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SUBJECT: TIME SERIES ANALYSIS AND FORECASTING OF VENTURA COUNTY NONFUMIGANT PESTICIDE VOLATILE ORGANIC COMPOUND OZONE SEASON EMISSIONS–2012 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; Tao 2011). 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 2011. This memorandum summarizes the model components estimated with the updated data and the prediction of the 2012 and 2013 emissions. The modeling procedure was described in a previous memorandum (Tao, 2009). The model was developed with a classical decomposition algorithm 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

Figure 1 presents the trend of VOC_{NF} over the past 21 years. The updated linear regression model $\{m_t\}$ is estimated as Eq.2:

$$m_t = 723852.8 - 349.27 \times t \quad (2)$$

R^2 of the model is 0.15. It suggests that the regression model accounts for 15 percent 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.

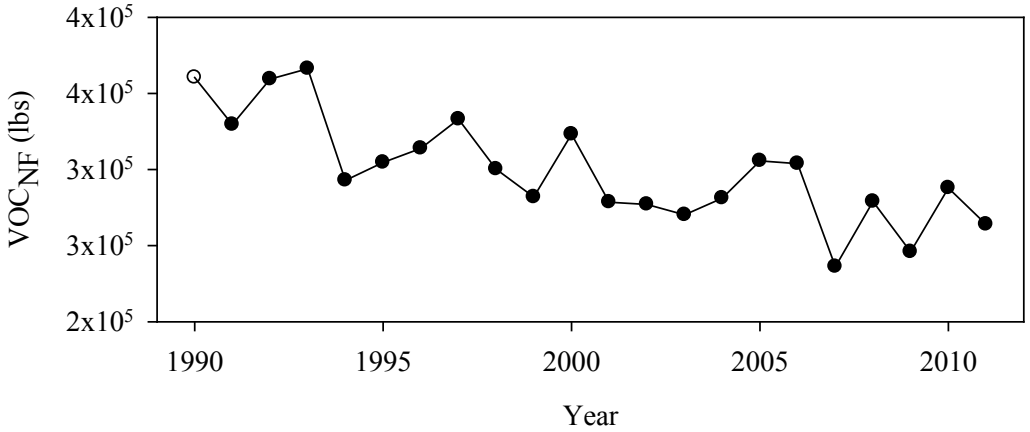

Figure 1. Yearly VOC_{NF} emissions (lbs) in Ventura County from 1990 to 2011.

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

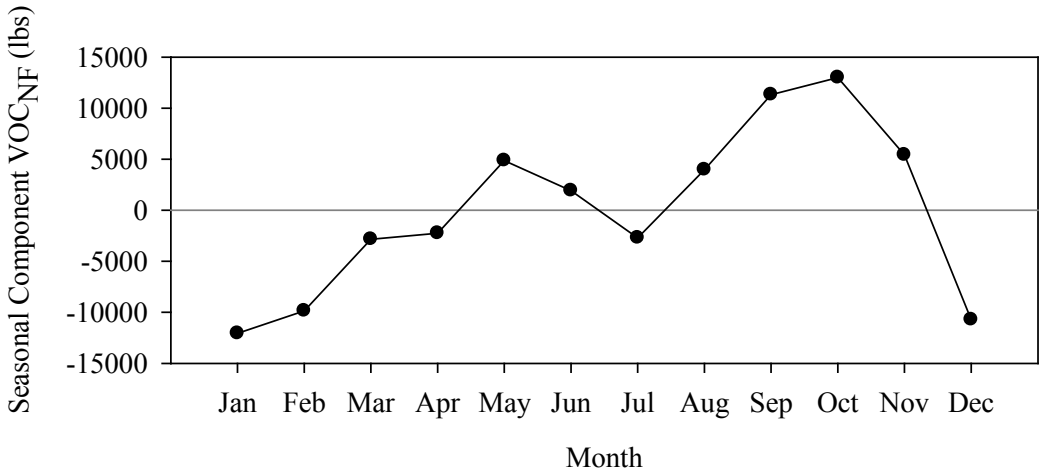

Figure 2. The estimates of seasonal component (lbs) in the VOC_{NF} series of 1990-2011.

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 -0.753; θ_1 and θ_2 are the nonseasonal moving average coefficient, estimated as 0.278 and 0.224; and w_t is a Gaussian white noise term with the distribution N(0, $\sigma_{wt}^2 = 26264418$). All of these numbers are very close to the previous estimates in Tao (2010, 2011).

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: 258210 lbs for 2012 and 252372 lbs for 2013. The emission predictions during ozone season, May – October, are shown in Table 1.

Table 1. The prediction of VOC_{NF} monthly emissions (lbs) in 2012 and 2013 ozone season.

Month	**VOC_{NF} Prediction (lbs)**	
	2012	**2013**
May	24678	24329
June	26291	25942
July	21166	20817
August	24200	23851
September	31649	31300
October	32299	31950
Total	**160284**	**158188**
Tons/Day	**0.438**	**0.432**

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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