

PREDICTION FOR NONFUMIGANT VOLATILE ORGANIC COMPOUND EMISSIONS OF 2011-2012

With the estimates of three components, 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) × $(0,1,1)_{12}$ (Eq. 3) for y_t as Eq.1. The estimates of entire year VOC emissions from nonfumigants in Ventura are 256765 lbs in 2011 and 252696 lbs in 2012. The prediction data for the May-October ozone season in these two years are shown in Table 1.

The prediction for VOC_{NF} emissions for two consecutive years has been conducted every year since 2009 (Figure 3). Overall, the estimate shows good agreement with the actual data. The pattern of estimated emissions is slightly different every time because of the change of use patterns in previous years.

Table 1. The prediction of VOC_{NF} monthly emissions (lbs) in 2011 and 2012 ozone season.

Month	VOC_{NF} Prediction (lbs)	
	2011	**2012**
May	24399.95	24036.04
June	25452.53	25088.62
July	20053.7	19689.79
August	24718	24354.09
September	33169.61	32805.7
October	35533.23	35169.32
Total	**163,327**	**161,144**

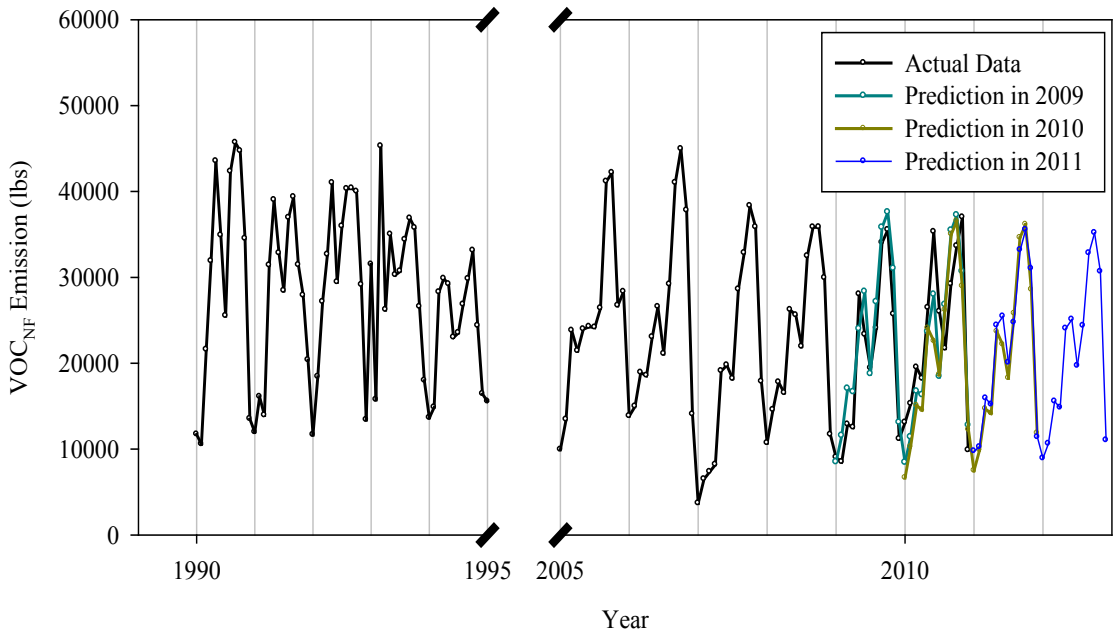

Figure 3. The prediction result estimated in 2009-2011 for the consecutive 2-year VOC_{NF} emissions.

REFERENCE

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

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Tao, J. 2010. Time Series Analysis and Forecasting of Ventura County Nonfumigant Pesticide Volatile Organic Compound Emissions – 2011 Update. December 2, 2010 Memorandum to Randy Segawa.