6. Biogenic Sources

6.1 Introduction

Biogenic emissions have been estimated for the 2008 Periodic Emissions Inventory for particulate matter in Maricopa County (9,223 square miles) and the PM_{10} Nonattainment Area (NAA) (2,887 square miles). The Model of Emissions of Gases and Aerosols from Nature (MEGAN) has been used to estimate the biogenic emissions. MEGAN is a state-of-the-art biogenic emissions model developed by the National Center for Atmospheric Research (NCAR). Some important corrections and improvements were made in the latest version of MEGAN2.04 (Guenther, 2007) compared to previous versions (Guenther, 2006, 2006a and 2006b). MEGAN2.04 was applied to compute biogenic emissions in Maricopa County and the PM_{10} NAA. Among the chemical species included in MEGAN, only nitric oxide (NO) is attributable to particulate matter formation. Therefore, only NO_x emissions are included in the inventory. The MEGAN runs were executed by the Maricopa Association of Governments. The contact person for the MEGAN emission estimates is Feng Liu (602-254-6300).

6.2 Modeling domain

As a numerical model, the MEGAN inputs and outputs are given in user-defined two-dimensional grid cells. To develop biogenic emissions for the 2008 Periodic Emission Inventory for particulate matter, the 4-km and 12-km modeling domains developed for the MAG eight-hour ozone plans for the Maricopa Nonattainment Area (MAG, 2007 and 2009), were employed for the PM_{10} NAA and Maricopa County, respectively. The definitions of these two domains in the Universal Transverse Mercator (UTM) coordinate system are presented in Table 6.2–1. Since MEGAN estimates biogenic emissions for entire modeling domains rather than specific areas, additional input files, masking areas covered by the PM_{10} NAA and Maricopa County, were developed by applying Geographic Information Systems (GIS) to calculate emissions for those two target areas. In order to represent the target area, the masking file assigns 1.0 for the grid cells fully covered by the target area, a fractional value for grid cells partially covered by the target area, and 0.0 for grid cells outside the target area. As shown in Figure 6.3–1, biogenic emissions for the PM_{10} NAA and Maricopa County were extracted from MEGAN runs for the masked grid cells in the 4-km and 12-km modeling domains, respectively.

Table 6.2–1. Two modeling domains defined in the UTM coordinate system.

Grid Horizontal Resolution	Grid Size	Domain Range (km)	Target Area
4-km	50 × 29	(297,3652) to (497,3768)	PM_{10} NAA
12-km	111 × 84	(275, 3188) to (1,057,4196)	Maricopa County

6.3 Input data

To calculate biogenic emissions using MEGAN, the following gridded input files for land cover and meteorological data were prepared:

1. EFMAP_LAI file: This file provides emission factors (EF) for 20 MEGAN species including NO, and monthly average leaf index (LAI) for 12 months for each grid cell.

2. PFTF file: This input file gives percentage of four plant function types (PFT) including broadleaf trees (BT), needle leaf trees (NT), grass and crops (HB) and shrubs (SB) for each model domain grid location.

3. METCRO2D file: This file contains meteorological parameters including temperature, short wave radiation, wind speed, humidity and soil moisture for each grid.

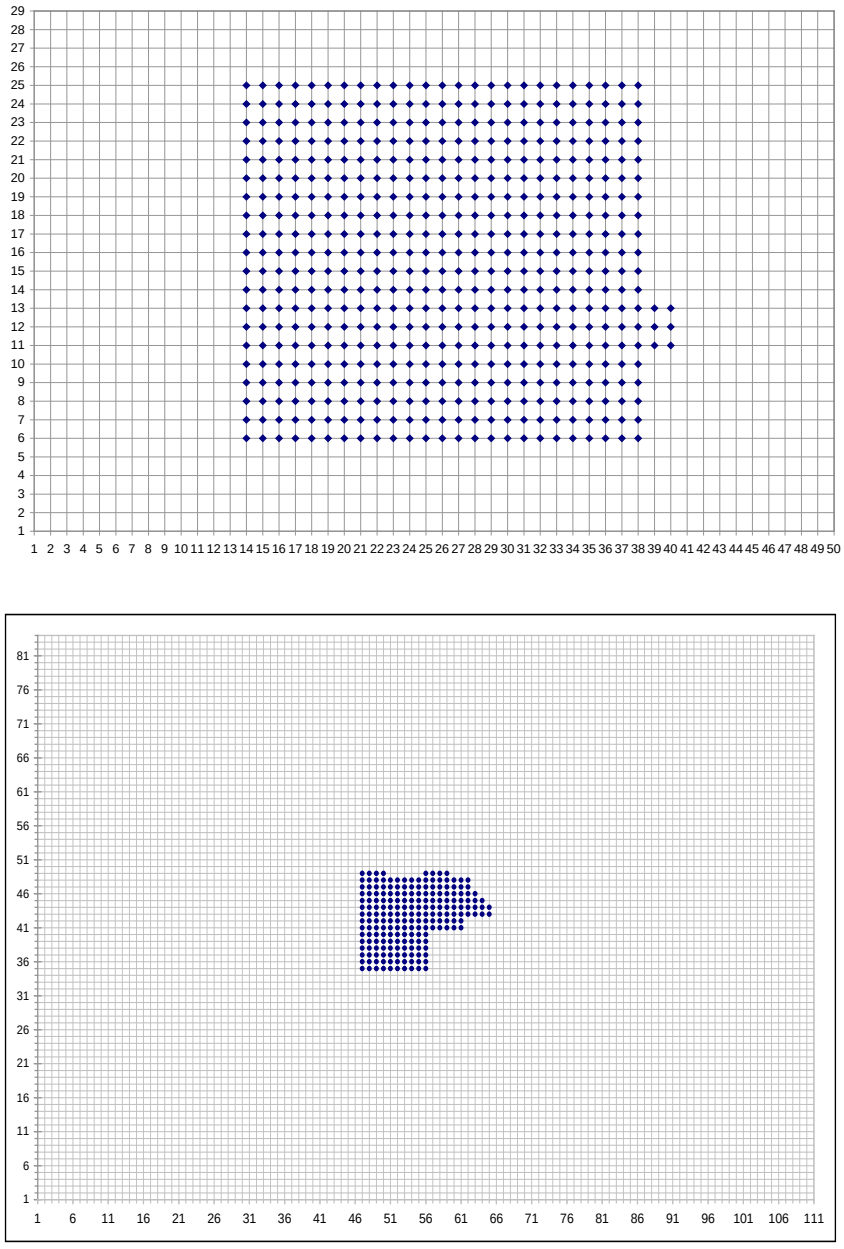

Figure 6.3–1. Mask of the PM_{10} NAA in the 4-km modeling domain (top) and mask of Maricopa County in the 12-km modeling domain (bottom).

6.3.1 Land cover data

The land cover data, including the monthly LAI, PFT, and EF, are provided by the EFMAP_LAI and PFTF files. These input data were derived from the MEGAN land cover database available

at a base resolution of 30 seconds latitude by 30 seconds longitude (~1×km^2) in ArcGIS format (http://acd.ucar.edu/~guenther/MEGAN/MEGAN.htm). For the MEGAN runs, however, the default land cover data during the summer season (June to August) were replaced by local data-sets, which were developed by a field study conducted by Dr. Guenther in June 2006 (ENVIRON, 2006). The substitution was made because the default database systematically underestimated the LAIs in Maricopa County.

6.3.2 Weather data

The weather data used by MEGAN are temperature, downward short wave radiation, wind speed, humidity and soil moisture. The Measurement and Instrumentation Data Center (MIDC) collects irradiance and meteorological data from nation-wide stations, one of which is located in northern Phoenix (33.83° N, 112.17° W, denoted by red star in Figure 6.3–2), and is operated by the Phoenix Federal Correction Institution (PFCI). The archived hourly temperature, wind speed, humidity and radiation data from this site are available to the public. Monthly mean diurnal cycles of the weather parameters were calculated based on hourly data for the year 2008, and a netCDF file representing 24-hour data for each month was prepared for MEGAN inputs.

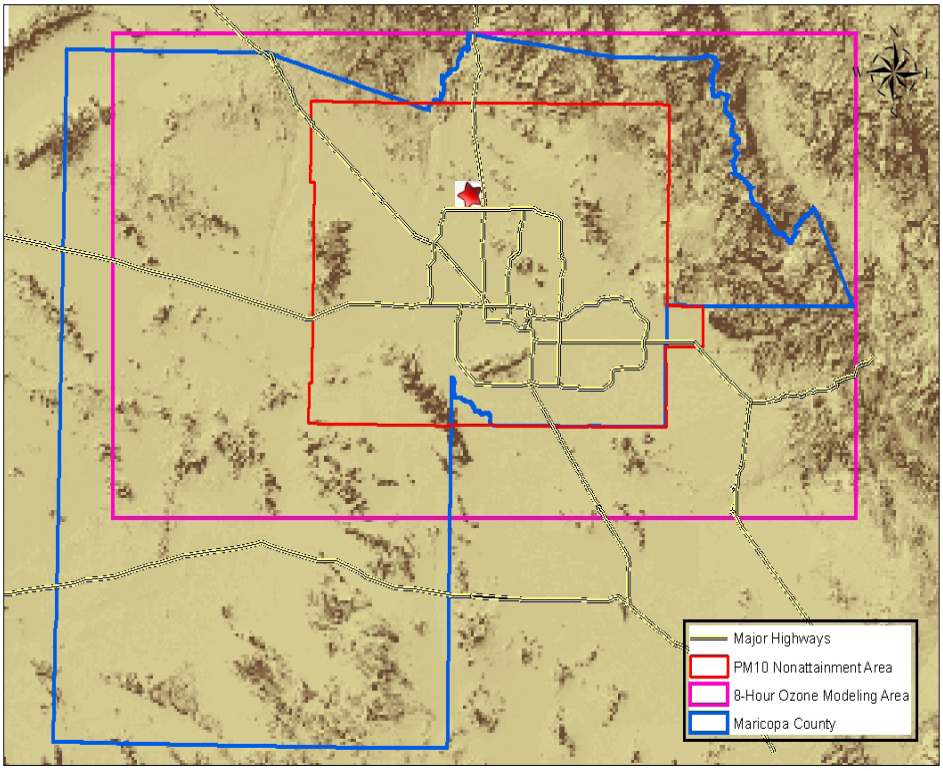

Figure 6.3–2. Boundaries of the PM_{10} NAA (red line), the 4-km eight-hour ozone modeling domain (pink line), Maricopa County (blue line), and the meteorological observation site (red star).

Biogenic NO is mainly emitted from wetted soil. The emission rate is dependent not only upon temperature and downward short wave radiation but also on soil moisture. Due to dry conditions year round in Maricopa County, the NO flux from the surface is very low compared to other states with higher precipitation. Only moisture delivery by Arizona monsoons leads to precipitation during the summer. This precipitation, in turn, increases soil moisture and humidity. According to weather records at the Phoenix Sky Harbor International Airport, the precipitation

in the Phoenix area was 0.0 and 2.15 inches in June and July 2008, respectively. Therefore, maximum monthly NO emissions occurred in July 2008. In general, however, NO emissions in the Maricopa County area are temperature and radiation dominated during the year. Figure 6.3–3 shows annual mean diurnal cycles of temperature and radiation. The peak temperature around 4:00–5:00 pm lags three hours behind the peak radiation. The delay is due to the fact that heating of the air occurs not from the sun's rays, but from heating of the earth and infrared radiation leaving the ground in the form of heat. As a result, maximum hourly emission rates take place in the afternoon because the emission rates are positively related to both temperature and short wave radiation (Guenther, 2006).

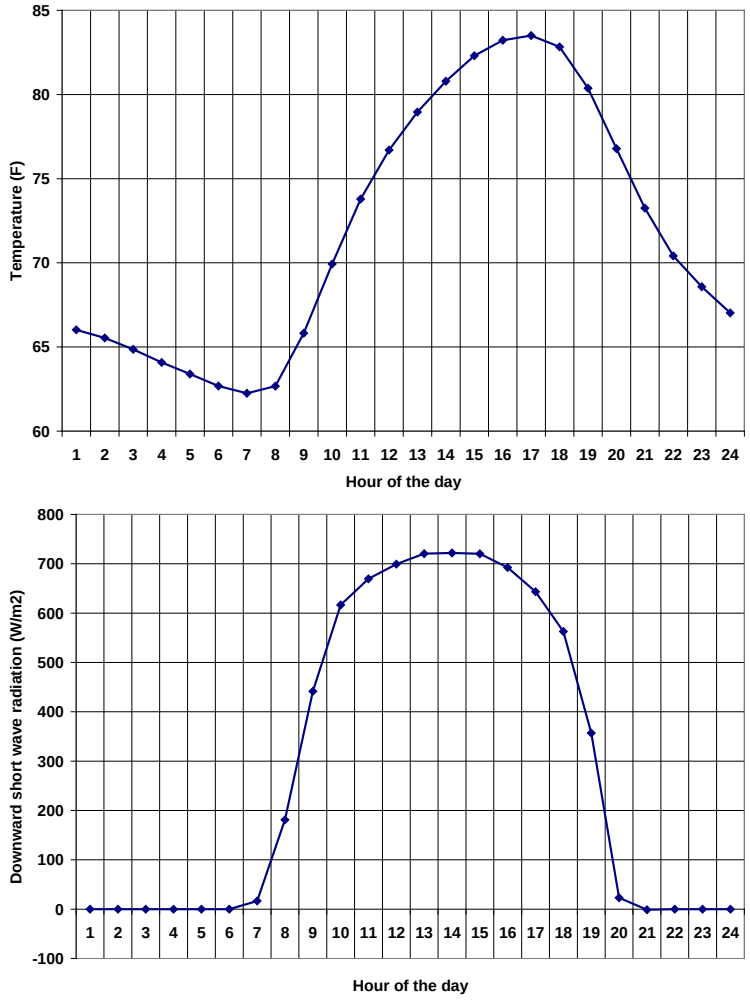

Figure 6.3–3. Annual mean diurnal cycles of measured temperature (top panel) and downward short wave radiation (bottom panel) in 2008.

6.4 Emissions estimation

MEGAN runs for the two modeling domains provide hourly emission outputs for the year 2008. Daily mean emissions for each month in 2008 were derived by using the hourly outputs for each month. In addition, monthly total emissions were obtained by multiplying the daily mean emissions for each month by the number of days in the month. The daily mean emissions for the 12 months of 2008 are shown in Table 6.4–1.

Table 6.4–1. Daily mean biogenic emissions of NO_x in the PM_{10} NAA and Maricopa County, by month.

	PM_{10} NAA		Maricopa County	
Month	**kg/day**	**lbs/day**	**kg/day**	**lbs/day**
January	127.2	280.4	355.2	783.1
February	168.0	370.4	480.9	1,060.2
March	413.3	911.2	1,131.0	2,493.4
April	601.7	1,326.5	1,658.8	3,657.0
May	721.0	1,589.5	1,923.1	4,239.7
June	1,818.8	4,009.8	4,729.4	10,426.5
July	1,878.7	4,141.8	4,930.0	10,868.8
August	1,702.0	3,752.3	4,485.1	9,888.0
September	1,331.9	2,936.3	3,784.7	8,343.8
October	651.1	1,435.4	1,839.9	4,056.3
November	328.5	724.2	910.8	2,008.0
December	138.6	305.6	388.0	855.4

Monthly mean emissions for Maricopa County and the PM_{10} NAA are illustrated in Figure 6.4–1. Monthly emission values are presented in Table 6.4–2. It can be seen that the monthly NO_x emissions reached the highest values in July. This is because biogenic emissions of nitric oxide (NO) are mainly from wetted soil. Thus, the NO emission rate depends not only on temperature and radiation, but also on soil moisture, which is related to precipitation. As discussed in Section 6.3, there were 2.15 inches of precipitation in July, but no precipitation in June, 2008. There is also one more day in July than June; therefore, the total NO_x monthly emissions in July are higher than in June.

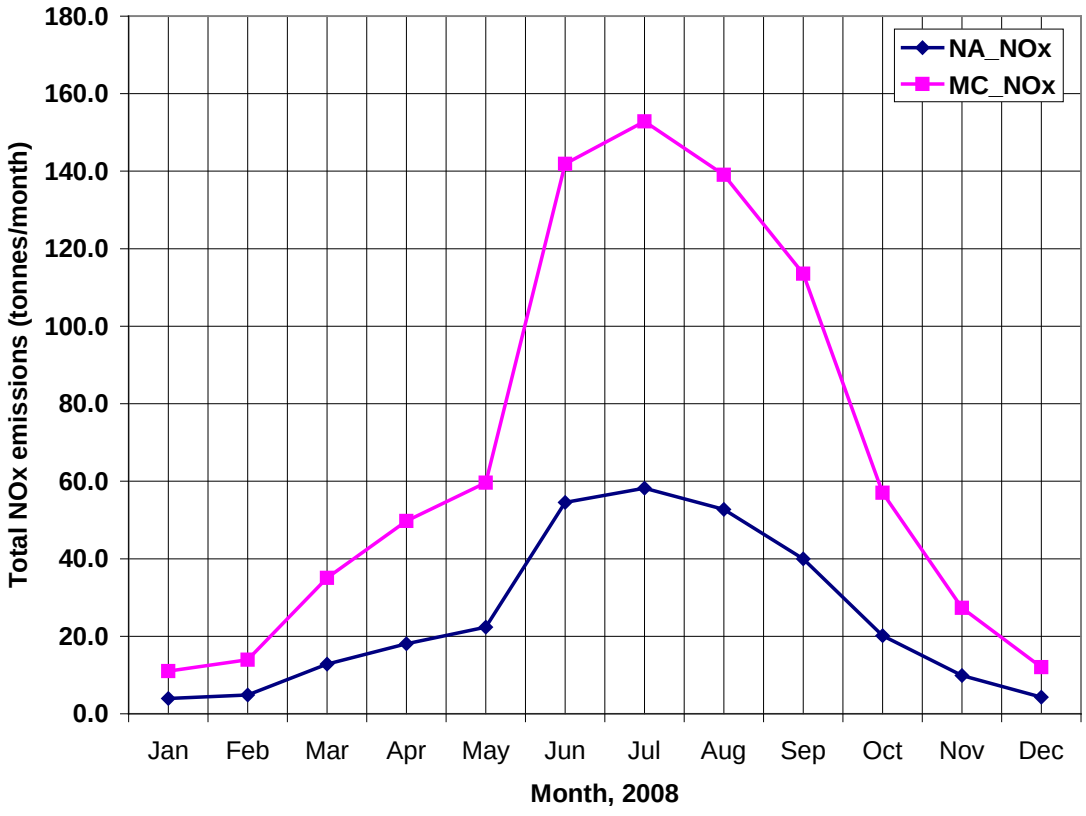

Figure 6.4–1. Monthly emissions of NO_x in Maricopa County (pink solid line, abbreviated as "MC") and the PM_{10} NAA (blue solid line, abbreviated as "NA").

Table 6.4–2. Monthly biogenic emissions of NO_x in the PM_{10} NAA and Maricopa County.

	PM_{10} NAA		Maricopa County	
Month	**Metric tons/mo**	**Tons/mo**	**Metric tons/mo**	**Tons/mo**
January	3.94	4.35	11.01	12.14
February	4.87	5.37	13.95	15.37
March	12.81	14.12	35.06	38.65
April	18.05	19.90	49.76	54.85
May	22.35	24.64	59.62	65.72
June	54.56	60.15	141.88	156.40
July	58.24	64.20	152.83	168.46
August	52.76	58.16	139.04	153.27
September	39.96	44.05	113.54	125.16
October	20.18	22.26	57.04	62.87
November	9.86	10.86	27.32	30.12
December	4.30	4.74	12.03	13.26
Totals:	**301.88**	**332.77**	**813.08**	**896.27**

6.5 Summary of biogenic source emissions

Daily mean and annual total biogenic NO_x emissions for Maricopa County and the PM_{10} NAA in 2008 are summarized in Table 6.5–1. Due to the incorporation of land cover data that are more characteristic of plants located in the desert southwest, as well as improvements to the MEGAN model, the 2008 data shown in Table 6.5–1 represent a substantial improvement over previous biogenic emission estimates for Maricopa County and the PM_{10} NAA.

Table 6.5–1. Daily mean and annual total NO_x emissions from biogenic sources.

	Daily mean		Annual total	
Geographic Area	**kg/day**	**lbs/day**	**Metric tons/yr**	**Tons/yr**
Maricopa County	2,218.1	4,890.0	813.08	896.27
PM_{10} NAA	823.4	1,815.3	301.88	332.77

6.6 References

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