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–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.

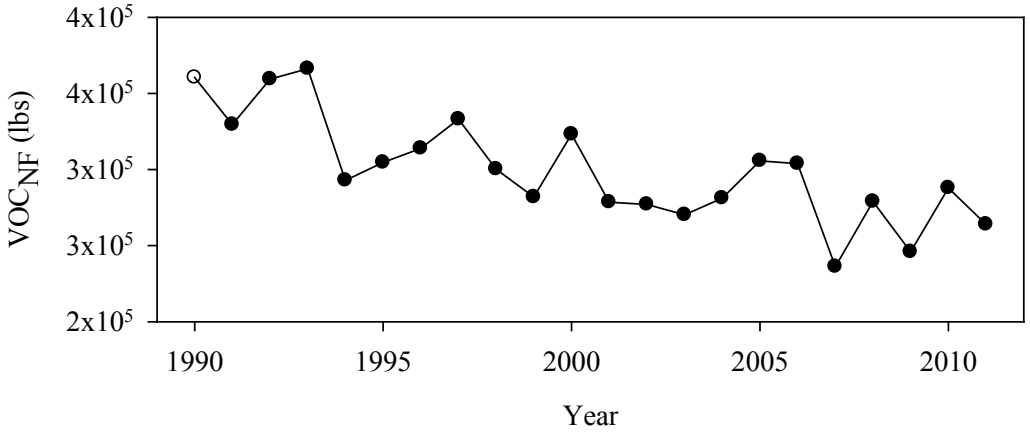


*Figure 1. Yearly $VOC_{NF}$ emissions (lbs) in Ventura County from 1990 to 2011.*

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

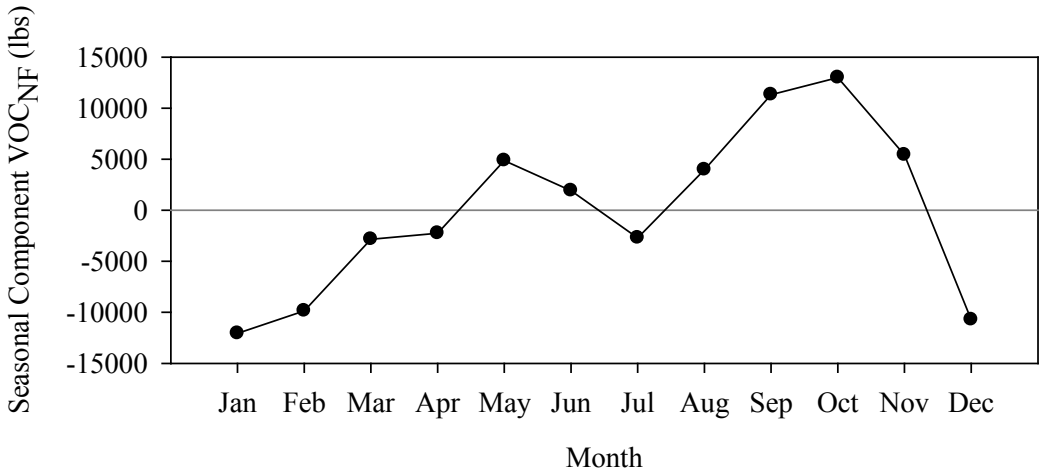


*Figure 2. The estimates of seasonal component (lbs) in the $VOC_{NF}$ series of 1990-2011.*

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; $\theta_1$ and $\theta_2$ 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.

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.

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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.