On-road Mobile Source Emission Inventory Development for the Central Regional Air Planning Association (CENRAP)

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Objectives

Develop emission inventories of criteria pollutants for on-road mobile sources that are suitable for photochemical modeling and consistent with EPA guidance.

- Develop county-level emission inventories on the basis of bottom-up activity data.
- Prepare county-level emissions modeling inputs suitable for running MOBILE6 within SMOKE.
- Generate annualized emission inventories of criteria pollutants for 2002 (NIF3.0 format).
CENRAP Region

Source: http://www.epa.gov/air/visibility/regional.html
MOBILE6 Inputs

Various inputs affect emission inventories of on-road mobile sources moderately to significantly.

- VMT (activity data)
- Distributions of VMT (by facility type, vehicle type, and time of day)
- Speed
- Fuel characteristics
- Regulatory controls
- Fleet characteristics (registration distributions and fuel fractions)

- Temperature
- Altitude
- Air conditioning
- Hot and cold soaks
- Mileage accumulation rates
- Humidity
Methods—VMT and Speeds  (1 of 3)

Highest priority was assigned to areas with large VMT or population near Class I areas.

Local data were acquired for non-attainment areas.

- Houston/Galveston, TX
- Beaumont/Port Arthur, TX
- El Paso, TX
- Dallas-Ft. Worth, TX
- Baton Rouge, LA
Local data were acquired for urban attainment areas.

- New Orleans, LA
- St. Louis, MO
- Kansas City, MO-KS
- Lincoln, NE

A combination of local data and MOBILE 6 defaults were developed for all other areas, which were mostly small urban and rural.
Data Acquisition Areas

- Nonattainment areas
- Urban attainment areas near Class I areas
- Other areas
Methods—VMT and Speeds (3 of 3)

Acquired Data

SMOKE Inputs

Emission Factors

County-level Emissions

The green boxes represent the mobile source activity data acquired from local agencies. These data are processed into files and formats that can be input to SMOKE.

The red boxes represent SMOKE input files. These are the files that are developed based on locally acquired mobile source activity data.

The blue box represents data generated within SMOKE based on the SMOKE input files. These Intermediate files are used to estimate mobile source emissions.

The orange box represents the output from SMOKE – county total on-road mobile source emissions estimates.
Data Summary Sheet: Arkansas
Data Source: ¹ Arkansas Dept. of Transportation & Highways
² Default Data
Methods—Fleets (1 of 2)

Inputs were developed at the county level.

- Registration distributions
  - Fractions of vehicles in each of 25 age groups
  - Separate distributions for each of 16 vehicle classes

- Fuel fractions
  - Fractions of diesel and/or natural gas vehicles in each age group and vehicle class
Inputs were based on records of vehicle identification numbers (VINs).
VINs were acquired from state departments of motor vehicles (DMVs) and decoded.
Two states were exceptions.

• Texas provided its own county-level fleet distributions.
• Arkansas is developing its own distributions through a state-funded project.
Example Results—Louisiana

Vehicle Registrations
MOBILE6 Default

Age (year)
Fraction of Fleet Population
Example Results—Another CENRAP State

Vehicle Registrations

MOBILE6 Default

Fraction of Fleet Population

Age (year)
Fuels and Controls

Fuels characteristics were acquired.
  • Gasoline volatility
  • Gasoline oxygenate content
  • Sulfur content (gasoline and diesel)

Regulatory controls exist in a few non-attainment areas: St. Louis, Baton Rouge, and a few cities in Texas.
  • Anti-tampering programs
  • I&M programs
  • Stage II refueling controls
MOBILE6 explicitly models areas that use federal reformulated gasoline (RFG).

Data were acquired from Northrop Grumman (NG).

- Data are available for many areas of CENRAP.
- However, NG’s data do not cover every area and are not always representative of an entire state.
Fuel Volatility

• NG’s data are often used and are assumed to be representative of all gasolines.

• However, fuel volatility data are available for summer and winter only and for limited sampling locations.

• Additionally, interpolations are based on ASTM standards.
Results: Fuels (2 of 6)

Example results for fuel volatility: Twin Cities, MN

![Graph showing RVP (psi) data from Northrop-Grumman and ASTM Standards over time from 1/1 to 12/30.]
Results: Fuels (3 of 6)

Fuel volatility data were improved by acquiring information from state departments of agriculture.

- Spring and fall observations deviated significantly from the ASTM interpolation.
- Requirements for regular-grade fuels did not necessarily apply to all other grades of fuel.
Example results for fuel volatility: Minnesota

- Statewide with Ethanol
- Statewide w/o Ethanol
- Data from Northrop-Grumman
- ASTM Standards
Results: Fuels (5 of 6)

Sulfur content directly affects \( \text{SO}_2 \) and sulfate PM emissions, and indirectly affects CO, NO\(_x\), and VOC emissions due to its damaging effects on catalysts.

- For non-RFG, MOBILE6 defaults are 279 ppmw (average) and 1000 ppmw (max).
- Observations for regular-grade gasoline are comparable to defaults.
- Observations for mid- and premium-grade gasoline are significantly lower than defaults.
- About 75% of gasoline sold nationally is regular-grade, and 25% is medium- or premium-grade.
Results: Fuels (6 of 6)

Sulfur content: weighted averages for each district.

Brackets on the x-axis indicate cities in similar districts of the petroleum pipeline distribution chain.
Results: NO\textsubscript{x} Emissions, July 10, 2002
Emissions by Vehicle Type

NOx

VOC
Monthly Pattern

Percentage of Total Annual VMT

- Light-Duty Vehicles
- Heavy-Duty Vehicles

8.3%
Weekly Patterns

Percentage of Total Weekly VMT

- Light-Duty Vehicles: Urban Areas
- Light-Duty Vehicles: Rural Areas
- Heavy-Duty Vehicles: All Areas

14.3%
Diurnal Patterns—Light-Duty Vehicles

Percentage of Total Daily VMT

Weekdays, Urban/Suburban Areas
Weekdays, Rural Areas
Weekends, All Areas

0% 2% 4% 6% 8%

0 4 8 12 16 20 Hour

4.2%
Diurnal Patterns—Heavy-Duty Vehicles

Percentage of Total Daily VMT

- Weekdays, All Areas
- Weekends, All Areas

- 4.2%
Comparison with the Draft 2002 NEI (1 of 3)

- **PM2.5**
  - CENRAP: 20 thousand tons per year
  - NEI: 30 thousand tons per year

- **SOx**
  - CENRAP: 60 thousand tons per year
  - NEI: 90 thousand tons per year

- **NOx**
  - CENRAP: 1,250 thousand tons per year
  - NEI: 1,500 thousand tons per year

- **VOC**
  - CENRAP: 500 thousand tons per year
  - NEI: 750 thousand tons per year
Comparison with the Draft 2002 NEI (2 of 3)

**NOₓ**

CENRAP

NEI

Emissions (1000 tons/year)

right-hand axis applies from here
Comparison with the Draft 2002 NEI (3 of 3)

NO\textsubscript{x}

VOC

PM\textsubscript{2.5}

SO\textsubscript{x}

CENRAP

NEI

right-hand axis applies from here

right-hand axis applies from here

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right-hand axis applies from here
Conclusions

**Take-home message:** Using data representative of local conditions (instead of national-average defaults) makes a difference.

Differences in state-level VOC, NO$_x$, and PM$_{2.5}$ emissions were as large as ±25%.
Opportunities for Further Improvements

Incorporate additional local data as they become available.

Investigate and improve vehicle registration databases.

Use fleet distributions to refine VMT distributions.

Improve inventories for alternative-fuel vehicles, which are likely to become more important in the future.
Glossary

ATP = Anti-Tampering program
CENRAP = Central States Regional Air Planning Association
DOT = Department of Transportation
HPMS = Highway Performance Monitoring System
IDA = Inventory Data Analyzer format
IM = Inspection and Maintenance program
NEI = National Emissions Inventory
NIF = NEI Input Format
SMOKE = Sparse Matrix Operator Kernel Emissions Modeling System
VMT = Vehicle miles traveled