Development of Gridded Air Toxic Emission Inventories for California's South Coast Air Basin

Mike Nazemi, Xinqiu Zhang, Thomas Chico, Joseph Cassmassi, Henry Hogo and Elaine Chang
South Coast Air Quality Management District
21865 E. Copley Drive, Diamond Bar, CA 91765
mnazemi@aqmd.gov

ABSTRACT

The South Coast Air Quality Management District conducted a Multiple Air Toxics Exposure Study (MATES-II) in the South Coast Air Basin. The study included one-year monitoring of various air toxic pollutants, developing spatially and temporally resolved air toxic emission inventories and modeling air toxic concentrations and risk assessment. This presentation describes the development of air toxic emission inventories in support of MATES-II.

The toxic emission inventories consist of three components: (1) on-road mobile sources; (2) area and off-road sources; and (3) major point sources and sources in the State of California's air toxic "hot" spot program (AB2588). Emissions of individual toxic compounds, more than 100, were typically calculated by applying speciation profiles to organic gas and particulate matter emissions. The inventoried emissions are spatially disaggregated to a 2x2 km resolution. The spatial resolution of on-road mobile source emissions incorporated link-based vehicle activity from transportation modeling and vehicle emission factors. Area source emissions were distributed using spatial surrogates, while emissions from major point sources, gasoline stations, dry cleaners and chromium plating facilities were assigned to the specific locations of the emitting facilities. The resulting emission inventories were used for grid-based regional modeling.

Diesel emissions account for roughly 80% of the overall air toxic cancer risk using toxicity weighted emissions and the compounds' unit risk factors. The other significant compounds are 1,3butadiene, benzene and hexavalent chromium. This risk profile is consistent with observed ambient concentrations. On-road and off-road mobile sources contribute to the majority of the risk.

INTRODUCTION

The Multiple Air Toxics Exposure Study (MATES-II)[1] is a landmark urban air toxics monitoring and evaluation study conducted for the South Coast Air Basin of California (the metropolitan area of Los Angeles). The study was initiated as a part of the Environmental Justice Initiatives adopted by the South Coast Air Quality Management District Governing Board in October 1997. The study represents one of the most comprehensive air toxics programs ever conducted in an urban environment, and is certainly much more comprehensive than a similar study (MATES-I)[2] conducted by the AQMD over a decade ago.

MATES-II project consisted of three base elements. The project included monitoring of various air toxic pollutants throughout the metropolitan Los Angeles area for a one-year period from April 1998 to March 1999. The second element involved developing spatially and temporally resolved air toxic emission inventories. Finally, regional and microscale modeling of air toxic concentrations was conducted to fully characterize risk.

To support the air toxic modeling effort, emissions inventories of various air toxic compounds in the metropolitan Los Angeles area were developed for 1998. The resulting emissions inventories have resolution of one hour temporally and 2x2 km spatially.

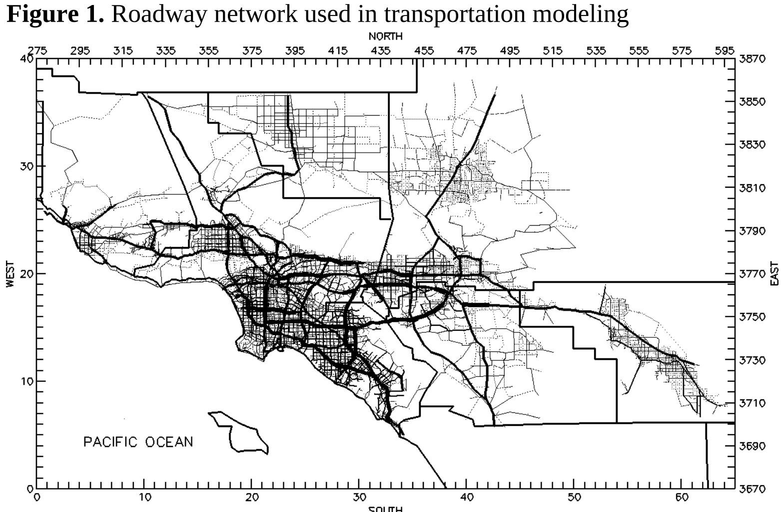
EMISSIONS INVENTORY DEVELOPMENT

The toxic emissions inventory for MATES-II consists of three components; (1) on-road mobile sources; (2) area and off-road mobile sources; and (3) major point sources and AB2588 sources (facilities in the State of California's air toxic "hot" spot program). The following is the description of how each portion of the inventory was developed.

On-Road Mobile Sources

On-road mobile sources include cars, trucks, buses and motorcycles. The on-road mobile source emissions are the product of emissions factors and vehicular activity. In California, the California Air Resources Board (ARB) develops motor vehicle emission factors and provides periodic updates. For this study, ARB's EMFAC7G emissions factors, the latest version available at the time, were used. The Southern California Association of Government (SCAG), the regional planning organization, provided link-based traffic volumes and speeds obtained from its regional transportation modeling. Figure 1 shows the roadway network used for this study.

Figure 1. Roadway network used in transportation modeling



Direct Travel Impact Model (DTIM)[3], originally developed by California Department of Transportation, was used to link emission factors and transportation modeling results and generate hourly gridded emissions of criteria pollutants (TOG, NOx, PM, CO and SOx). Toxic compound emissions were calculated by applying the latest ARB speciation profiles for mobile sources to the hydrocarbon and particulate matter emissions. ARB maintains a database of speciation profiles for both hydrocarbon and PM emissions[4,5], and provides periodic updates. The latest update at the time was in September 1998.

Stationary Point Sources

The AQMD maintains two major emissions data banks: (1) the Annual Emissions Reporting (AER) system, containing emissions information for criteria pollutants and some toxic compounds; and (2) the Toxic Hot Spots (AB2588) program containing source specific emissions information on numerous toxic compounds. The AER database provided criteria pollutant emissions from about 5000 facilities that emit more than 4 tons per year. There are about 1800 facilities in the AB2588 program. These facilities presumably have high air toxic risk associated with their emissions. For the MATES-II project, the emissions inventory of major toxic compounds was updated by utilizing the existing information, augmented by special studies.

The AB2588 database was updated by surveying top emitters for the latest emissions. About 150 facilities responded to the survey with their latest information on emissions. The emissions of the non-surveyed facilities were updated by adjusting emissions collected from early 1990s with consideration of growth and control implementation that occurred during the interim.

The toxic emissions of non-AB2588 facilities were derived utilizing the AER point source inventory. This data bank contains information on criteria pollutants such as particulate matter (PM) and volatile organic compounds (VOC). Appropriate PM and VOC speciation profiles[4,5] were applied to these emissions in order to obtain specific toxic compound emissions. The original AER system contained 1993 data. These data were projected to 1998 level by applying appropriate growth and control factors. The growth factors are county and industry specific and are based on the SCAG's growth projection. The control factors reflect the impact from 1993 to 1998 of existing rules. In addition, several larger sources were reviewed to determine if their emissions are correctly projected to 1998.

The spatial allocation of point source emissions is straightforward since facility locations are known. The temporal resolution of these emissions is according to the reported operating schedule of the facilities.

Area and Off-Road Sources

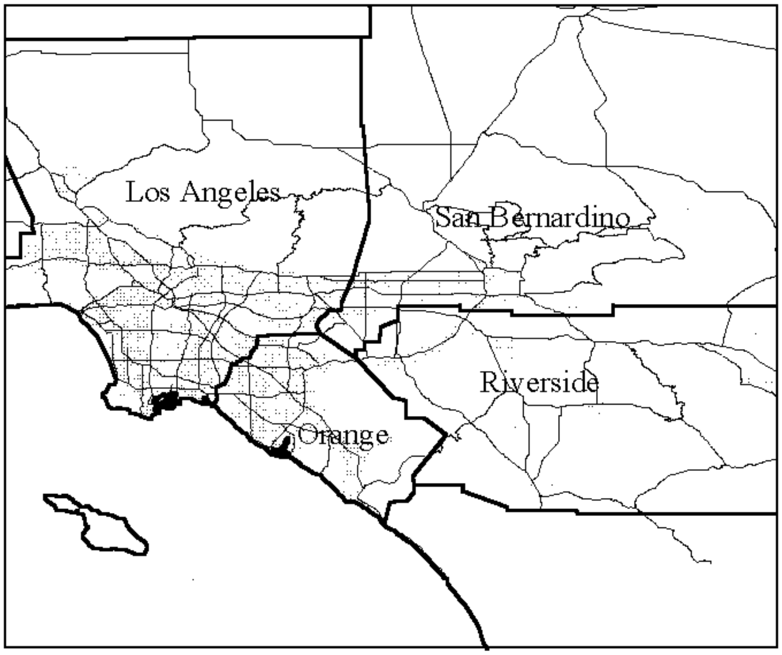
Area and off-road sources represent numerous small sources of emissions that can collectively have significant emissions and can contribute to high risks. Examples of area sources are dry cleaners, gasoline stations, auto body shops, and chrome platers. Examples of off-road sources are construction equipment, motor boats and airplanes. Area source emissions are distributed throughout the modeling domain using various spatial surrogates such as population, housing and employment. The 1993 base level emissions are adjusted to reflect 1998 conditions, through applying growth and control factors, similar to the treatment of point sources. Temporal resolution of emissions was obtained through diurnal profiles assigned to each type of emissions. Again, the ARB speciation profiles were used to determine individual toxic compound emissions from criteria pollutants.

Special care was given to treating three types of area sources, namely dry cleaners, gasoline stations and chrome platers, because these sources may have significant localized air toxic impacts. Their treatment is discussed below.

Perchloroethylene Dry Cleaning

Countywide emissions of perchloroethylene from dry cleaning were apportioned to individual dry cleaners according to the share of permitted annual emissions of each facility and located at their specific address. The countywide perchloroethylene dry cleaning emissions were derived from California import and domestic-production records. Total perchloroethylene emissions were approximately 6.6 tons per day and distributed over 1,300 facilities in SCAB. Figure 2 shows the spatial distribution of the dry cleaners.

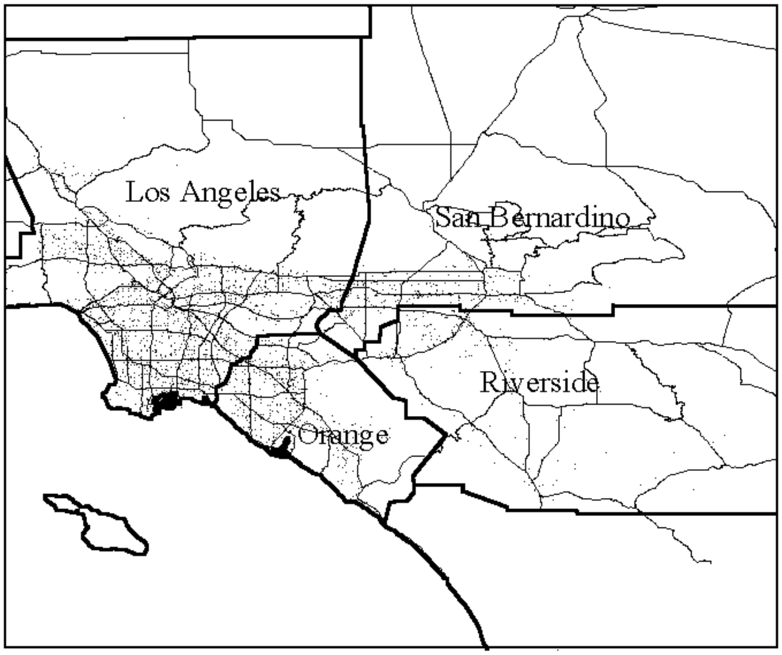
Figure 2. Spatial distribution of dry cleaners



Retail Gasoline Dispensing

The emissions from gas stations are treated similarly to dry cleaner emissions. The countywide emissions were apportioned to individual gas stations according to the share of permitted annual emissions of each facility and located at their specific address. The countywide retail gasoline dispensing emissions were derived from gasoline shipping and taxable sales records. Retail gasoline dispensing emissions of approximately 18 tons per day were distributed over 2,970 facilities in SCAB. Figure 3 shows the spatial distribution of gas station.

Figure 3. Spatial distribution of gas stations

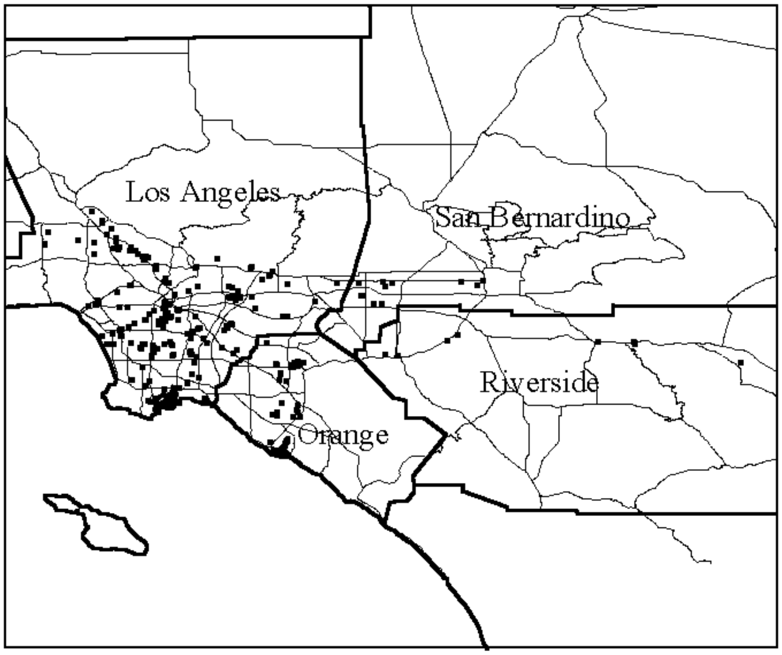


Hexavalent Chromium Plating

The AB2588 program contains information for the larger chromium plating facilities. There are approximately 74 plating facilities in the AB2588 program. In addition, there are approximately 84 aerospace facilities that may have plating operations in the AB2588 program. The facility counts are approximate because some of the plating facilities may not emit hexavalent chromium.

To augment the AB2588 facility list, a search was performed in the permit database to identify the smaller chromium plating facilities. Hexavalent chromium emissions from those identified small chromium plating facilities were added to the overall inventory and located to their specific address. Four types of sources were identified: hard chrome plating tanks, decorative chrome plating tanks, chrome anodizing tanks, and spray booths. Through the aforementioned process, 87 smaller chromium facilities were identified, assigned emissions, and added to the MATES II modeling inventory. Figure 4 shows the spatial distribution of chrome plating facilities.

Figure 4. Spatial distribution of chrome plating facilities



CONCLUSIONS

Table 1 presents the emissions from selected compounds by source category. A detailed emissions inventory is available in the MATES-II report[1]. A useful way to put the emissions into perspective is to weigh the emissions by the compounds' unit risk factors (URF). Figure 5 shows the species apportionment of risk using URF-weighted emissions, where California cancer potencies are used as URF values, for example, URF for diesel is $3x10^{-4}$ $(\mu g/m^3)^{-1}$. As is shown in the figure, diesel emissions account for 80 percent of the overall cancer risk. The other significant compounds are 1,3 butadiene, benzene, and hexavalent chromium. This risk profile is consistent with ambient measurements conducted during MATES-II[1]. Similarly, Figure 6 shows the URF-weighted emissions by major source category. The on-road and off-road mobile sources contribute to the majority of the risks.

Figures 7 through 11 show the spatial distribution of emissions for diesel particles, benzene, 1,3 butadiene, perchloroethylene, and hexavalent chromium, respectively. These spatial distributions help in understanding where the emissions occur and in understanding ambient data. These spatial distributions are also important diagnostic tools for modeling.

Table 1. Annual average day emissions for the south coast air basin

Pollutant	Emissions (lbs/day)					
	On-Road	**Off-Road**	**Point**	**AB2588**	**Area**	**Total**
Acetaldehyde*	5485.8	5770.3	33.9	57.1	189.1	11536.2
Acetone**	4945.8	4824.7	3543.5	531.4	23447.4	37292.8
Benzene	21945.5	6533.4	217.7	266.8	2495.4	31458.8
Butadiene [1,3]	4033.8	1566.1	6.7	2.0	151.3	5759.9
Carbon tetrachloride	0.0	0.0	8.8	1.8	0.0	10.6
Chloroform	0.0	0.0	0.0	35.5	0.0	35.5
Dichloroethane [1,1]	0.0	0.0	0.0	0.1	0.0	0.1
Dioxane [1,4]	0.0	0.0	0.0	105.0	0.0	105.0
Ethylene dibromide	0.0	0.0	0.0	0.2	0.0	0.2
Ethylene dichloride	0.0	0.0	4.9	17.6	0.0	22.5
Ethylene oxide	0.0	0.0	58.1	12.3	454.1	524.4
Formaldehyde*	16664.9	16499.3	521.6	674.7	1107.5	35468.0
Methyl ethyl ketone*	905.1	906.9	3240.2	385.9	14535.4	19973.5
Methylene chloride	0.0	0.0	1378.6	1673.6	9421.7	12473.9
MTBE	58428.9	2679.2	40.5	434.4	5473.7	67056.7
p-Dichlorobenzene	0.0	0.0	0.0	4.5	3735.6	3740.1
Perchloroethylene	0.0	0.0	4622.0	2249.1	22813.1	29684.2
Propylene oxide	0.0	0.0	0.0	22.3	0.0	22.3
Styrene	1114.8	287.1	447.0	3836.7	21.4	5707.0
Toluene	63187.6	11085.9	5689.6	3682.4	52246.7	135892.2
Trichloroethylene	0.0	0.0	1.1	58.0	2550.3	2609.3
Vinyl chloride	0.0	0.0	0.0	4.3	0.0	4.3
Arsenic	0.1	0.3	2.7	0.7	21.4	25.2
Cadmium	1.6	1.5	0.5	0.7	27.5	31.8
Chromium	2.4	2.3	3.9	2.2	302.2	313.0
Diesel particulate	23906.3	22386.3	0.0	5.4	815.3	47113.4
Elemental carbon***	27572.1	6690.3	702.8	0.0	16770.5	51735.7
Hexavalent chromium	0.4	0.4	0.3	1.0	0.1	2.2
Lead	0.7	0.9	1.9	24.5	1016.3	1044.3
Nickel	2.5	2.2	2.9	21.6	85.6	114.9
Organic carbon	16426.2	15381.8	0.0	0.0	108612.1	140420.2
Selenium	0.1	0.1	3.0	5.7	2.6	11.6
Silicon**	68.6	67.6	167.2	0.0	248614.0	248917.4

* Primarily emitted emissions. These materials are also formed in the atmosphere as a result of photochemical reactions.

** Acetone and silicon are not toxic compounds. Their emissions are included here because they were measured in the sampling program and were subsequently modeled for the purpose of model evaluation.

*** Includes elemental carbon from all sources (including diesel particulate).

Figure 5. Species apportionment using toxicity-weighted emissions

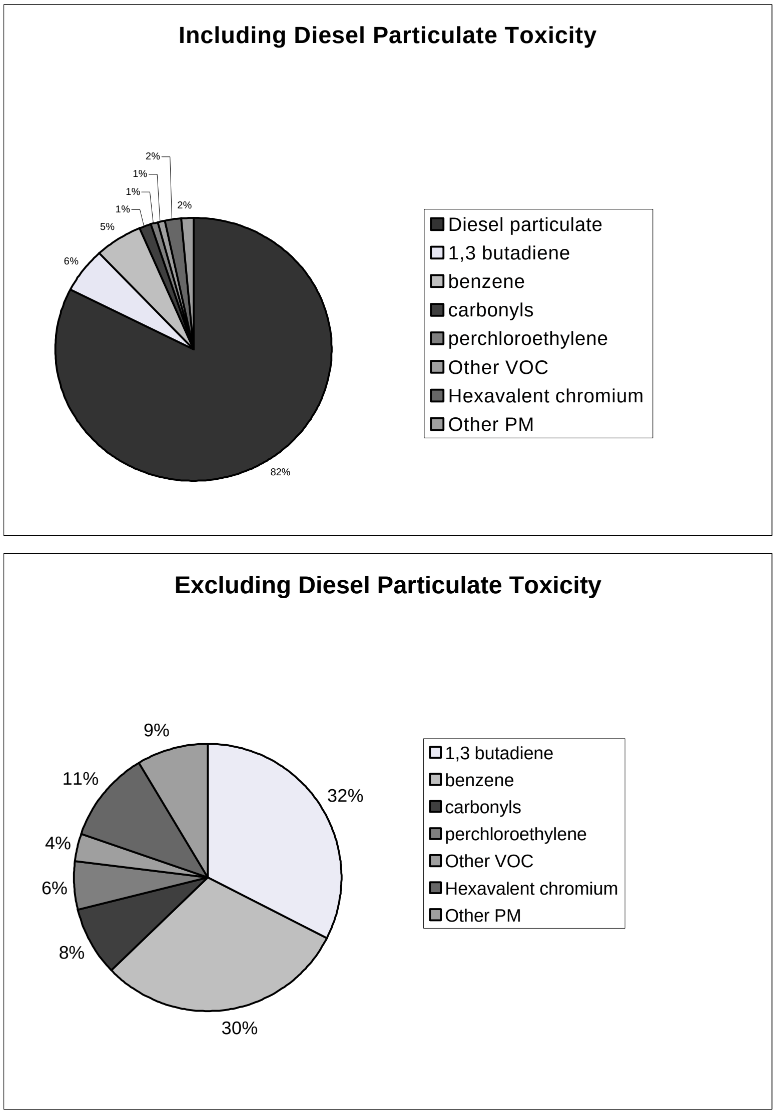
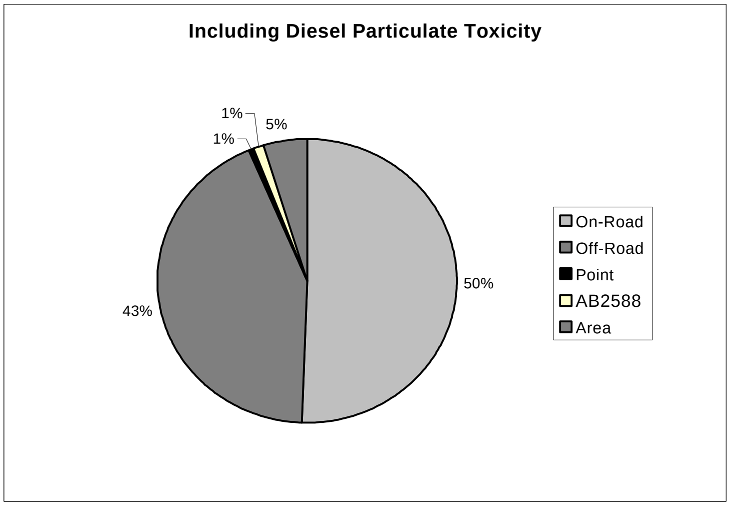


Figure 6. Source apportionment using toxicity-weighted emissions



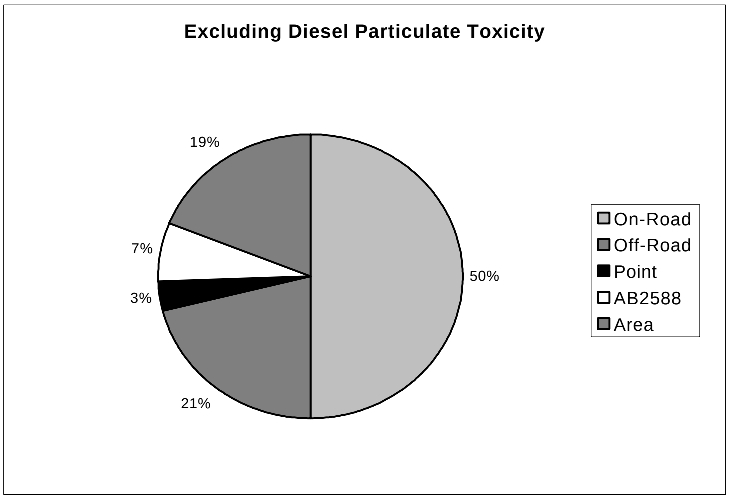


Figure 7. Spatial distributions of diesel particle emissions from all sources (kg/day)

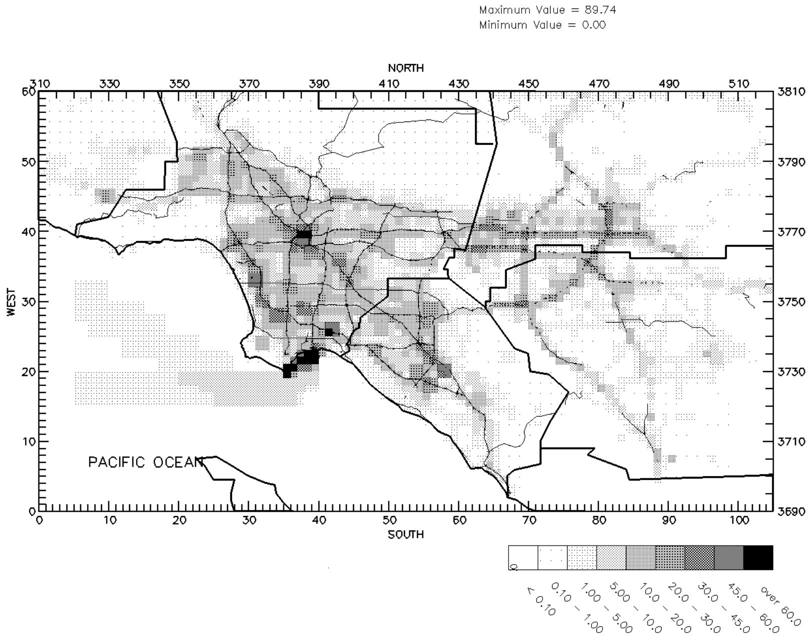


Figure 8. Spatial distributions of benzene emissions from all sources (kg/day)

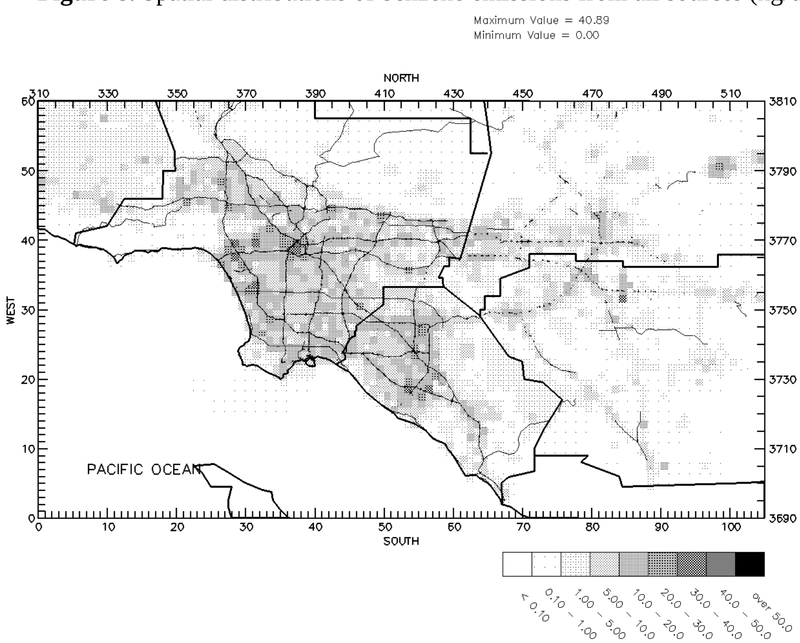


Figure 9. Spatial distributions of 1,3butadiene emissions from all sources (kg/day)

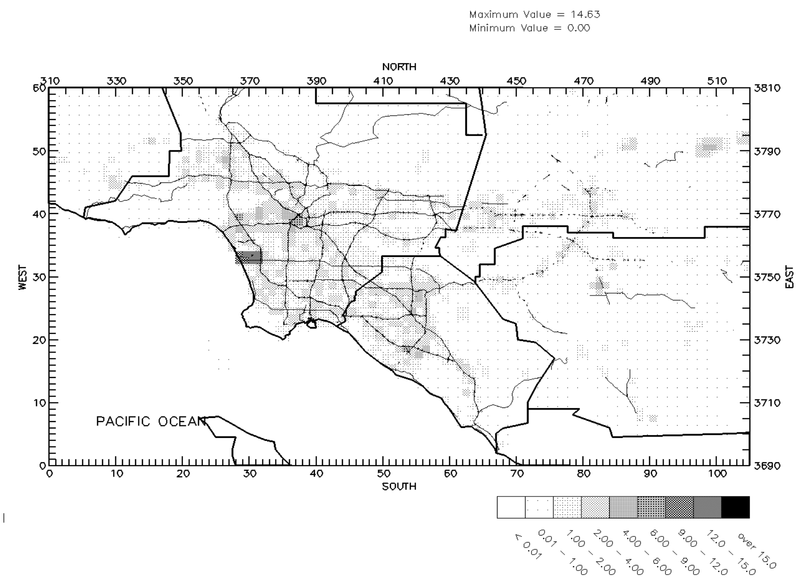


Figure 10. Spatial distributions of perchloroethylene emissions from all sources (kg/day)

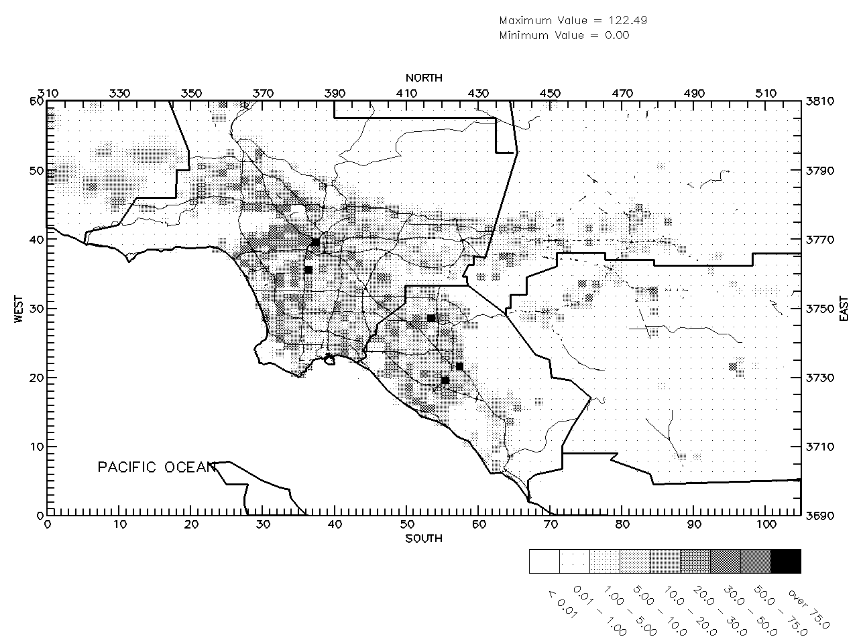
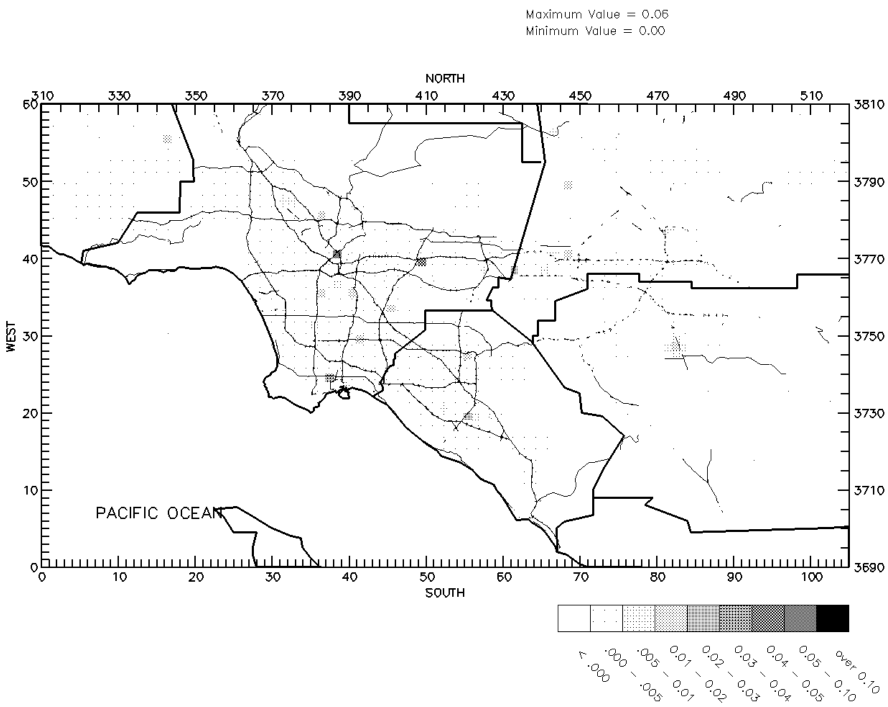


Figure 11. Spatial distributions of hexavalent chromium emissions from all sources (kg/day)



RFERENCES

1. SCAQMD, *The Multiple Air Toxics Exposure Study in the South Coast Air Basin, MATES-II*. South Coast Air Quality Management District, Diamond Bar, CA, March 2000.
2. SCAQMD, *The Magnitude of Ambient Air Toxic Impacts from Existing Sources in the South Coast Air Basin.* Planning Division, South Coast Air Quality Management District, Diamond Bar, CA, June 1987.
3. CalTans, *Direct Travel Impact Model 2 (DTIM2) User's Guide*, California Department of Transportation, June 1994.
4. ARB, *Identification of Volatile Organic Compound Species Profiles*, State of California Air Resources Board, Sacramento, CA, August 1991.
5. ARB, *Identification of Particulate Matter Species Profiles*, State of California Air Resource Board, Sacramento, CA, August 1991.

KEY WORDS
MATES
Toxics
Emissions
Gridded
Speciation

BIBLIOGRAPHY

Mike Nazemi is a Planning and Rules Manager at the SCAQMD. His current responsibilities include the development of emission inventories, development of mobile source regulations and policies, and the implementation of the Toxic Hot Spot Program. He is a registered professional engineer and holds an M.S. degree in Electrical Engineering.

Xinqiu Zhang is an Air Quality Specialist at the SCAQMD. His current responsibilities include the development of emissions inventories and regional air quality models. He holds a Ph.D. in Mechanical Engineering.

Thomas Chico is a Program Supervisor at the SCAQMD. His current responsibilities include the implementation of the Toxic Hot Spot Program and conducting point-source modeling. He holds an M.S. degree in Atmospheric Sciences.

Joseph Cassmassi is the Senior Meteorologist for the SCAQMD. His current responsibilities include the supervision of the regional modeling program, the air quality evaluation program, and the air quality forecasting. He holds an M.S. in Meteorology.

Henry Hogo is a Planning and Rules Manager at the SCAQMD. His current responsibilities include the development and implementation of fleet rules, as well as over-all responsibility for all air quality modeling efforts in the District. He holds a B.S. degree in Chemistry.

Elaine Chang is the Assistant Deputy Executive Officer, Planning, Rule Development and Area Sources Division, SCAQMD. Her current responsibilities include the development of AQMP's, overseeing the rulemaking process, evaluating emission trading issues, and implementing the Toxic Hot Spot Program. She holds a Ph.D. in Public Health.