Implementation of MOVES-based PM2.5 emissions approach for onroad gasoline sources, using hourly, gridded temperatures

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Overview

- Study approach
- Motor Vehicle Emissions Simulator (MOVES) updates
- Incorporation of MOVES-based emissions
- Impacts of MOVES on PM emissions for use in air quality modeling
- Impacts of MOVES on modeled air quality
Study Approach

- 2005 base year
- SMOKE – MM5 – CMAQ annual simulations
- National, 36-km modeling domain
- Three simulation cases:
  - NMIM: Uses only National Mobile Inventory Model (NMIM) based onroad, using MOBILE6.2
  - MOVES72: Uses MOVES-based onroad gasoline, without PM temperature adjustments
  - MOVES: Uses MOVES-based onroad gasoline with PM adjustments
- All other emissions were the same across the cases
36-km Gridded Modeling Domain
Major MOVES Updates from MOBILE

- **Light duty** – Emission factors developed from
  - Thousands of in-use vehicles from I/M programs
  - Kansas City gasoline PM study, including temperature impacts

- **Heavy duty diesel** – Emission factors developed from
  - 100+ in-use vehicles
  - ROVER (Real time On-road Vehicle Emission Reporter)

- Updated information on vehicle fleet and activity (national defaults)
  - Instrumented vehicles
  - VIUS2002 (Census survey of trucks)
  - DOE Annual Energy Outlook

- Most of the database for MOVES is national defaults or derived from them (our NMIM / MOBILE6-based modeling uses local supplied inputs via the NEI process)

- We are not yet using the Heavy Duty Diesel updates in our modeling

- MOVES draft release soon, final by end of 2009
MOVES-based Approach

Summary

- MOVES creates emissions by state/SCC for onroad gasoline CO, NOX, VOC, PM$_{2.5}$, elemental carbon, primary sulfate, naphthalene, benzene, acetaldehyde, formaldehyde, acrolein, and butadiene
- All MOVES emissions allocated from state to county using NEI 2005 v2 (existing NMIM-MOBILE6-based approach)
- PM$_{2.5}$ and species computed at 72º
- Running and start emissions kept separate so temperature adjustments could be applied separately for each
- Not using MOVES for California
- Compute all PM species at 72º from MOVES species and assumptions (in paper)
- Process PM species at 72º through SMOKE
- Apply temperature corrections to hourly, gridded data using hourly, gridded temperatures. Applied to elemental carbon (PEC), organic carbon (POC), and non-carbon organic mass (in PMFINE species)
Approach for using MOVES

NMIM

MOVES

California annual NEI emissions

County-SCC emissions

Onroad gas state-SCC emissions

Disaggregate California annual to monthly and include road types

Disaggregate MOVES to County

Pre-speciate PM2.5

on_noadj - all pollutants

Running PM2.5 & Naphthalene

Start PM2.5 & Naphthalene

SMOKE

SMOKE

SMOKE

Temp Adjustment

Temp Adjustment

Merge

Emissions from other sectors

CO, NOX, VOC, PM2.5, PEC, PSO4, naphthalene, benzene, acetaldehyde, formaldehyde, acrolein, butadiene
Onroad gasoline MOVES PM$_{2.5}$ Temperature Adjustments

- Factors are much higher for “start” mode (but “start” 72° emissions are much less than “running”)
- Factors converge at higher temperatures
- Factors get applied only to elemental carbon, organic carbon, and other non-carbon mass associated with OC (affecting CMAQ “PMFINE” species)
2005 48-state MOVES PM$_{2.5}$
Temperature Adjustments Impact (onroad gas)

- Impacts on gasoline onroad emissions are dramatic.
- Impact on “Other PM$_{2.5}$” comes from organic carbon particles (oxygen, hydrogen and other compounds) that are part of the organic carbon from MOVES.
- Start emissions increase from 24% to 34% of onroad gasoline.

Percentages show increase from temperature adjustment.
National/annual Comparison of national inventories
NMIM vs. MOVES for onroad gasoline

* Transportable fraction applied to fugitive dust sources

- NOX [M tons/yr]: 4.0%
- VOC [M tons/yr]: -4.7%
- PM2.5 [M tons/yr]: 1.0%
- POC [M tons/yr]: 2.3%
- PEC [M tons/yr]: 1.8%
Impact of MOVES emissions on onroad gasoline vs. NMIM

PM2.5 national onroad gasoline

- NMIM
- MOVES @72°F
- MOVES w/Temp

 tons/month

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Organic Carbon Comparison
Sum over all Sectors, January tons/month

Take away: plots look very similar. Next slide shows differences

All Sector POC sum including NMIM

All Sector POC sum including MOVES w/ Temperature Adjustments
Organic Carbon Impact
Sum over all Sectors, January tons/month

All Sector Absolute Difference
POC MOVES onroad gas minus NMIM

Take away:
- largest impact in large cities, particularly the cold ones.
January 2005 PM$_{2.5}$ onroad gasoline
MOVES vs. NMIM by state

PM$_{2.5}$ [tons/month]
January 2005 PM$_{2.5}$ onroad gasoline
w/ MOVES onroad gas vs. NMIM by NA area
top 30 largest January MOVES emissions for PM nonattainment areas

Note: does not include additional emissions from MOVES HDD
Impact across all sectors
January 2005 PM$_{2.5}$ onroad gasoline
w/ MOVES onroad gas vs. NMIM by NA area
top 6 largest January MOVES PM$_{2.5}$ emissions for PM nonattainment areas

Note: does not include additional emissions from MOVES HDD
Impact across all sectors
January 2005 POC onroad gasoline
w/ MOVES onroad gas vs. NMIM by NA area
top 6 largest January MOVES PM$_{2.5}$ emissions for PM nonattainment areas

Note: does not include additional emissions from MOVES HDD
CMAQ Results

Absolute change in 2005 base case annual average PM$_{2.5}$ concentrations (MOVES – NMIM)
CMAQ Results

Percent change in 2005 base case annual average PM$_{2.5}$ concentrations (MOVES – NMIM)/NMIM
CMAQ Results

Absolute change in 2005 base case **JANUARY**
average PM$_{2.5}$ concentrations (MOVES – NMIM)

Impacts as much as 1μg/m$^3$ in these areas
CMAQ Results
Percent change in 2005 base case \textit{JANUARY} average PM$_{2.5}$ concentrations (MOVES – NMIM)/NMIM
MOVES Impact on Modeled Air Quality

Percent change in monthly average organic carbon concentrations from using temperature-adjusted PM2.5 rather than unadjusted at five PM2.5 nonattainment areas.
Emissions Conclusions

- Nationally/annually, MOVES impact on all-sector PM$_{2.5}$ is $\sim$1.0%, (including only onroad gasoline impacts)

- MOVES PM$_{2.5}$ impacts are much greater in cities in northern (colder) climates (e.g., 15% increase in total PM$_{2.5}$ in NY PM NA area)

- Larger impact on organic carbon (e.g., 31% increase in total POC in NY PM NA area)

- Summertime PM$_{2.5}$ changes relatively little

- NOx impact 4% increase nationally/annually across all sectors (including only onroad gasoline impacts)

- VOC decrease $\sim$4.7% nationally/annually, may be significant in some cities

- Key caveats:
  - Use of MOVES national defaults
  - State-based MOVES processing
  - Onroad gasoline only (not HDD impacts)
Modeled Air Quality Conclusions

- MOVES-based emissions increase modeled base case air quality PM$_{2.5}$ concentrations increased by up to 1.0 $\mu$g/m$^3$ in highly-populated urban areas of the U.S. in the wintertime, as compared to MOBILE6-based emissions only

- The majority of the air quality changes were due to the temperature adjustments as opposed to the other MOVES-based emissions updates
Future Work

- Ozone impacts of the NOx and VOC emissions changes
- Revised CMAQ model performance evaluations using the MOVES-based inventories
- Incorporate diesel MOVES impacts
- Adapt temperature adjustment approaches for use of local-specific MOVES inputs
- Possible extension of approaches to VOC