Estimating the Monthly Variation in California's Nonroad Equipment Emissions For the 2002 Emissions and Air Quality Modeling Platform

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ABSTRACT

The Environmental Protection Agency (EPA)'s Office of Air Quality Planning and Standards (OAQPS) is developing a 2002 Emissions and Air Quality Modeling Platform using the 2002 National Emissions Inventory (NEI) Version 3.0. In the 2002 modeling platform (also called Version 3.0), monthly emission data consistent with the 2002 NEI are input into the Sparse Matrix Operator Kernel Emissions (SMOKE) processor for onroad and nonroad categories to generate air quality model inputs for these categories. With the exception of California, these data are generated using the National Mobile Inventory Model (NMIM). The NMIM model accounts for the monthly variation in activity, temperature, and fuels in estimating emissions. In addition, NMIM outputs provide emission mode information (e.g., exhaust and evaporative) in addition to the source category information. Because California uses different models to estimate onroad and nonroad emissions than NMIM, NMIM-generated California emissions are replaced by California-submitted emissions. The California nonroad data from the 2002 NEI are annual emissions and do not include the emission mode. A different approach than for the rest of the country was thus needed to process the California nonroad data to generate air quality model inputs. This paper discusses two options, focusing on the temporal aspects of the emissions processing. We compare the use of monthly temporal profiles based solely on equipment-based activity data to the computation of NMIM-like monthly emissions. This paper will discuss these two methods of disaggregating the annual emissions and describe the differences in the resultant monthly emissions.

INTRODUCTION

The temporal resolution of inventories has become more refined as emission estimation methods have become more sophisticated and as computer disk space has become less expensive. Inventories with highly resolved temporal scales can be input into the Sparse Matrix Operator Kernel Emissions (SMOKE)[1] processor to prepare air quality modeling inputs. SMOKE uses the inventories at these scales and performs additional temporal allocation, as well as speciation and spatial allocation to generate emission inputs for the air quality model.

The Environmental Protection Agency (EPA)'s Office of Air Quality Planning and Standards (OAQPS) is developing an Air Quality Modeling Platform using the 2002 National Emissions Inventory (NEI) and several tools, including SMOKE, to process the emissions. In the 2002 modeling platform, the temporal resolution of the emissions data input into SMOKE varies across the inventory sectors. The most detailed resolution is hourly data from electric generating units that have continuous emission monitors. The platform also includes day specific fire emissions for wild fires and prescribed fires. For onroad and nonroad categories, generated by EPA's National Mobile Inventory Model (NMIM)[2], the temporal resolution of the emissions input into SMOKE is monthly.

This paper focuses on the 2002 NEI nonroad component as covered by NMIM. That is, we exclude aircraft, locomotive and commercial marine emissions. NMIM develops nonroad inventories (excluding aircraft, locomotives and commercial marine vessels) using EPA's NONROAD emissions model utilizing county, year, and month specific inputs that are stored in the NMIM County Database (NCD). The nonroad equipment categories included in NONROAD and NMIM are recreational, construction, industrial, lawn and garden, farm, commercial, logging, airport service, railway maintenance, and recreational marine vessels. For NONROAD, inputs include temperatures, fuel properties, and equipment population. Equipment temporal activity patterns are part of the NONROAD model. These factors account for the monthly variation in the nonroad emissions from NMIM. In addition, NMIM separates emissions into three modes depending upon the pollutant. For nonroad equipment, pollutants can have up to three modes: exhaust, refueling, and evaporative. Note that evaporative emissions are defined to exclude the refueling component. Combustion products such as carbon monoxide (CO) and nitrogen oxides (NOX) have only the exhaust mode. Volatile organic compounds (VOC) and its components present in liquid fuel also have refueling and evaporative emissions. Mode distinctions are important for air quality modeling because exhaust VOC are chemically different from evaporative and refueling VOC.

The version of NMIM used in Version 3.0 of the 2002 NEI uses NONROAD2005, which includes updated small spark ignition and recreational marine emissions. The 2002 NEI Version 3.0 uses state-submitted model inputs to NMIM, but it does not utilize state-submitted emission data for states other than California. The California Air Resources Board (CARB) does not use NMIM to compute onroad or nonroad emissions. Since the California models are considered superior to NMIM in predicting California emissions, California emission data submitted to EPA based on the state's own models are used for the 2002 NEI. Unlike the NMIM-generated emissions for the rest of the country, the nonroad equipment emissions EPA received for California are annual and are not resolved by emissions mode.

We considered several options for allocating California emissions from annual to monthly (prior to SMOKE or within SMOKE) and for allocating VOC to exhaust, refueling, and evaporative modes. This paper focuses on the following two approaches:

1. NONROAD Equipment Activity-based approach: Create monthly emissions within SMOKE using the NONROAD model's monthly equipment activity factors for California.
2. NMIM-results based approach: Disaggregate the California annual emissions prior to SMOKE using the temporal/mode-specific information from the NMIM emission results for California.

The first approach is the easiest to implement, as the NONROAD model's monthly equipment activity factors for California depend only on the source classification code (SCC), and do not vary across pollutants nor California's counties. Since SMOKE can process annual (California) and monthly (rest of US) data within the same run, these equipment activity-based temporal factors can be added to the SMOKE temporal cross reference file with relatively little effort, and can be applied to the annual emissions by SMOKE. No intermediate monthly emission files need to be created under this approach. This approach, does not however, account for temporal variation due to temperature and fuels, nor does it disaggregate VOC emissions into modes. Without the mode information, the VOC must be speciated with a composite speciation profile for California emissions, whereas the rest of the country utilizes mode-specific VOC speciation profiles for nonroad emissions.

The second approach is more resource intensive, since it involves the use of an additional inventory for California, the NMIM-generated inventory, and it requires the computation of factors for each source and pollutant. This option provides the most consistency with the approach used for the other states because the resulting emission inputs to SMOKE are monthly and mode-specific.

While we chose to use the NMIM-results based approach for the 2002 platform, we decided to investigate the temporal profiles generated from the NMIM results further, and analyze the difference in monthly emissions between these approaches.

A more detailed description of each of the approaches is provided in the next section, followed by an analysis of the temporal profiles computed using the "NMIM-results based" approach. Finally, we provide a comparison of the monthly emissions obtained using the two approaches.

DISCUSSION

NONROAD Equipment Activity-based approach

For this approach, we apply the equipment activity-based monthly temporal factors used in the NONROAD model for California to the annual California emissions based on the SCC. These monthly allocation fractions were developed for 10 composite regions as described in a technical report supporting the NONROAD model[3]. The entire state of California was assigned to the WCST (west coast) composite region; thus, the temporal factors do not vary across counties. Because the factors are based only on equipment activity, they also do not vary by pollutant. Figure 1 shows the eight unique equipment activity-based profiles for the WCST region.

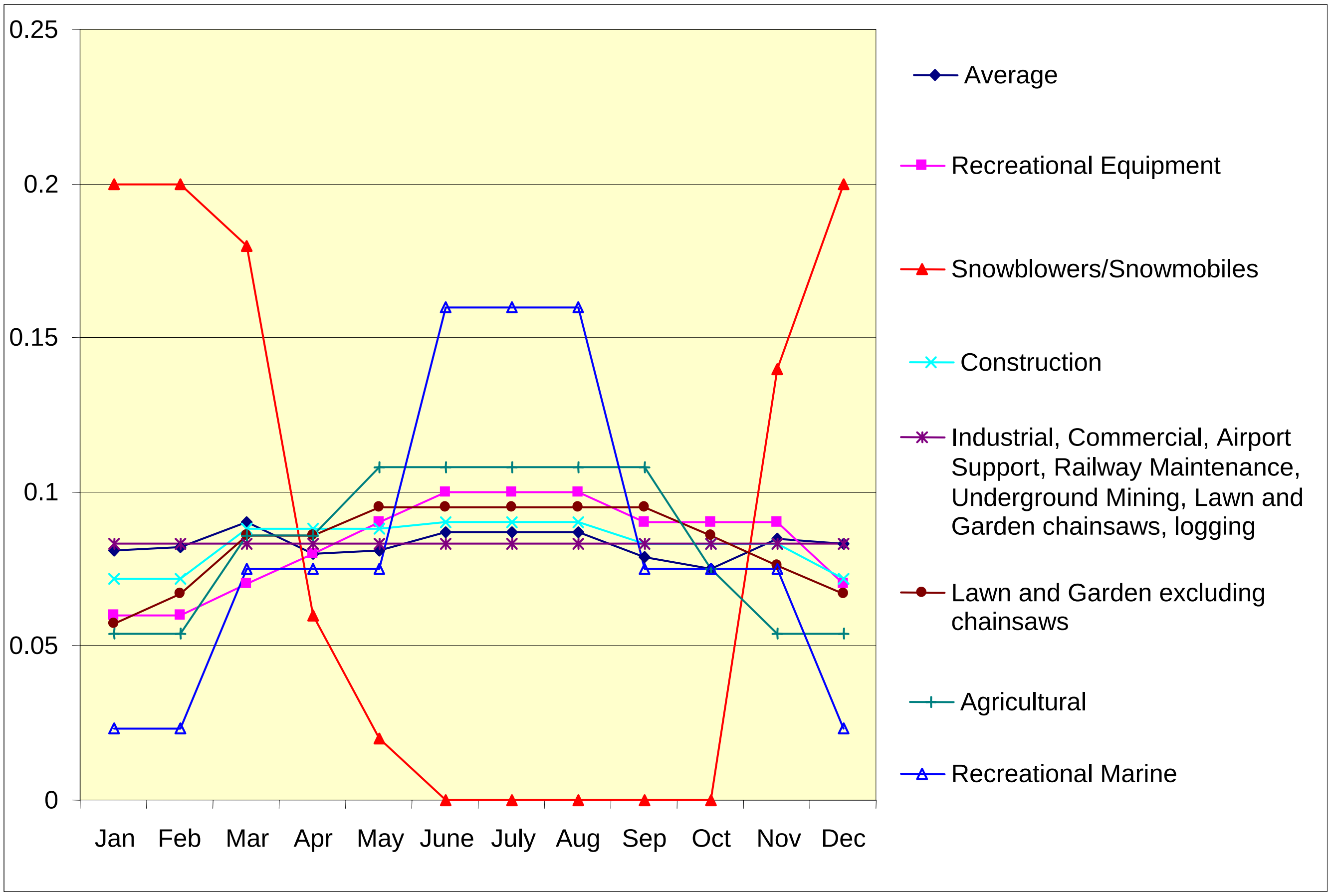


Figure 1. Equipment Activity-Based Monthly Temporal Factors for the West Coast (California) Region in the NONROAD model.

As expected, most nonroad equipment types have significant monthly variation. Using this approach, emissions for snowmobiles would be zero from June from October when the activity for this type of equipment in California is zero. Recreational marine shows an approximately inverse relationship to snowmobiles.

To implement this approach, we assign monthly profiles to the SCCs in the California inventory. The assignment is straightforward since the SCC describes the equipment type (as well as engine and fuel). Table 1 summarizes the assignment of the SCCs to the above equipment activity-based profiles.

Table 1. Assignment of Equipment-Activity-based Monthly Temporal Profiles to nonroad SCCs

Equipment Activity-based Temporal Profile Code Assignment	SCC code pattern
Average	22AA000000
Recreational Equipment	22AA001*** except for 22AA001020
Snowblowers/Snowmobiles	22AA001020, 22AA004035, 22AA004036
Construction	22AA002***
Industrial, Commercial, Airport Support, Railway Maintenance, Underground Mining, Lawn and garden chainsaws, logging	22AA003***, 22AA004020, 22AA004021,22AA006***, 22AA007***, 22AA008***, 22AA010***
Lawn and Garden excl. chainsaws	22AA004*** except: 22AA004020, 22AA004021, 22AA004035, 22AA004036
Agricultural	22AA005***
Recreational Marine	2282005***, 2282010***
NOTES: AA can be 60, 67, 68, 70 (represents engine type/fuel) and * can be any value (specific values are used to represent detailed equipment within the broader equipment category)	

<u>NMIM-results based approach:</u>

The NMIM-results based approach requires the development of apportionment factors that both disaggregate the California annual emissions into months and into the applicable emission modes. For the nonroad criteria pollutant inventory, the only pollutant with multiple modes is VOC. For VOC, the emissions are divided into exhaust, evaporative and refueling modes. For the other pollutants, the apportionment factor is equivalent to the monthly temporal factor.

The equations below show the computation of the apportionment factor, which is county, pollutant, mode and SCC-specific:

For pollutants with a single mode in NMIM:

$$\text{Factor}_{\text{FIPS,SCC,Poll,month}} = \frac{\text{Emissions}_{\text{NMIM, FIPS,SCC,Poll,month}}}{\text{Emissions}_{\text{NMIM,FIPS,SCC,Poll,annual}}} \qquad (1)$$

For pollutants with multiple modes:

$$\text{Factor}_{\text{FIPS,SCC,Poll,mode, month}} = \frac{\text{Emissions}_{\text{NMIM, FIPS,SCC, Poll,mode, month}}}{\text{Emissions}_{\text{NMIM,FIPS,SCC,Poll, annual}}} \qquad (2)$$

Where: FIPS is the county code and poll is the pollutant code

The factor is then applied to the California annual emissions by SCC and FIPS as follows:

For pollutants with a single mode in the NMIM, California monthly emissions are computed for each source as:

$$\text{Emissions}_{FIPS,SCC,Poll,month} = \text{Factor NMIM},_{FIPS,SCC,Poll,month} * \text{Emissions}_{Calif, FIPS,SCC,Poll, annual} \quad (3)$$

For pollutants with multiple modes:

$$\text{Emissions}_{,FIPS,SCC, Poll,mode, month} = \text{Factor}_{FIPS,SCC, Poll,,mode, month} * \text{Emissions}_{Calif\ FIPS,SCC,Poll, annual} \quad (4)$$

For pollutants with one mode the monthly temporal Factor equals the factor.

For VOC, we computed the temporal factor as

$$\text{Factor}_{FIPS,SCC,Poll,month} = \frac{\text{Emissions}_{Calif, FIPS, SCC, Poll, mode, momth}}{\text{Sum over months(Emissions}_{Calif, FIPS,SCC,Poll,, mode, month)}}$$

A key complication in implementing this approach is that nearly none of the nonroad SCCs submitted by CARB match the NMIM SCCs; the CARB SCCs reflect broader equipment categories than the NMIM SCCs. In order to apply the NMIM-based allocation factor to the California annual emissions, we chose to select a surrogate NMIM SCC for each California SCC and apply its allocation factor for each county/ SCC/pollutant combination. Of the 32 SCCs in the California nonroad inventory, surrogate NMIM SCCs were required for 28 SCCs. These are shown in Table 2. The four SCCs submitted by California which are also in NMIM and therefore did not require a surrogate are:

- 2265001030 (4-Stroke, Recreational Equipment, All Terrain Vehicles),
- 2270003060 and 2265003060 (Diesel and Gasoline 4-Stroke Industrial Equipment, AC\Refrigeration), and
- 2270010010 (Diesel, Industrial Equipment, Other Oil Field Equipment).

Table 2: California SCCs requiring an NMIM surrogate SCC to compute the allocation factor

NEI SCC in CA		NMIM SCC used as a surrogate	
2260002000	Gasoline, 2-Stroke;Construction & Mining Equip.;Total	2270002051	Diesel;Construction and Mining Equip.;Off-highway Trucks
2260003000	Gasoline, 2-Stroke;Industrial Equip.;Total	2260003040	Gasoline, 2-Stroke;Industrial Equip.;Other General Industrial Equip.
2260004000	Gasoline, 2-Stroke;Lawn and Garden Equip.;All	2260004071	2-Stroke;Lawn & Garden Equip.;Turf Equip. (Comm)
2260005050*	Gasoline, 2-Stroke;Agricultural Equip.;Hydro-power Units	2260005035	Gasoline, 2-Stroke;Agricultural Equip.;Sprayers
2260006000	Gasoline, 2-Stroke;Commercial Equip.;Total	2260006005	Gasoline, 2-Stroke;Commercial Equip.;Generator Sets
2260007000	Gasoline, 2-Stroke;Logging Equip.;Total	2260007005	Gasoline, 2-Stroke;Logging Equip.;Chain Saws > 6 HP
2265001020	Gasoline, 4-Stroke;Recreational Equip.;Snowmobiles	2260001020	Gasoline, 2-Stroke;Recreational Equip.;Snowmobiles
2265002000	Gasoline, 4-Stroke;Construction and Mining Equip.;Total	2270002051	Diesel;Construction and Mining Equip.;Off-hwy Trucks
2265003000	Gasoline, 4-Stroke;Industrial Equip.;Total	2265003020	Gasoline, 4-Stroke;Industrial Equip.;Forklifts
2265004000	Gasoline, 4-Stroke;Lawn and Garden Equip.;All	2265004056	Gasoline, 4-Stroke;Lawn and Garden Equip.;Lawn and Garden Tractors (Commercial)
2265005000	Gasoline, 4-Stroke;Agricultural Equip.;Total	2265005015	Gasoline, 4-Stroke;Agricultural Equip.;Agricultural Tractors
2265005050*	Gasoline, 4-Stroke;Agricultural Equip.;Hydro-power Units	2265005060	Gasoline, 4-Stroke;Agricultural Equip.;Irrigation Sets
2265006000	Gasoline, 4-Stroke;Commercial Equip.;Total	2265006015	Gasoline, 4-Stroke;Comm. Equip.;Air Compressors
2265007000	Gasoline, 4-Stroke;Logging Equip.;Total	2265007010	Gasoline, 4-Stroke;Logging Equip.;Shredders > 6 HP
2265008000	Gasoline, 4-Stroke;Airport Ground Support Equip.;Total	2265008005	Gasoline, 4-Stroke;Airport Ground Support Equip.;Airport Ground Support Equip.
2268003000	Mobile Sources;CNG;Industrial Equip.;All	2268003040	Mobile Sources;CNG;Industrial Equip.;Other General Industrial Equip.
2268006000	Mobile Sources;CNG;Commercial Equip.;All	2268006015	Mobile Sources;CNG;Commercial Equip.;Air Compressors
2268008000	Mobile Sources;CNG;Airport Ground Support Equip.;All	2270008005	Diesel;Airport Ground Support Equip.;Airport Ground Support Equip.
2270002000	Diesel;Construction and Mining Equip.;Total	2270002051	Diesel;Construction and Mining Equip.;Off-hwy Trucks
2270003000	Diesel;Industrial Equip.;Total	2270003040	Diesel;Industrial Equip.;Other General Industrial Equip.
2270004000	Diesel;Lawn and Garden Equip.;All	2270004076	Diesel;Lawn and Garden Equip.;Other Lawn and Garden Equip. (Commercial)
2270005000	Diesel;Agricultural Equip.;Total	2270005055	Diesel;Agricultural Equip.;Other Agricultural Equip.
2270005050*	Diesel;Agricultural Equip.;Hydro-power Units	2270005035	Diesel;Agricultural Equip.;Sprayers
2270006000	Diesel;Commercial Equip.;Total	2270006015	Diesel;Commercial Equip.;Air Compressors
2270007000	Diesel;Logging Equip.;Total	2265007010	Diesel;Logging Equip.;Shredders > 6 HP
2270008000	Diesel;Airport Ground Support Equip.;Total	2270008005	Diesel;Airport Ground Support Equip.;Airport Ground Support Equip.
2282005000	Pleasure Craft;Gasoline 2-Stroke;Total	2282005010	Pleasure Craft;Gasoline 2-Stroke;Outboard
2282010000	Pleasure Craft;Gasoline 4-Stroke;Total	2282010005	Pleasure Craft;Gasoline 4-Stroke;Inboard/Sterndrive
2282020000	Pleasure Craft;Diesel;Total	2282020005	Pleasure Craft;Diesel;Inboard/Sterndrive

* these SCCs have EPA-generated NH3 only. They were not submitted by California, but were based on a previous version of the NONROAD model and therefore required a surrogate NMIM SCC for the allocation factor calculation.

RESULTS

NMIM-results based profiles

Figures 2 -13 show the monthly profiles computed from the NMIM-results based approach for select SCCs (based on state-total emissions of VOC and NOX). We discuss the variation in the monthly profiles by pollutant and by county and compare the variation by engine type (i.e., 2 -stroke versus 4-stroke). We also provide a comparison of the NMIM-based profiles to the activity-based profiles. Table 3 below indicates the SCCs selected and the annual emission of VOC and NOX statewide in the California nonroad inventory. The emissions are presented in descending order.

Table 3: Nonroad Equipment With Highest VOC and NOX in California (excluding aircraft, locomotive and commercial marine)

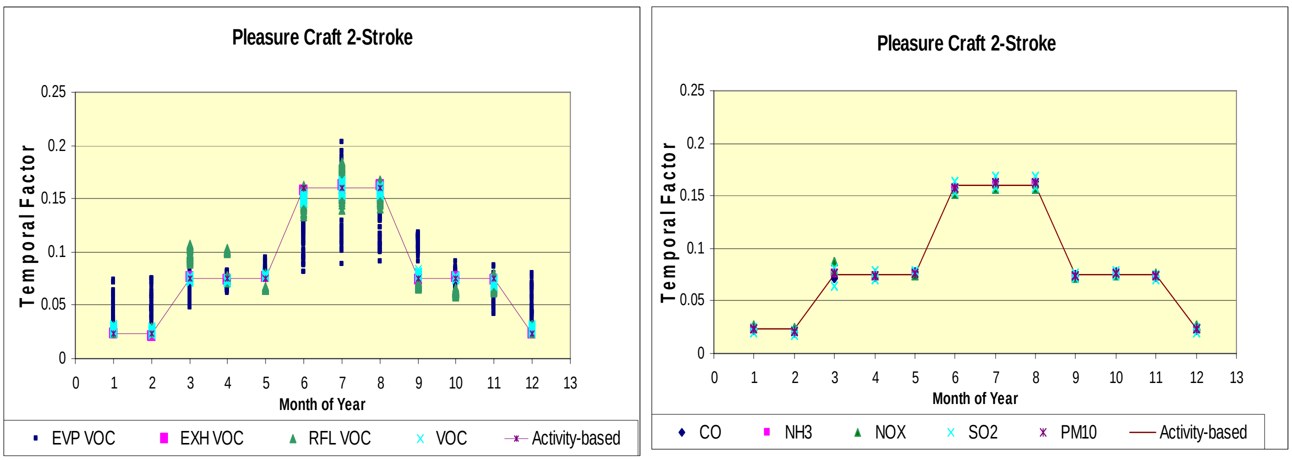
SCC	Description	Calif . state total VOC from 2002 NEI, V3 (tons)
2282005000	Pleasure Craft;Gasoline 2-Stroke;Total	37,256
2260004000	Off-highway Vehicle Gasoline, 2-Stroke;Lawn and Garden Equipment;All	29,234
2265004000	Off-highway Vehicle Gasoline, 4-Stroke;Lawn and Garden Equipment;All	19,146
2265001020	Off-highway Vehicle Gasoline, 4-Stroke;Recreational Equipment;Snowmobiles	15,186
2270002000	Off-highway Vehicle Diesel;Construction and Mining Equipment;Total	12,089
2282010000	Pleasure Craft; Gasoline 4-Stroke;Total	6,838
SCC	**Description**	**Calif state total NOX from 2002 NEI, V3 tons)**
2270002000	Off-highway Vehicle Diesel;Construction and Mining Equipment;Total	117,031
2270005000	Off-highway Vehicle Diesel;Agricultural Equipment;Total	48,885

The figures show the variation in NMIM monthly temporal factors across the 58 California counties, for different pollutants and for specific source categories discussed above. The county variation is shown in the scatter by temporal factor (Y-axis) at each month (X-axis). The graphs also show the equipment activity-based ratio (from Figure 1) applicable to the specific source category. The equipment activity ratios do not vary across county or pollutant, and thus results in a line on the graph.
For total VOC, a composite VOC temporal factor was computed based on the emissions-weighted average of the mode-specific VOCs.

Figures 2 and 3 show the variation in the monthly factors for Pleasure Craft Gasoline 2 stroke (SCC 2282005000) for each of the three modes of VOC, and total VOC, and for other criteria air pollutants, respectively, across the California counties. Although the mode-specific VOC monthly temporal factors vary greatly across counties, particularly in the summer, the overall VOC temporal profile variation is small. This is because the total VOC from 2-stroke pleasure craft is dominated by the exhaust mode (roughly 75-80%) which does not exhibit a large temporal profile variation across the

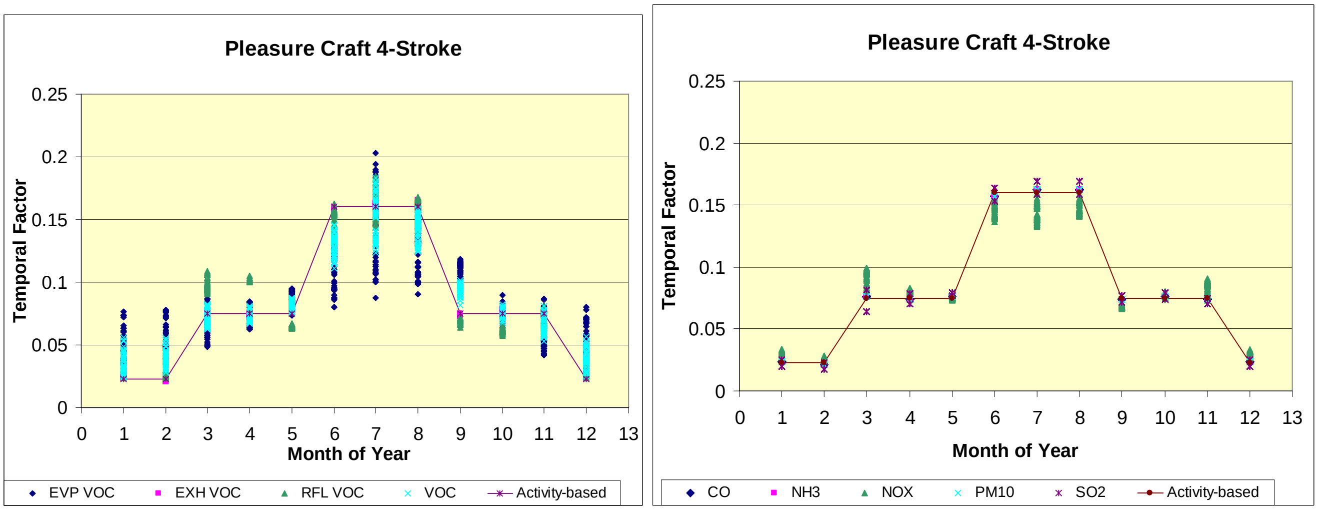
California counties. The greatest variation in the NMIM-results based factors for VOC can be seen in the summer months where the temperature fluctuation across counties is the greatest. Monthly profiles for evaporative VOC, which is most greatly impacted by temperature, show the largest variability.

Figure 3 shows the temporal profiles for computed from the NMIM California results for CO, NH3, NOX, PM10 and SO2 across all counties for this category. As can be seen, there is practically no variation in the temporal profiles either across pollutants or counties, and the profiles are nearly equivalent to the activity based temporal profile. PM10 and NH3 have identical temporal profiles because for these pollutants, emissions estimates from the NONROAD model are not influenced by either fuel properties or temperature. PM is affected by fuel sulfur content, but only for diesel engines. Note that there is a very small variation in SO2 temporal profiles across counties, because SO2 is affected by fuel sulfur and oxygenate content. NOX is also affected by fuel oxygen content; this effect is also very small across California counties as shown by the figure.



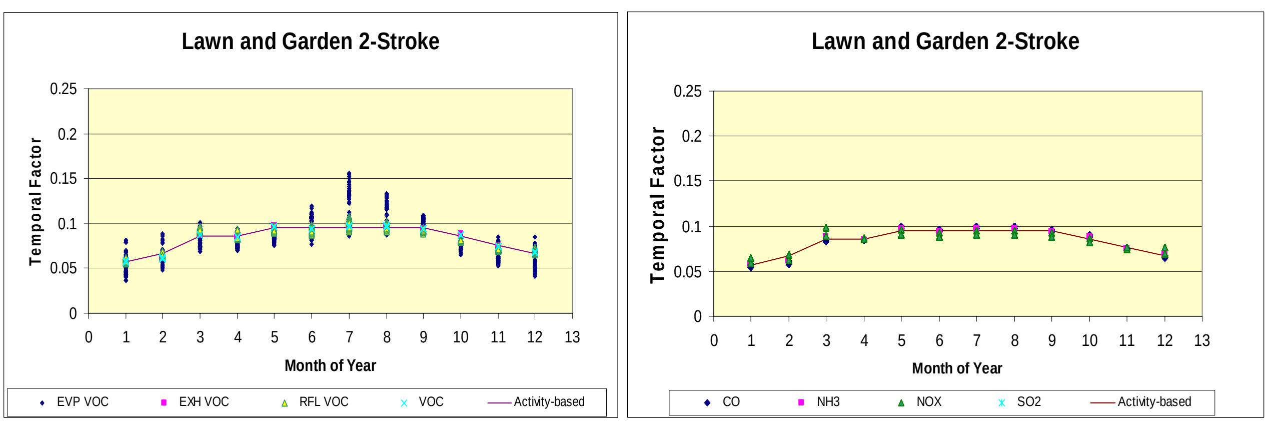
<u>Figures 2 and 3.</u> Monthly temporal Profiles for 2-stroke Gasoline Pleasure craft (SCC= 2282005000) for Evaporative VOC, Exhaust VOC, Refueling VOC and total VOC (Figure 2) and CO, NH3, NOX, SO2 and PM10 (Figure 3) as compared to the activity based profile for recreational marine equipment.

Figures 4 and 5 show the temporal profile variation for 4-stroke gasoline pleasure craft. As shown in Table 2, the emissions from this category are considerably lower than from 2-stroke pleasure craft for California. The variation in temporal profiles for VOC is significantly greater for 4-stroke than 2-stroke, particularly in the summer months. In the NONROAD model, the influence of temperature on exhaust VOC for 4-stroke engines is temperature is greater than for two-stroke engines. In addition, for these engines, evaporative VOC makes up a large portion of total VOC, ranging (across counties) from about 48% to 65% of the total VOC on an annual average. Figure 5 shows a noticeable variation in the temporal profiles for NOX, which was not seen for 2-stroke pleasure craft. While the NONROAD model incorporates a temperature impact on NOX for 4-stroke engines, it does not for 2-stroke engines due to insufficient data from 2-stroke engines.



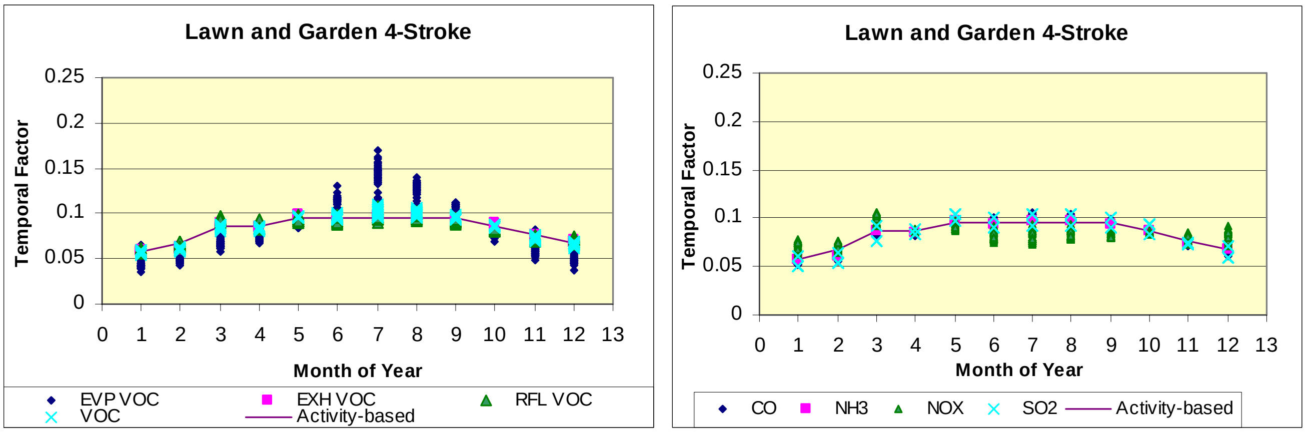
Figures 4 and 5. Monthly temporal Profiles for 4-stroke Gasoline Pleasure craft (SCC= 2282010000) for Evaporative VOC, Exhaust VOC, Refueling VOC and total VOC (Figure 5) and CO, NH3, NOX, SO2 and PM10 (Figure 3) as compared to the activity based profile for recreational marine equipment.

Another important nonroad source category for VOC is lawn and garden equipment. Figures 6 and 7 show the temporal profiles for 2-stroke lawn and garden variation across the three modes of VOC, and CO, NH3 and NOX, respectively. Similar to pleasure craft, the variation of the profiles is greatest for evaporative VOC. In the summer, the evaporative VOC tends to be higher than the activity-based profile for lawn and garden compared to a more even distribution for pleasure craft. This is because the NONROAD model accounts for temperature swing reduction of due to pleasure craft being in the water, which would result in both lower temperatures and lower temperature variation than for lawn and garden equipment. Similar to pleasure craft, lawn and garden equipment shows very little variation in the temporal profile for CO, NH3, NOX or SO2.



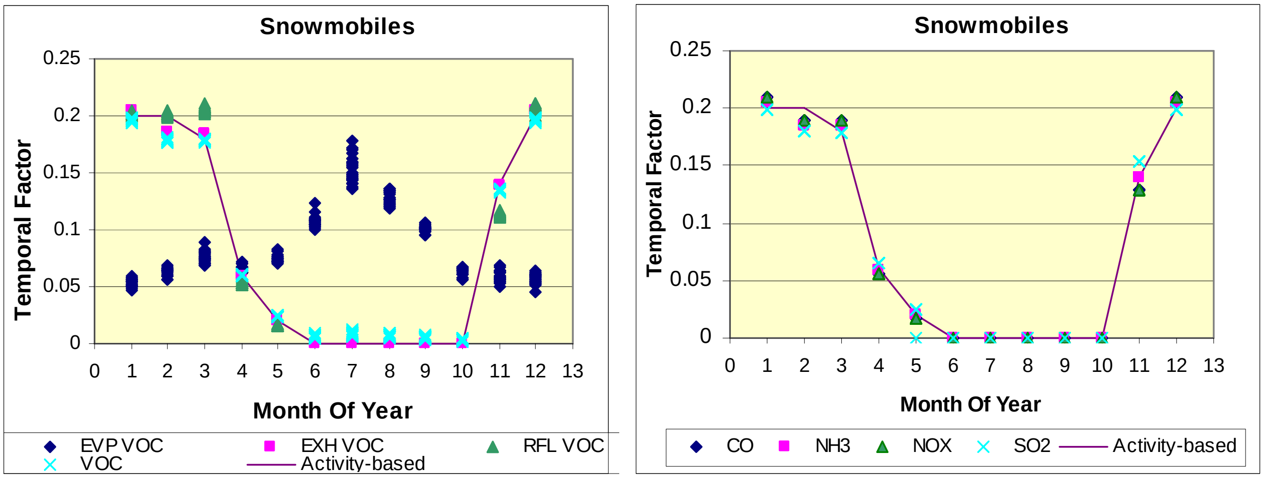
Figures 6 and 7. Monthly temporal Profiles for 2-Stroke Gasoline Lawn and Garden Equipment (SCC= 2260004000) for Evaporative VOC, Exhaust VOC, Refueling VOC and total VOC (Figure 6) and CO, NH3, NOX and SO2 (Figure 7) as compared to the activity based profile lawn and garden equipment.

Figures 8 and 9 show the temporal profiles for 4-stroke lawn and garden equipment. There is less variation in 4-stroke lawn and garden profiles than 4-stroke pleasure craft profiles because less of the VOC for lawn and garden is evaporative VOC (11 – 15% as compared to 48 to 65% for 4 stroke pleasure craft). Evaporative VOC is impacted more by temperature by exhaust VOC, as can be seen in all of the figures.



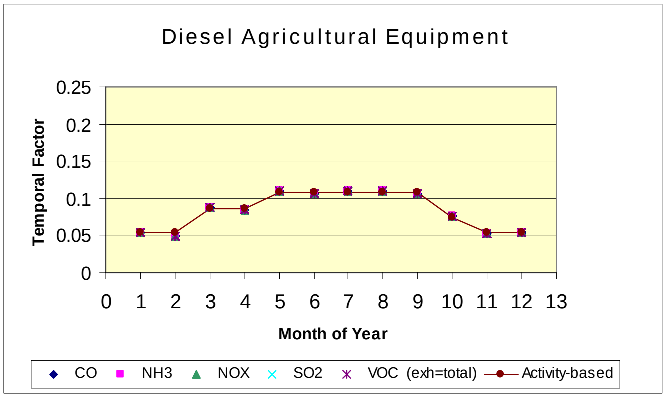
<u>Figures 8 and 9.</u> Monthly temporal Profiles for 4-Stroke lawn and garden equipment (SCC= 2265004000) for Evaporative VOC, Exhaust VOC, Refueling VOC and total VOC (Figure 8) and CO, NH3, NOX and SO2 (Figure 9) as compared to the activity based profile lawn and garden equipment.

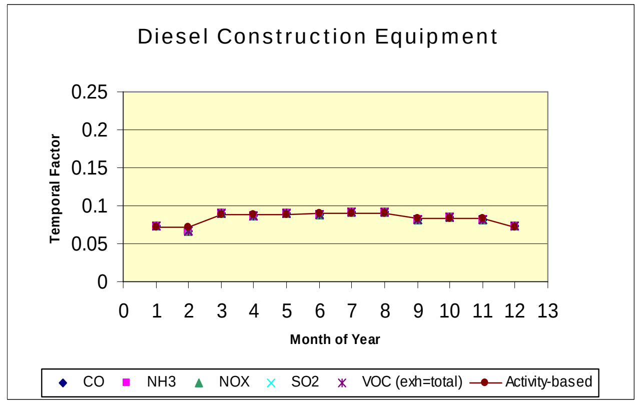
Figures 10 and 11 show the temporal factors for snowmobiles. There is very little variation among the two approaches in snowmobile temporal factors except for the refueling and evaporative VOC. While total exhaust VOC dominates and is zero for the summer months, the total VOC is slightly above zero. This is because for the summer months the NMIM emissions include VOC evaporative emissions from non-operating snowmobiles.



Figures 10 and 11: Monthly temporal Profiles for 2-stroke snowmobiles (SCC= 2260001020) for Evaporative VOC, Exhaust VOC, Refueling VOC and total VOC (Figure 10) and CO, NH3, NOX and SO2 (Figure 11) as compared to the activity based profile for snowmobiles.

Figures 12 and 13 show the variation in temporal profiles for the two SCCs with the highest emissions of NOX in the California nonroad inventory. Because these SCCs are for diesel engines, there is no evaporative or refueling component for VOC. For both of these equipment categories the NMIM-results based profiles are practically identical to the NONROAD activity-based profile for each of the pollutants.





Figures 12 and 13. Monthly temporal Profiles for agricultural equipment (SCC= 2270005000), on the left, and construction equipment (SCC= 227000200) on the right, for CO, NH3, NOX, SO2 and VOC as compared to the activity based profiles for these categories.

Note that in these figures, the NMIM-results based factor is slightly below the NONROAD activity-based factor for February. This is actually due a small error in the way the NMIM factors were generated (see discussion in Conclusions).

<u>Monthly Emissions comparisons between NMIM-results based approach and Equipment Activty based Approach</u>

The next set of illustrations compare the monthly VOC and NOX emissions obtained using the NMIM-results based factors versus the NONROAD-activity based factors. Panel plots (Figures 14 and 15) compare county-SCC level VOC and NOX emissions for four individual months using the two temporal approaches. Each point represents the monthly emissions for a unique county-SCC combination from these approaches. A point on the line indicates a one-to-one correlation, meaning the two approaches result in the same answer. As can be seen, in all four months, the NONROAD-activity based emission values line up closely with the emissions allocated using the NMIM-results based approach. The greatest difference in the values can be seen in the largest county-SCC emissions which occur in July: the 2-stroke pleasure craft (2282005000) emissions in Los Angeles county. The NONROAD activity-based emissions are slightly higher than the NMIM emissions for this situation, but the result is only a 3% percent difference. This category/county also results in the largest difference in January emissions.

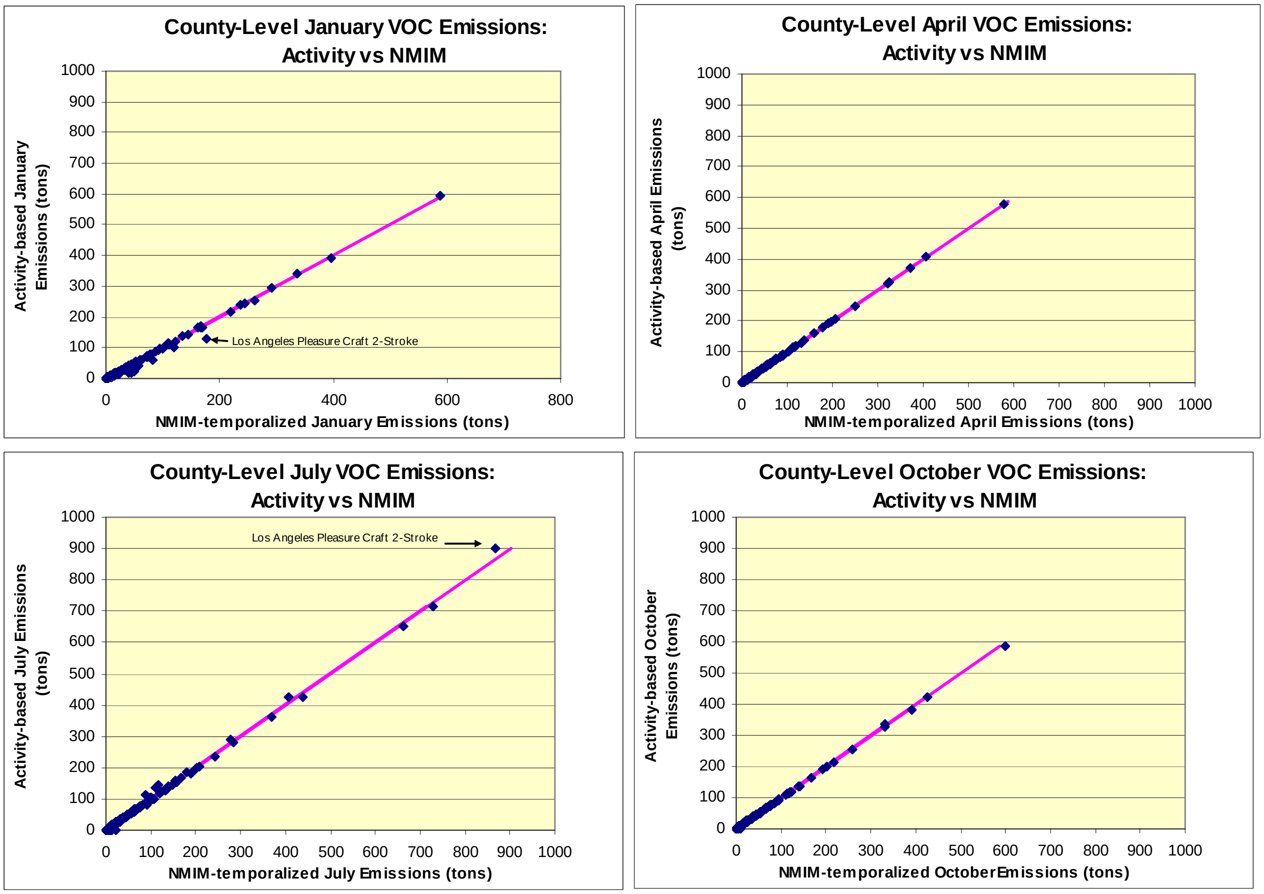


Figure 14. Panel plots comparing county-SCC monthly VOC emissions for January, April, July and October, computed using the NMIM-results versus NONROAD-activity based temporal profiles.

For NOX, a similar result can be seen. The largest emissions for NOX (also in July) are also seen in Los Angeles county, for diesel construction equipment. (SCC=2270002000).

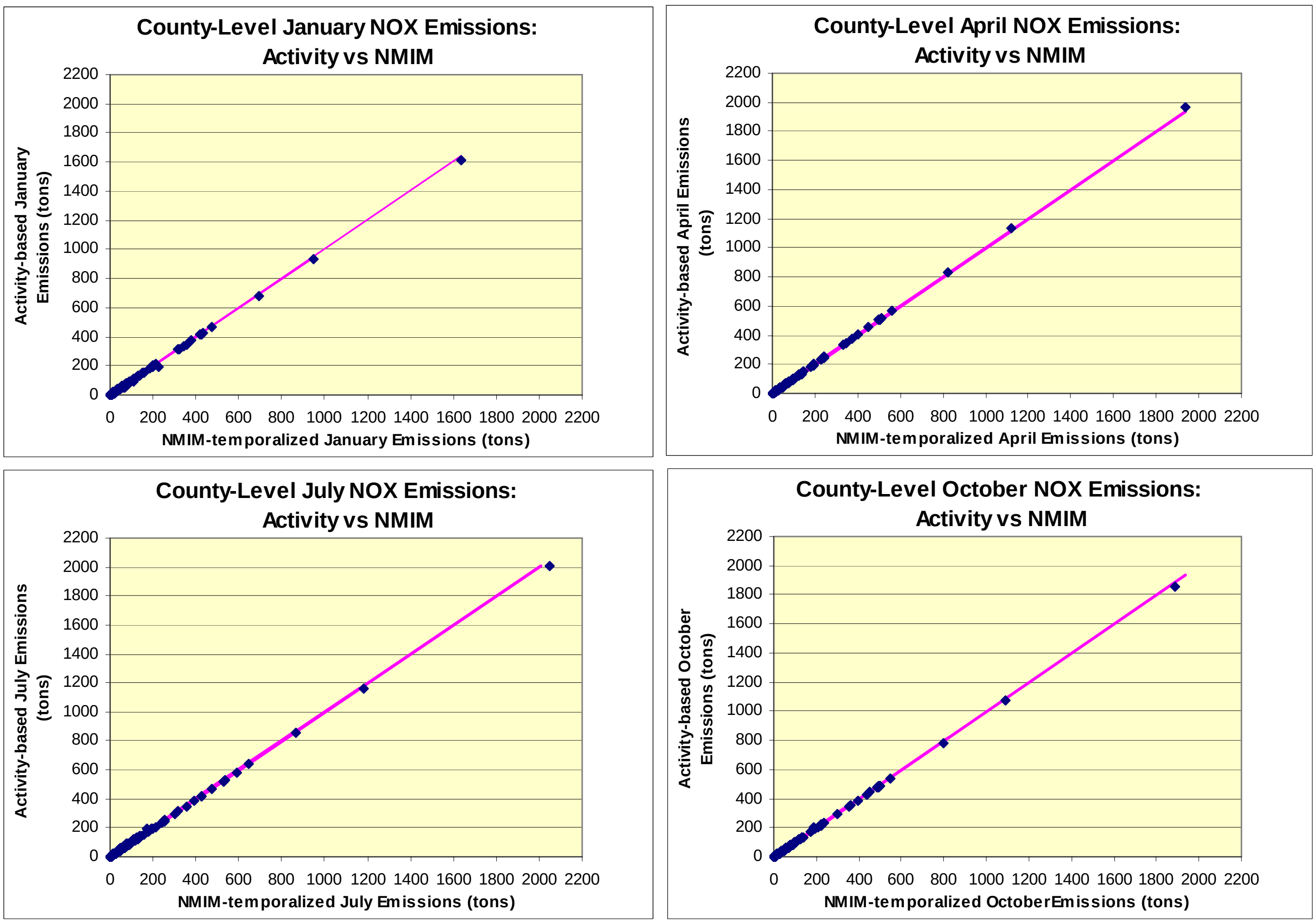


Figure 15. Panel plots comparing county-SCC monthly NOX emissions for January, April, July and October, computed using the NMIM-results versus NONROAD-activity based temporal profiles.

We also show the comparison between the NMIM-results based factors and the NONROAD activity-based factors on total monthly nonroad emissions for Los Angeles County.

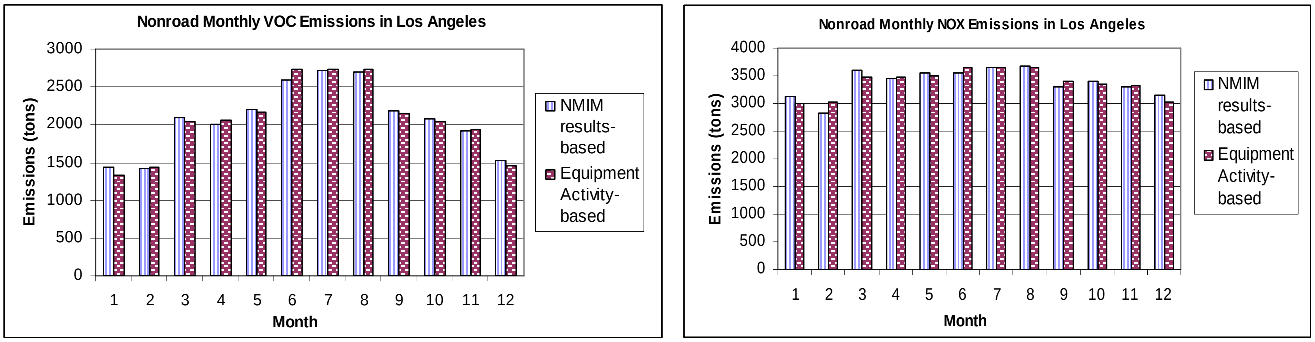


Figure 16. Comparison of NMIM-results based and Equipment Activity-based Temporal Allocation Methods on Los Angeles County Nonroad Equipment VOC and NOX Emissions.

As the figures show, the emissions variation across the two approaches is small.

CONCLUSIONS

Annual California nonroad emissions estimates submitted to the 2002 NEI were disaggregated to monthly, mode-specific emissions for the 2002 Modeling Platform using the NMIM results for California. The NMIM results account for temperature and fuel variations across the California counties which have different impacts across the pollutants. We computed NMIM-based monthly temporal profiles and examined their variation across different pollutants and California counties for specific nonroad SCCs. The resulting temporal factors showed more variation across California counties for VOC and NOX than for other pollutants. We found that the pollutant and county variation of the profiles is affected by both equipment type and engine type. The evaporative VOC monthly profiles showed the largest variation due to its strong dependence on temperature. Total (sum across all modes) VOC and other criteria air pollutants had less variation, and compared closely to the monthly temporal profiles based on equipment activity for California.

We also compared the NMIM approach for computing monthly emissions with the approach of using equipment activity based profiles. The equipment activity based profiles do not vary within California, and depend solely on the nonroad equipment type. We found that the two approaches resulted in very similar monthly emissions. While allocation of annual emissions to months could have been done more simply using equipment activity factors, the more complex NMIM-results method provided mode allocation as well. While not the focus of this paper, we did find large differences in the mode-specific emissions for different equipment types, which may have an impact on VOC speciation, considering the modes use different speciation profiles. Additional effort would be needed to explore whether the use of NMIM results to disaggregate California pollutants into the modes enhances the air quality model inputs.

In addition, while we found that the monthly emissions were nearly the same when allocated with NONROAD activity profiles as with the NMIM-results based approach, this finding may not apply across the country. The variation in mode and counties may prove more important where there may be more prominent temperature and fuel property variations in other states, and where temperatures may be more extreme during summer months.

We have also found that the inconsistent set of SCCs used in the California submitted emissions makes the NMIM approach complicated to implement and can lead to errors. One error we made resulted from a mistake caused by the need to reconcile NMIM SCCs and the SCCs in the California inventory. We were not aware that not all NMIM SCCs are present for all counties, and as a result we dropped emissions for some SCCs for some counties. The error was small, since it only affected a few SCCs in a few counties. Nonetheless this could have been avoided if we had summed the emissions of all possible NMIM surrogate SCCs before computing the allocation factors rather than choosing a single NMIM surrogate SCC.

We also uncovered a small in the allocation factors computed from the NMIM approach due to the misinterpretation of the format of the NMIM emissions, which we assumed to be average day values rather than monthly totals. This caused us to slightly underestimate the February emissions and slightly overestimate emissions for 31-day months.

An advantage of our implementation of the NMIM-results based approach is that we now have a readily available set of monthly nonroad emissions for California that are consistent with the rest of the states, in terms of the temporal resolution and the mode information. This allows for more flexible summaries of the monthly emissions by pollutant and emissions mode and for use in air quality models without further processing to allocate VOC emissions to mode.

A recommendation for future inventory development is to reconcile the SCC and mode information from California's models with EPA's models as it would improve consistency in the emissions processing techniques used to prepare inputs for air quality models.

REFERENCES

1. Sparse Matrix Operator Kernel Emissions (SMOKE) model website: http://www.smoke-model.org/index.cfm

2. Michaels, H.; Brzezinski, D.; Cook, R. *EPA's National Mobile Inventory Model (NMIM), A Consolidated Emissions Modeling System for MOBILE6 and NONROAD*; EPA-420-R-05-003, U. S. Environmental Protection Agency, Office of Transportation and Air Quality, Assessment and Standards Division, Ann Arbor, MI, 2005. (Available at http://www.epa.gov/otaq/nmim.htm).

3. U. S. Environmental Protection Agency. Seasonal and Monthly Activity Allocation Fractions for Nonroad Engine Emissions Modeling, NR-004c (EPA420-R-05-017, December 2005). Available from http://www.epa.gov/otaq/nonrdmdl.htm#techrept.