# Revised Methodology for the Spatial Allocation of VMT and Mobile Source Emissions Data

Ellen Kinnee and Allan Beidler
DynTel Corporation
P.O. Box 12804
Research Triangle Park, North Carolina 27709

Norm Possiel and Gregory Stella
Office of Air Quality Planning and Standards
United States Environmental Protection Agency
Mail Drop 14
Research Triangle Park, North Carolina 27711

**ABSTRACT**
In an effort to improve the existing methodology of allocating highway mobile source emissions and vehicle miles traveled (VMT) for modeling purposes, EPA recommended using a more complete set of geocoded information than what had previously been used to spatially allocate these data. Reclassifying Arc/Info coverage of roads from TIGER files and 1990 census rural block data developed new major and local road and urban/rural area coverages. Overlaying the roads and the newly defined urban area coverages further developed coverages of major and local road surrogates. Calculating the total county road lengths of the four roadway classes and the county population for the two new local classes then generated final grid surrogate ratios.

These procedures resulted in six new emissions surrogates from which to spatially allocate highway mobile source emissions or VMT: urban primary roads, rural primary roads, urban secondary roads, rural secondary roads, urban population, and rural population. Initial sensitivity tests using these surrogates show better allocation of emissions and VMT to appropriate grid cells. The new spatial allocation of roadway lengths to grid cells approximates actual road networks and, as seen in the initial results, the effect of improved spatial allocation definitely will enhance results as the modeling grid cell size decreases.

**INTRODUCTION**
In an effort to improve the existing methodology of allocating highway mobile source emissions and vehicle miles traveled (VMT) for modeling purposes, EPA recommended using a more complete set of TIGER/Line (Census, 1991) information than what had previously been used to spatially allocate these data. Reclassifying Arc/Info coverage of roads from TIGER files and 1990 census rural block data developed new major and local road and urban/rural area coverages. Overlaying the roads and the newly defined urban area coverages further developed coverages of major and local road surrogates. Calculating the total county road lengths of the four roadway classes and the county population for the two new local classes then generated final grid surrogate ratios.

Although highway mobile sources are sometimes grouped with area sources in an inventory, their spatial allocation is somewhat different. Specifically, many mobile sources are limited in operation on linear transportation networks. Highway motor vehicle emissions or VMT is often modeled on the road network using travel demand models or other transportation models. These transportation models can be used to allocate emissions or VMT to individual network segments. VMT can then be adjusted for any special conditions that exist at the individual network segment level. For example, the effects of higher vehicle speeds, temperature fluctuations, or traffic congestion can be assigned to individual segments.

The modeling inventory ultimately needs to have emissions or VMT assigned to specific grid cells. As a result, motor vehicle emissions are spatially allocated to specific grid cells depending on the relevant activity occurring within those grid cells. Activity data may be split into multiple grid cells based upon the fraction of activity within each grid cell. For instance, a road segment that crosses three grid cells and has equally distributed motor vehicle activity along its entire length would have one-third of its emissions assigned to each one of the three relevant grid cells.

As part of a "proof of concept" exercise, EPA is conducting applications of the Community Multiscale Air Quality (CMAQ) model (Jang, 2001). One of these applications simulates ozone and particulate matter at a 36-km resolution over a national grid covering the continental United States. A scenario for the entire year of 1996 was modeled for this effort utilizing emission inventories prepared in support of EPA's Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur study (EPA, 2000) and processed through the Sparse Matrix Operator Kernel Emissions (SMOKE) modeling system (Houyoux, 1999).

The emissions and VMT by vehicle class for the Atlanta Metropolitan area and Maricopa County, Arizona used for this analysis and developed for the 1996 scenario are presented in Table 1 below for each area of application.

Table 1. 1996 VMT and Annual NOx Emissions by Facility Type for Study Domains

| | **Vehicle Miles Traveled (Millions)** | | **Annual NOx Emissions (Tons)** | |
|---|---|---|---|---|
| **Facility Type** | **Atlanta Metro** | **Maricopa Co.** | **Atlanta Metro** | **Maricopa Co.** |
| Rural Interstate | 2,430 | 975 | 15,675 | 5,929 |
| Rural Other Principal Arterial | 1,741 | 388 | 9,778 | 2,082 |
| Rural Minor Arterial | 1,929 | 306 | 7,790 | 1,164 |
| Rural Major Collector | 1,781 | 471 | 7,299 | 1,821 |
| Rural Minor Collector | 594 | 77 | 2,421 | 294 |
| Rural Local | 1,327 | 278 | 5,405 | 1,070 |
| Urban Interstate | 11,887 | 3,038 | 45,076 | 10,849 |
| Urban Other Freeways & Expressways | 1,659 | 2,177 | 6,290 | 7,774 |
| Urban Other Principal Arterial | 6,714 | 7,118 | 19,639 | 19,417 |
| Urban Minor Arterial | 7,314 | 3,863 | 21,393 | 10,536 |
| Urban Collector | 3,502 | 2,283 | 10,243 | 6,229 |
| Urban Local | 6,523 | 2,243 | 19,077 | 6,120 |
| **Total** | **47,401** | **23,217** | **170,086** | **73,285** |

## ALLOCATION METHODS

### Earlier and Existing Methodologies

<u>TIGER Only Approach</u>

Initial approaches to allocating highway vehicle emissions or VMT data to grid cells attempted to match surrogates to the facility classes associated with the county emissions or activity. These attempts were limited to eight facility classes: interstate, principal arterial – freeway, principal arterial – other, collectors, minor arterials, major collectors, minor collectors, and local. There were two primary problems encountered with the existing methodology.

One problem was that there is a spatial discontinuity with the TIGER/Line classification system. It appears that state and local areas may have classified roadways differently. For example, a United States map produced with major arterials showed gaps in the network where portions of the roadway were classified differently. This created a problem in some areas where a large amount of VMT or emissions were associated with an arterial source category code (SCC), for example, but the total miles of this facility type from the TIGER/Line were relatively small. Resulting emissions were thereby unevenly distributed.

The other problem was the definition of urban and rural used to generate the original surrogate ratios. Emissions and VMT SCCs are divided by facility type and urban/rural classification. The standard census definition of urban/rural was not consistent with the SCCs in many counties. There were many smaller counties that have no urban areas as classified by the census but were allocated urban emissions and VMT in the inventory.

Population-Based Approach

The most commonly utilized approach to spatially allocate highway mobile source emissions or VMT used interstate road miles for interstate highway source categories and population for the remaining source emissions or VMT. Additional rural and urban designation was overlain on the domain to generate four surrogates used for gridding: urban interstate, rural interstate, urban population, and rural population. Based on an SCC, emissions or VMT were assigned to one of these categories. Table 2 shows these assignments. This methodology limited the allocation of intermediate facility types (arterials and collectors) to the same procedures used for local roads. And as rural or urban populations were the sole surrogates available for allocating these data, small counties or densely populated areas were given the majority of highway vehicle emissions or VMT, regardless of their transportation potential.

Table 2. Population-Based Source Category Code / Spatial Surrogate Associations

| **SCC** | **Description** | **Spatial Surrogate** |
|---|---|---|
| **Prefix 220 or 223** | **Highway Mobile Source** | |
| xxxxxxx110 | Rural Interstate | Rural Interstate |
| xxxxxxx130 | Rural Other Principal Arterial | Rural Population |
| xxxxxxx150 | Rural Minor Arterial | Rural Population |
| xxxxxxx170 | Rural Major Collector | Rural Population |
| xxxxxxx190 | Rural Minor Collector | Rural Population |
| xxxxxxx210 | Rural Local | Rural Population |
| xxxxxxx230 | Urban Interstate | Urban Interstate |
| xxxxxxx250 | Urban Other Freeways & Expressways | Urban Interstate |
| xxxxxxx270 | Urban Other Principal Arterial | Urban Population |
| xxxxxxx290 | Urban Minor Arterial | Urban Population |
| xxxxxxx310 | Urban Collector | Urban Population |
| xxxxxxx330 | Urban Local | Urban Population |

Mixed Approach

Finally, to try to resolve problems related to allocating emissions or VMT by roadway type or population when both surrogates have spatial validity, one method utilized a mix of facility type and population. The theory behind this application involved a “common sense” approach to allocating emissions or VMT data from a source category type. For example, knowing that emissions or activity from heavy duty diesel vehicles would occur mainly in populated areas (construction, mass transportation, school buses), but occasionally on interstates (transport, trucking), a 25 percent roadway miles / 75 percent population based surrogate was developed and assigned to these categories. Although the results generated “felt” and looked better graphically than alternate approaches, the development and assignment of these surrogates to source categories was a purely objective activity and not physically meaningful.

**Revised Methodology**

New major road coverages were developed by reclassifying Arc/Info coverage of major roads from TIGER files into three classes. Primary roads are identified as all Census Feature Class Codes (CFCC) A00 through A18 data, secondary roads are identified as all CFCC A20 through A38 data, and the remainder of CFCC data were classified under local roads. Table 3 provides full descriptions of these CFCCs. A coverage of urban areas was next generated by importing 1990 census rural block data. The urban area was calculated by subtracting rural population from the total population within an area.

The TIGER/Line files are a digital database of geographic features, such as roads, railroads, rivers, lakes, political boundaries, census statistical boundaries, etc. covering the entire United States. The database contains information about these features such as their location in latitude and longitude, the name, the type of feature, address ranges for most streets, the geographic relationship to other features, and other related information. They are the public product created from the Census Bureau's TIGER database of geographic information. TIGER was developed at the Census Bureau to support the mapping and related geographic activities required by the decennial census and sample survey programs.

These files are not graphic images of maps, but rather digital data describing geographic features. To make use of these data, a user must have mapping or Geographic Information System (GIS) software that can import TIGER/Line data.

The percent urban population for each area was then generated and polygons identified as having more than 50% urban population were extracted from the area. Internal block data boundaries were then dissolved to create new population areas. These new areas, designated as urban or rural, were then merged with coastal boundaries to obtain a complete urban and rural U.S. coverage. Figures 1 and 2 show these population areas for the studied Atlanta Metro and Maricopa County, Arizona areas.

Next, coverage of major road surrogates was developed by overlaying the major roads and the newly defined urban area coverages. This resulted in four new road classes: urban primary, rural primary, urban secondary, and rural secondary.  These new surrogates are represented in Figures 3 and 4.

The major road gridded emission surrogates were then further defined by overlaying the 36-km national grid with the new road classes and running statistics to sum the road lengths by grid column and row, state, county, and road class.

Similarly, overlaying the census block groups with the new urban/rural coverage to calculate the amount of urban and rural population within each block group developed local road coverage. The local road gridded emission surrogates were defined by again overlaying the national grid with the coverage of local roads and running statistics to sum urban and rural population by grid column and row, state, and county.

Calculating the total county road lengths of the four roadway classes and the county population for the two new local classes then generated final grid surrogate ratios. The road lengths and population were summed by grid column and row, and a cell to county ratio was calculated for each class. This resulted in six new emission surrogates from which to spatially allocate VMT or mobile source emissions: urban primary roads, rural primary roads, urban secondary roads, rural secondary roads, urban population, and rural population.

Table 3. Road Feature Census Feature Class Codes

| CFCC | Description |
|---|---|
| A00 | Road, classification unknown or not elsewhere classified |
| A01 | Road, unseparated |
| A02 | Road, unseparated, in tunnel |
| A03 | Road, unseparated, underpassing |
| A04 | Road, unseparated, rail line in center |
| A05 | Road, divided |
| A06 | Road, divided, in tunnel |
| A07 | Road, divided, underpassing |
| A08 | Road, divided, rail line in center |
| A10 | Primary road with limited access or interstate highway |
| A11 | Primary road with limited access or interstate highway, unseparated |
| A12 | Primary road with limited access or interstate highway, unseparated, in tunnel |
| A13 | Primary road with limited access or interstate highway, unseparated, underpassing |
| A14 | Primary road with limited access or interstate highway, unseparated, with rail line in center |
| A15 | Primary road with limited access or interstate highway, separated |
| A16 | Primary road with limited access or interstate highway, separated, in tunnel |
| A17 | Primary road with limited access or interstate highway, separated, underpassing |
| A18 | Primary road with limited access or interstate highway, separated, with rail line in center |
| A21 | Primary road without limited access, US highways, unseparated |
| A22 | Primary road without limited access, US highways, unseparated, in tunnel |
| A23 | Primary road without limited access, US highways, unseparated, underpassing |
| A24 | Primary road without limited access, US highways, unseparated, with rail line in center |
| A25 | Primary road without limited access, US highways, separated |
| A26 | Primary road without limited access, US highways, separated, in tunnel |
| A27 | Primary road without limited access, US highways, separated, underpassing |
| A28 | Primary road without limited access, US highways, separated, with rail line in center |
| A31 | Secondary and connecting road, state highways, unseparated |
| A32 | Secondary and connecting road, state highways, unseparated, in tunnel |
| A33 | Secondary and connecting road, state highways, unseparated, underpassing |
| A34 | Secondary and connecting road, state highways, unseparated, with rail line in center |
| A35 | Secondary and connecting road, state highways, separated |
| A36 | Secondary and connecting road, state highways, separated, in tunnel |
| A37 | Secondary and connecting road, state and county highways, separated, underpassing |
| A38 | Secondary and connecting road, state and county highway, separated, with rail line in center |
| A41 | Local, neighborhood, and rural road, city street, unseparated |
| A42 | Local, neighborhood, and rural road, city street, unseparated, in tunnel |
| A43 | Local, neighborhood, and rural road, city street, unseparated, underpassing |
| A44 | Local, neighborhood, and rural road, city street, unseparated, with rail line in center |
| A45 | Local, neighborhood, and rural road, city street, separated |
| A46 | Local, neighborhood, and rural road, city street, separated, in tunnel |
| A47 | Local, neighborhood, and rural road, city street, separated, underpassing |
| A48 | Local, neighborhood, and rural road, city street, separated, with rail line in center |
| A51 | Vehicular trail, road passable only by 4WD vehicle, unseparated |
| A52 | Vehicular trail, road passable only by 4WD vehicle, unseparated, in tunnel |
| A53 | Vehicular trail, road passable only by 4WD vehicle, unseparated, underpassing |
| A60 | Special road feature, major category used when the minor category could not be determined |
| A61 | Cul-de-sac, the closed end of a road that forms a loop or turn-around |
| A62 | Traffic circle, the portion of a road or intersection of roads forming a roundabout |
| A63 | Access ramp, the portion of a road that forms a cloverleaf or limited-access interchange |
| A64 | Service drive, the road or portion of a road that provides access to businesses, facilities, and rest areas along a limited-access highway; this frontage road may intersect other roads and be named |
| A65 | Ferry crossing, the representation of a route over water that connects roads on opposite shores; used by ships carrying automobiles or people |
| A70 | Other thoroughfare, major category used when the minor category could not be determined |
| A71 | Walkway or trail for pedestrians, usually unnamed |
| A72 | A72 Stairway, stepped road for pedestrians, usually unnamed |
| A73 | Alley, road for service vehicles, usually unnamed, located at the rear of buildings and property |
| A74 | Driveway or service road, usually privately owned and unnamed, used as access to residences, trailer parks, and apartment complexes, or as access to logging areas, oil rigs, ranches, farms, and park lands |

Figure 1. Urban Boundaries – Atlanta Metro Area

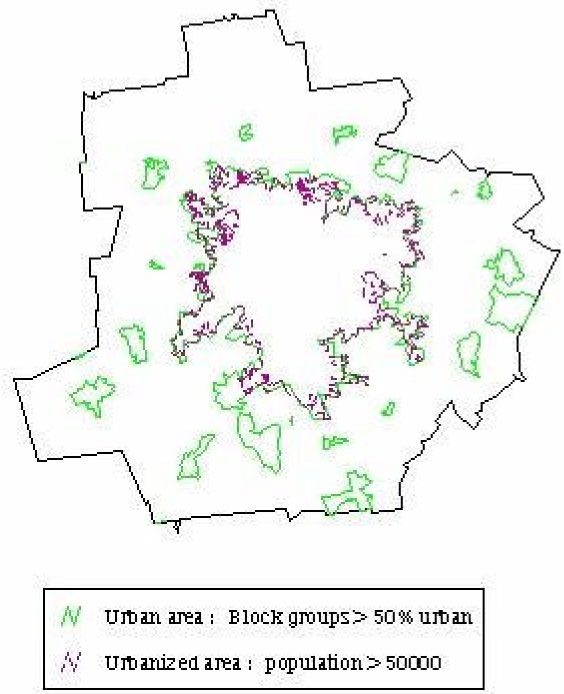



Figure 2. Urban Boundaries – Maricopa County, Arizona

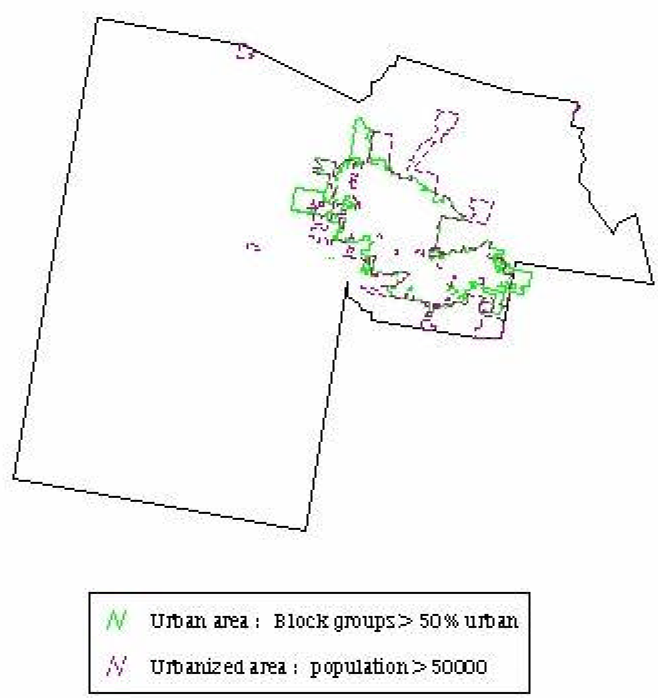


Figure 3. Resulting Highway Mobile Spatial Surrogates – Atlanta Metro Area

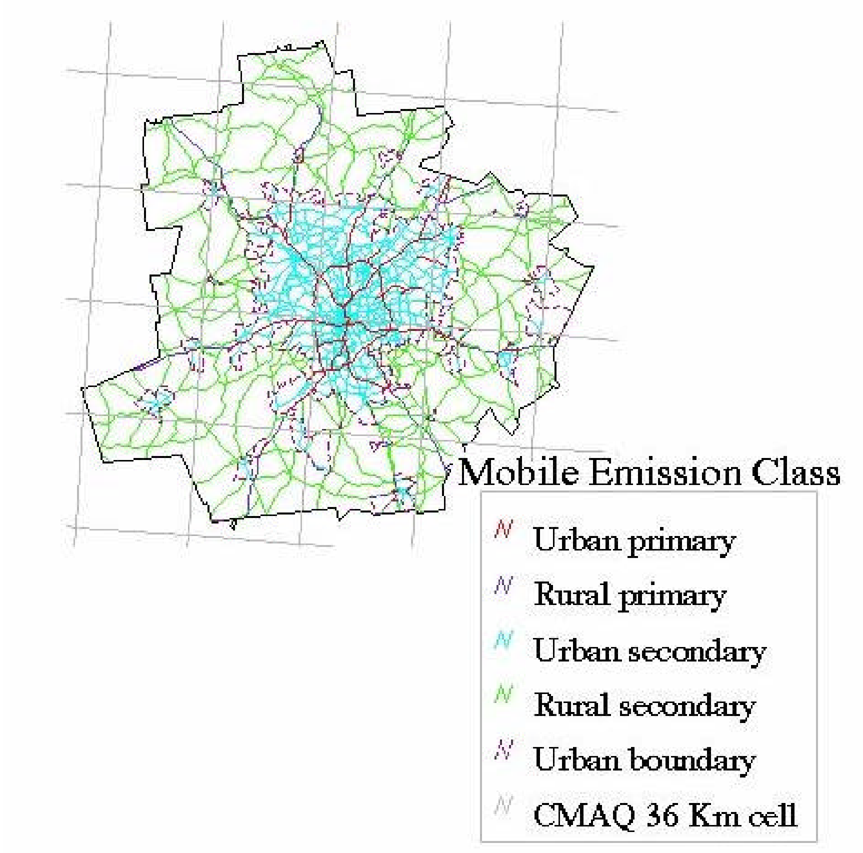
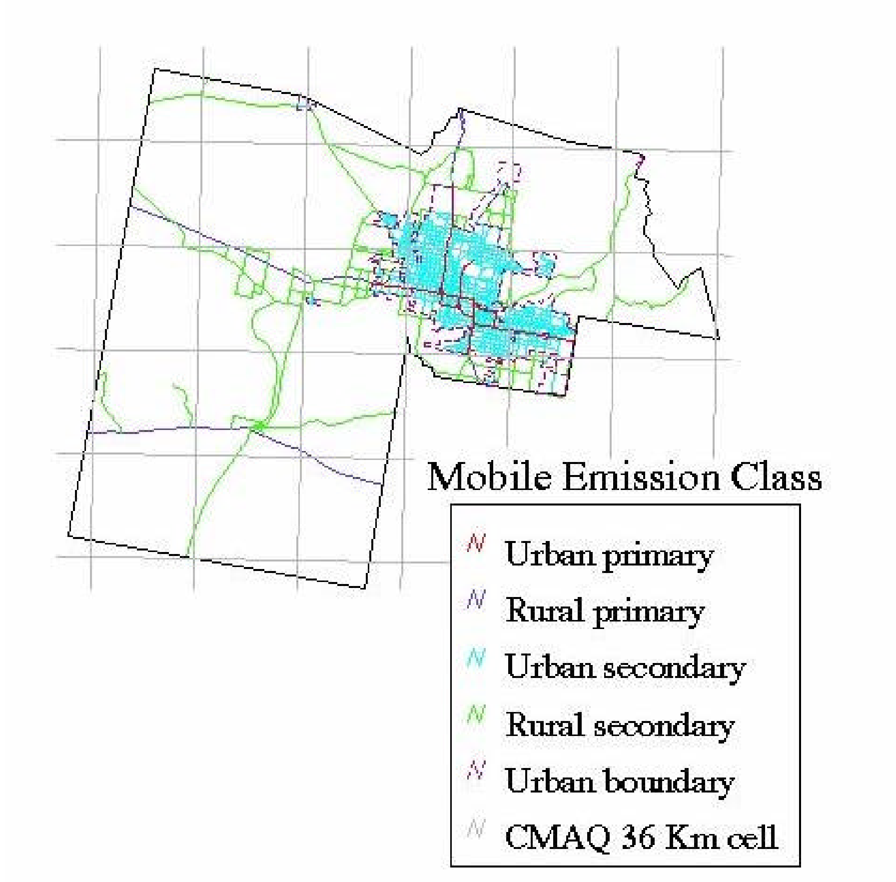



Figure 4. Resulting Highway Mobile Spatial Surrogates – Maricopa County, Arizona



These new surrogates were then matched back to SCCs and assigned for spatially allocating highway mobile VMT or emissions. Table 4 provides these new associations.

Table 4. Revised Source Category Code / Spatial Surrogate Associations

| SCC | Description | Spatial Surrogate |
|---|---|---|
| **Prefix 220 or 223** | **Highway Mobile Source** | |
| xxxxxxx110 | Rural Interstate | Rural Primary Roads |
| xxxxxxx130 | Rural Other Principal Arterial | Rural Primary Roads |
| xxxxxxx150 | Rural Minor Arterial | Rural Primary Roads |
| xxxxxxx170 | Rural Major Collector | Rural Secondary Roads |
| xxxxxxx190 | Rural Minor Collector | Rural Secondary Roads |
| xxxxxxx210 | Rural Local | Rural Population |
| xxxxxxx230 | Urban Interstate | Urban Primary Roads |
| xxxxxxx250 | Urban Other Freeways & Expressways | Urban Primary Roads |
| xxxxxxx270 | Urban Other Principal Arterial | Urban Primary Roads |
| xxxxxxx290 | Urban Minor Arterial | Urban Primary Roads |
| xxxxxxx310 | Urban Collector | Urban Secondary Roads |
| xxxxxxx330 | Urban Local | Urban Population |

## Results

Comparing the gridding methods of population-based and revised surrogate for allocation, it can be seen that both VMT and emissions are better distributed among spatial surrogate classes with the revised method.

### Annual Vehicle Miles Traveled

The population-based allocation method heavily weights VMT to the "Other" category based on the rural and urban population densities within the study domain. In this analysis, Atlanta's population-based VMT accounts for 66 percent of the annual VMT total whereas interstates account for the remaining 34 percent. Similar results are seen in Table 5 for Maricopa County, where fewer interstate links exist, as population-based VMT accounts for 73 percent of the annual total and the remaining 27 percent are allocated to interstates.

Table 5. Annual VMT (Millions) Distribution Using Population-Based Approach

| | Interstate | | Other | | |
|---|---|---|---|---|---|
| **Study Domain** | **Rural** | **Urban** | **Rural** | **Urban** | **Total** |
| Atlanta Metro | 2,430 | 13,546 | 7,372 | 24,054 | 47,402 |
| Maricopa Co. | 975 | 5,214 | 1,520 | 15,507 | 23,216 |

Utilizing the six new highway mobile source spatial surrogates, the contribution of population-based VMT decreases significantly as the VMT is allocated to more primary and secondary road links. Table 6 shows that in the Atlanta Metro domain, VMT attributed to rural and urban primary roads increased to over 70 percent of the annual total. Maricopa County's primary roads now contribute 77 percent to the annual VMT total. In the same respect, secondary roads now account for 12 percent of the annual VMT total in both in the Atlanta Metro and Maricopa County domains. Population-based local roads are now allocated only 17 and 11 percent of the total VMT in the Metro Atlanta area and Maricopa County, respectively.

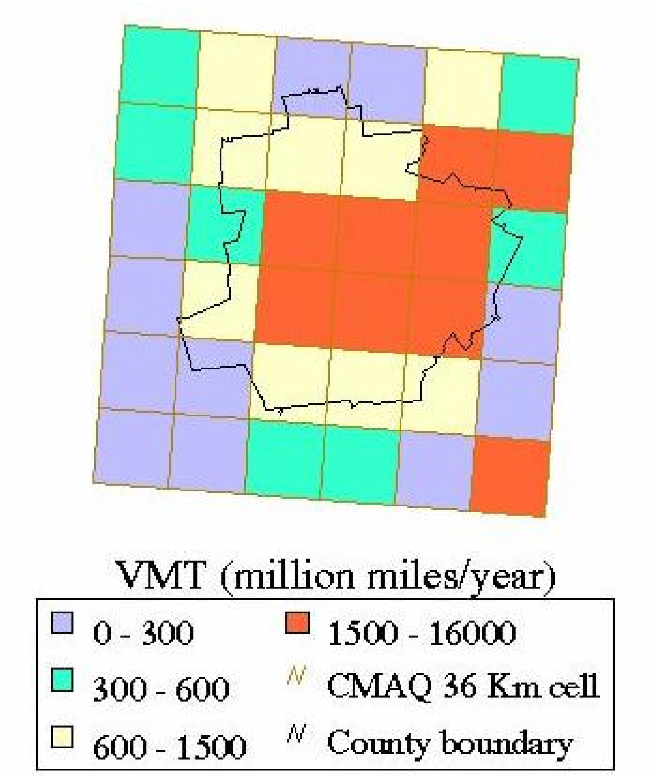
Table 6. Annual VMT (Millions) Distribution Using Revised Approach

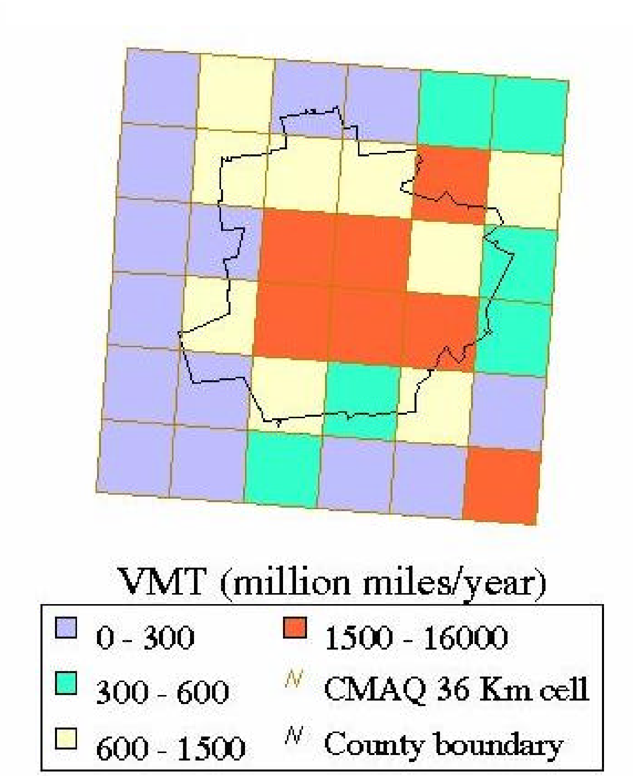
| | Primary | | Secondary | | Local | | |
|---|---|---|---|---|---|---|---|
| **Study Domain** | **Rural** | **Urban** | **Rural** | **Urban** | **Rural** | **Urban** | **Total** |
| Atlanta Metro | 6,101 | 27,575 | 2,375 | 3,502 | 1,327 | 6,523 | 47,403 |
| Maricopa Co. | 1,669 | 16,195 | 548 | 2,283 | 278 | 2,243 | 23,216 |

Figure 5 presents the distribution of annual highway vehicle VMT to 36-km grid cells for the Atlanta Metro area using the population-based approach. As can be seen, the majority of activity are centered on the residential districts of the city where population density is at its highest.

Shifts in the VMT from the residential core to the interstates and secondary roads can be seen in Figure 6. Although the greatest density of VMT in this domain still is centered on the downtown Atlanta area, because of the allocation of activity to the primary and secondary links, this density is more widespread and extends along the interstates running in and out of the city.

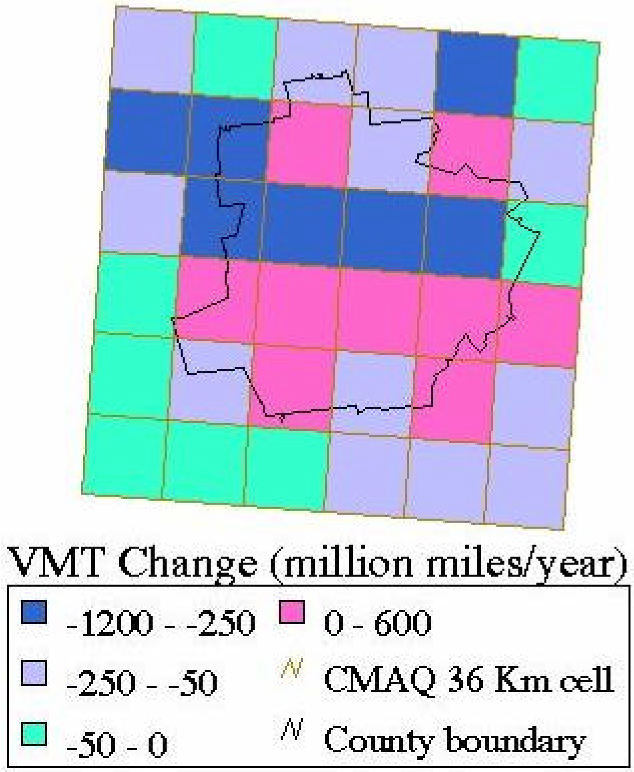
Figures 5 & 6. Population-Based and Revised Annual VMT Distribution – Atlanta Metro Area




A better demonstration of the shift in VMT from the city's center to the primary and secondary routes is presented in Figure 7. Due to the large number of small counties associated with the Atlanta Metro area, these shifts are not as prominent as they would be for smaller grid cells or in larger counties. However, in Figure 7, VMT reductions on the order of 1,200 million VMT per year can be seen in the northern population-based grid cells indicating the distribution of these emissions to other road allocated cells.

Figure 7. Annual VMT Distribution Difference – Atlanta Metro Area




Contrary to the small size of the counties located within the Atlanta Metro area, Maricopa County's domain extends to multiple 36-km grid cells. In this case, population-based distribution of annual VMT is more easily seen along the county's residential core. Figure 8 shows that the majority of VMT allocated to the county are centered in the highly populated zones and lower activity densities are seen along the major interstates and freeways.

Using the revised emission allocation methodology and surrogates, Figure 9 shows that VMT are more evenly distributed along the primary and secondary routes, where the majority of highway vehicle traffic is expected to occur.

The difference in VMT density is made more apparent in Figure 10, where annual VMT activity from highway vehicle sources are dispersed along the various primary, secondary, and local roads in a fashion more realistic to actual conditions. The revised allocation surrogates better define urban and rural interstate and secondary routes and therefore the VMT associated with them are better defined, too.

In fact, as can be seen in Figure 10, annual reductions of up to 975 million VMT are realized in the north and eastern part of the city's core where greater population, but fewer roadways exist. Concurrently, annual increases of over 700 million VMT are distributed along the highly road populated cells.

Figures 8 & 9. Population-Based & Revised Annual VMT Distribution – Maricopa County, Arizona

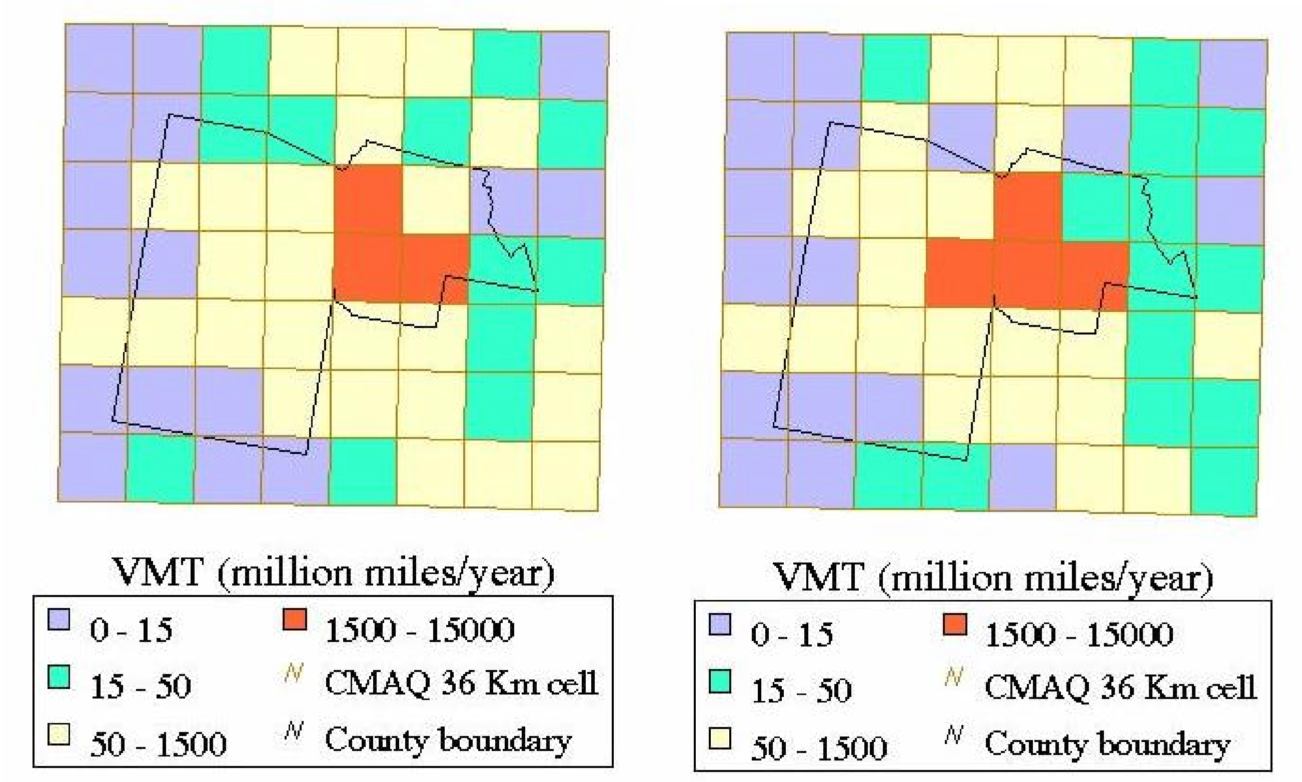
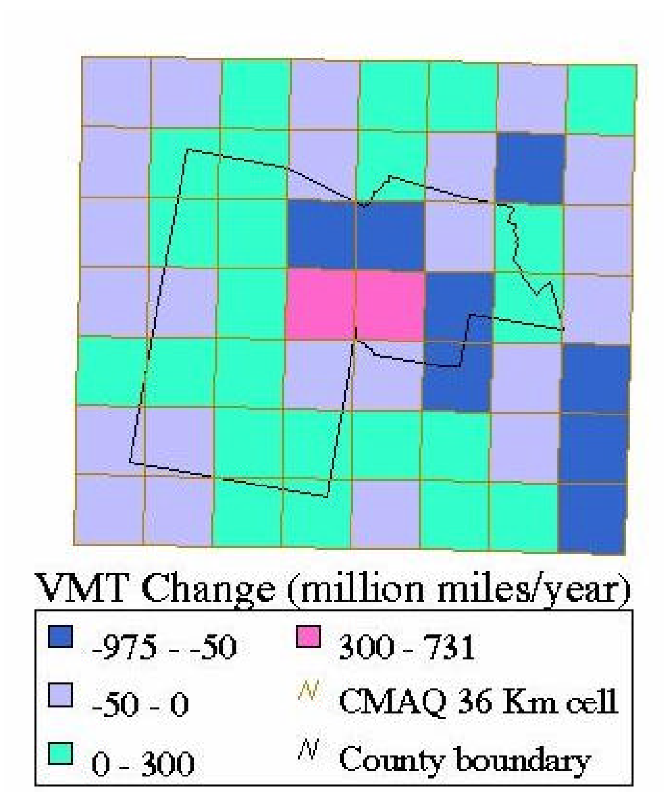



Figure 10. Annual VMT Distribution Difference – Maricopa County, Arizona



Annual NOx Emissions

In the original population-based approach, about 61 percent of the annual NOx emissions in Atlanta and 66 percent of the annual NOx emissions in Maricopa County were population allocated to the study domain. This compares to the 14 percent and 10 percent allocation by population in these same areas using the revised methods.

Table 7. Annual NOx Emission (Tons) Distribution Using Population-Based Approach

| | **Interstate** | | **Other** | | |
|---|---|---|---|---|---|
| **Study Domain** | **Rural** | **Urban** | **Rural** | **Urban** | **Total** |
| Atlanta Metro | 15,675 | 51,366 | 32,692 | 70,351 | 170,084 |
| Maricopa Co. | 5,929 | 18,622 | 6,432 | 42,301 | 73,284 |

Additionally, as can be seen in Tables 7 and 8, 74 percent of these annual NOx emissions are allocated to primary roadway links in Atlanta using the revised method, whereas only 39 percent were allocated using the population-based approach. A larger change in primary road allocation is seen in Maricopa County as the contribution of this facility type increases from 34 percent to 79 percent. The new secondary road surrogate accounts for 12 percent of the annual NOx emissions in the Atlanta Metro area and 11 percent in Maricopa County. Only 14 percent of the annual NOx emissions are now spatially allocated with population in the Atlanta Metro area and only 10 percent in Maricopa County.

Table 8. Annual NOx Emission (Tons) Distribution Using Revised Approach

| | **Primary** | | **Secondary** | | **Local** | | |
|---|---|---|---|---|---|---|---|
| **Study Domain** | **Rural** | **Urban** | **Rural** | **Urban** | **Rural** | **Urban** | **Total** |
| Atlanta Metro | 33,243 | 92,397 | 9,720 | 10,243 | 5,405 | 19,077 | 170,085 |
| Maricopa Co. | 9,176 | 48,575 | 2,116 | 6,229 | 1,070 | 6,120 | 73,286 |

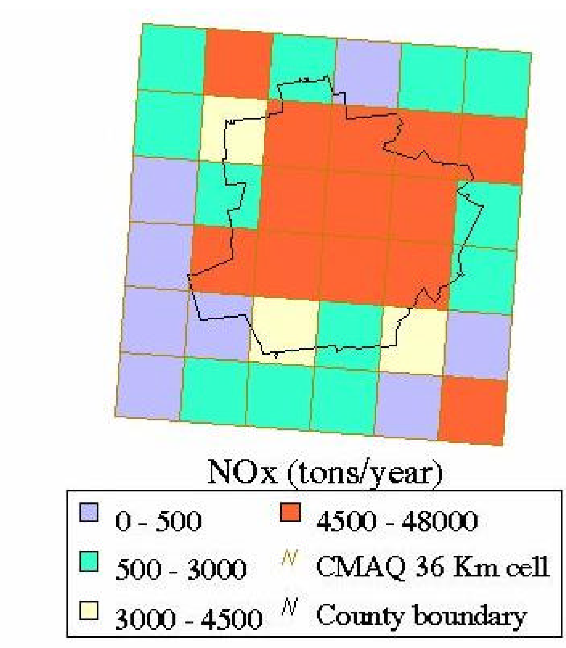
These emission-related results of the revised allocation surrogate use in Metro Atlanta can be seen in the following figures. Although the VMT and emissions reported in the previous tables accounts for the complete area of the counties located within the area of study, the gridded domain partitions some of the outer counties, removing some of the total.

Figure 11 presents the distribution of annual highway vehicle NOx emissions for the Atlanta Metro area using the population-based approach. As with VMT, the majority of emissions are centered on the residential districts of the city where population density is at its highest.

Shifts in the emission from the residential core to the interstates and secondary roads can be seen in Figure 12. Although the greatest density of emissions in this domain still is centered on the downtown Atlanta area, because of the allocation of emissions to the primary and secondary links, this density is more widespread and again extends along the interstates running in and out of the city.

A better demonstration of the shift in these emissions from the city’s center to the primary and secondary routes is presented in Figure 13. In Figure 13, NOx reductions of close to 300 annual tons can be seen in population-based grid cells indicating the distribution of these emissions to other road allocated cells.

Figures 11 & 12. Population-Based and Revised Annual NOx Distribution – Atlanta Metro Area



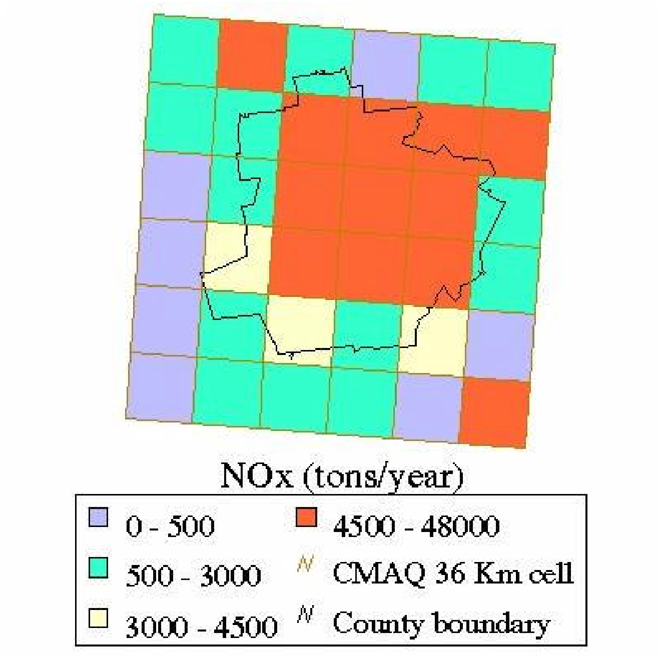
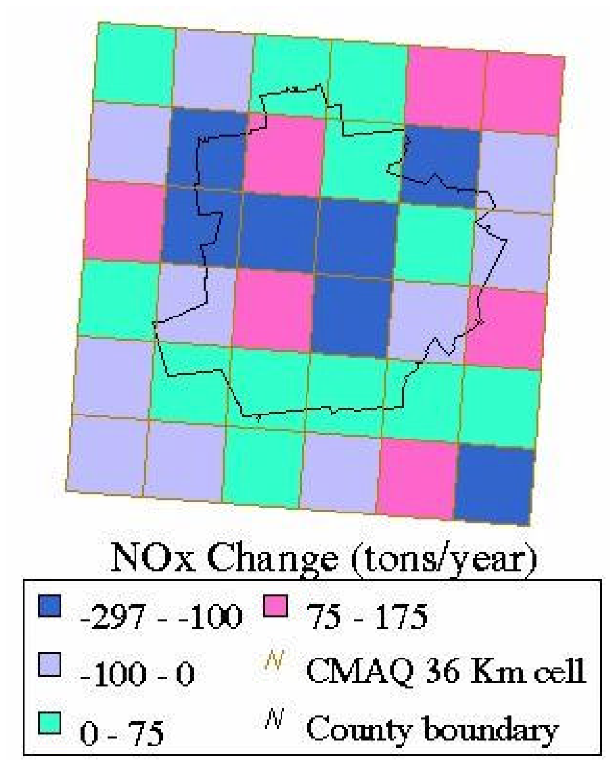




Figure 13. Annual NOx Distribution Difference – Atlanta Metro Area

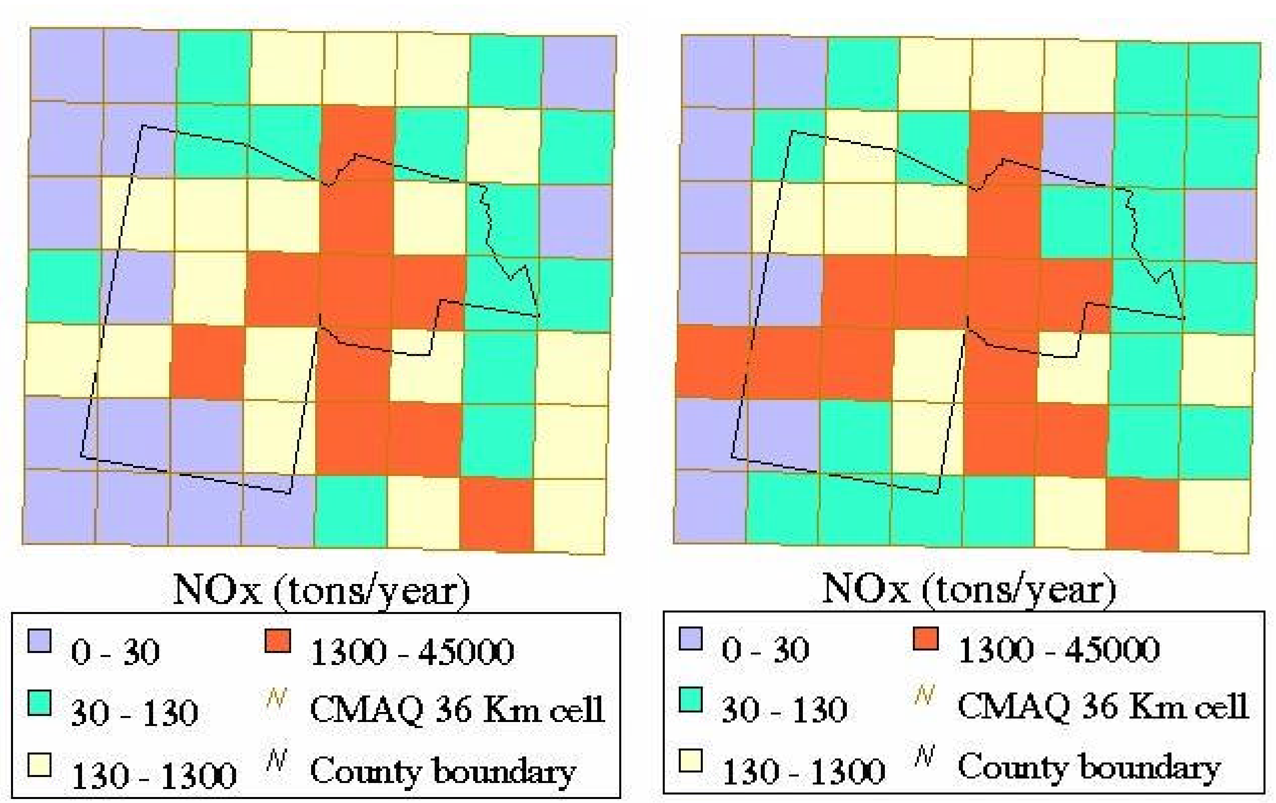


As Maricopa County's boundaries extend over a number of 36-km grid cells, population-based distribution of annual NOx emissions is more easily seen along the county's residential core. Figure 14 shows that the majority of emissions allocated to the county are centered in the highly populated zones and very low emission densities are seen along the major interstates and freeways.

Using the revised emission allocation methodology and surrogates, Figure 15 shows that annual NOx emissions are more evenly distributed along the primary and secondary routes, where the majority of highway vehicle traffic is expected to occur.

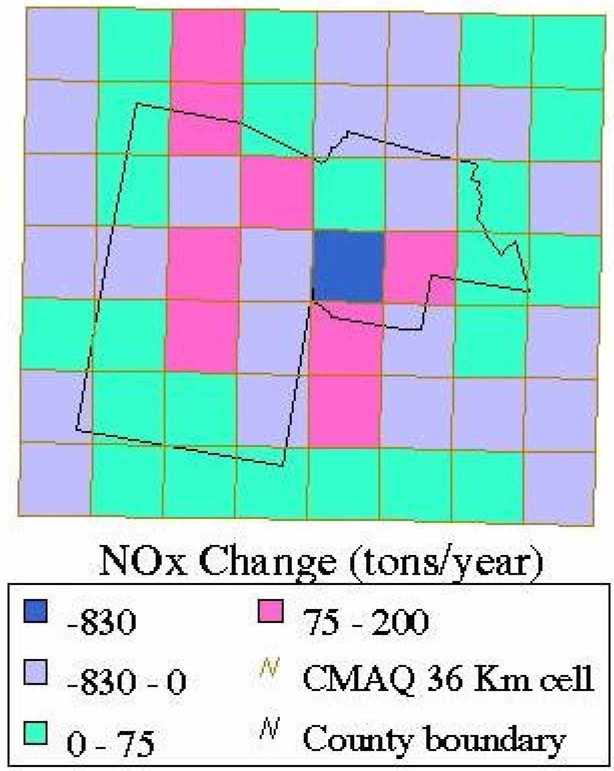
The difference in emission density is made apparent in Figure 16, where annual NOx emissions from highway vehicle sources are dispersed along the various primary, secondary, and local roads in a fashion more realistic to actual conditions.

Figures 14 & 15. Population-Based & Revised Annual NOx Distribution – Maricopa County, Arizona




Additionally, in Figure 16, annual reductions of 830 tons NOx are achieved in the central populated core of the county using the revised allocation method. Simultaneously, annual increases of up to 200 tons NOx can be seen along interstate and primary road routes again indicating better distribution of these emissions to road populated cells.

Figure 16. Annual NOx Distribution Difference – Maricopa County, Arizona




**CONCLUSIONS**

Initial sensitivity tests using the revised census and TIGER/Line-based surrogates show better allocation of VMT and emissions to appropriate grid cells. The new spatial allocation of roadway lengths to grid cells approximates actual road networks and, as seen in the initial results, the effect of improved spatial allocation definitely will enhance results as the modeling grid cell size decreases. This new method moves away from the commonly used population-based allocation of non-link highway source emissions and allows us to better utilize census and TIGER/Line data for this purpose.

**REFERENCES**

Houyoux, M., R. and J. M. Vukovich, 1999 "Updates to the Sparse Matrix Operator Kernel Emissions (SMOKE) Modeling System and Integration with Models-3", presented at The Air & Waste Management Association Conference, Emission Inventory: Regional Strategies for the Future, Raleigh, NC, 26-28 October 1999.

*Procedures for Developing Base Year and Future Year Mass and Modeling Inventories for The Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel (HDD) Rulemaking*, U.S. Environmental Protection Agency, Office of Air and Radiation, Research Triangle Park, NC, 2000; EPA420-R-00-020.

*TIGER/Line Census Files*, *1990 [machine-readable data files]* / prepared by the Bureau of the Census. U.S. Bureau of the Census, Washington, DC, 1991.

Jang, C.; Dolwick, P.; Possiel, N.; and Tikvart, J. "Annual Application of USEPA's Third-Generation Air Quality Modeling System over the Continental United States", Proceedings of the 94th Annual Meeting of the Air and Waste Management Association, Orlando, FL, June 24-28, 2001.

**KEYWORD**

Highway Vehicles
Emission Modeling
Spatial Allocation
TIGER/Line