Implementation of MOVES-based PM2.5 emissions approach

for onroad gasoline sources, using hourly, gridded temperatures

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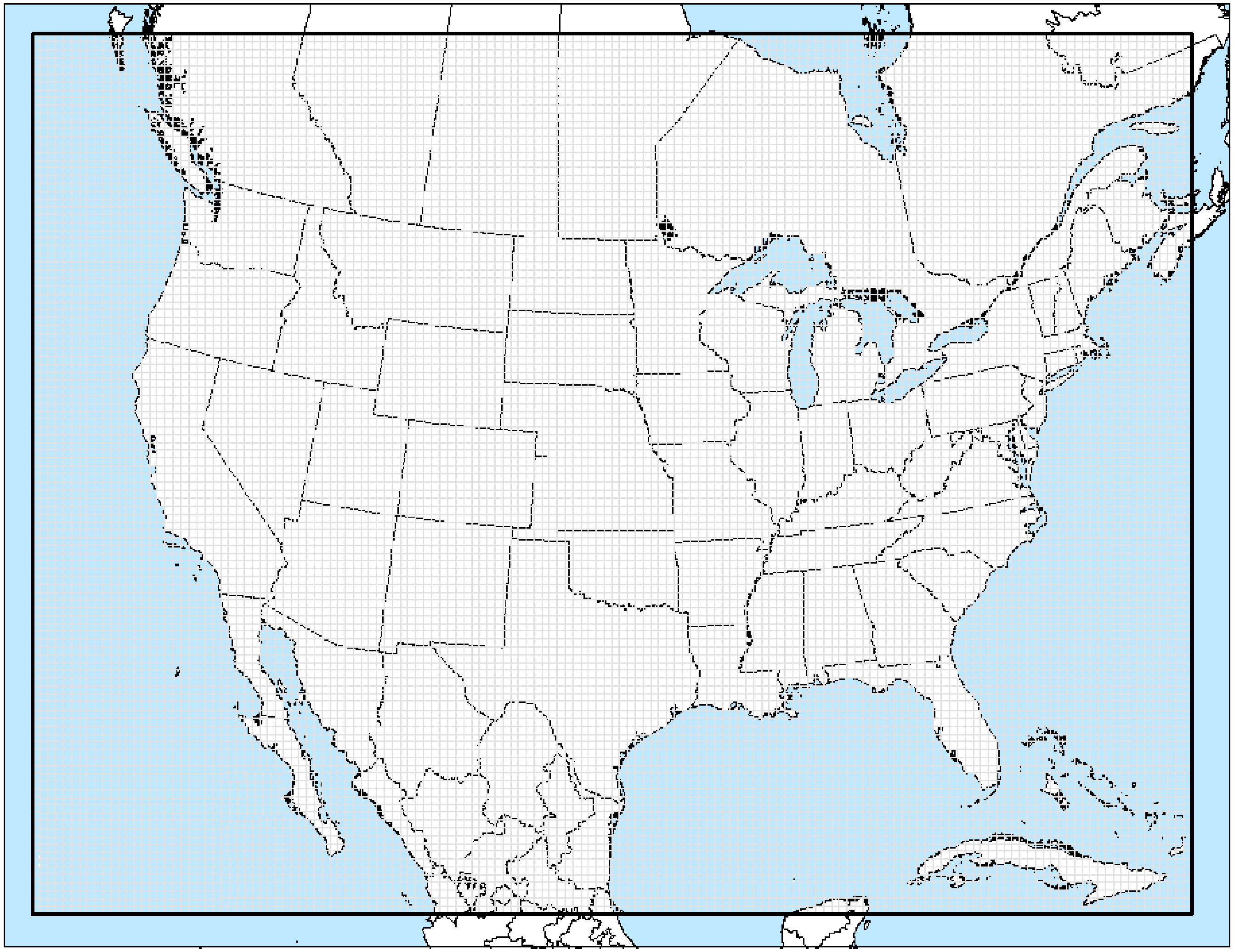
Overview

- 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:
  - <u>NMIM</u> : Uses only National Mobile Inventory Model (NMIM) based onroad, using MOBILE6.2
  - <u>MOVES72</u> : Uses MOVES-based onroad gasoline, without PM temperature adjustments
  - <u>MOVES</u> : Uses MOVES-based onroad gasoline with PM adjustments
- All other emissions were the same across the cases

36-km Gridded Modeling Domain



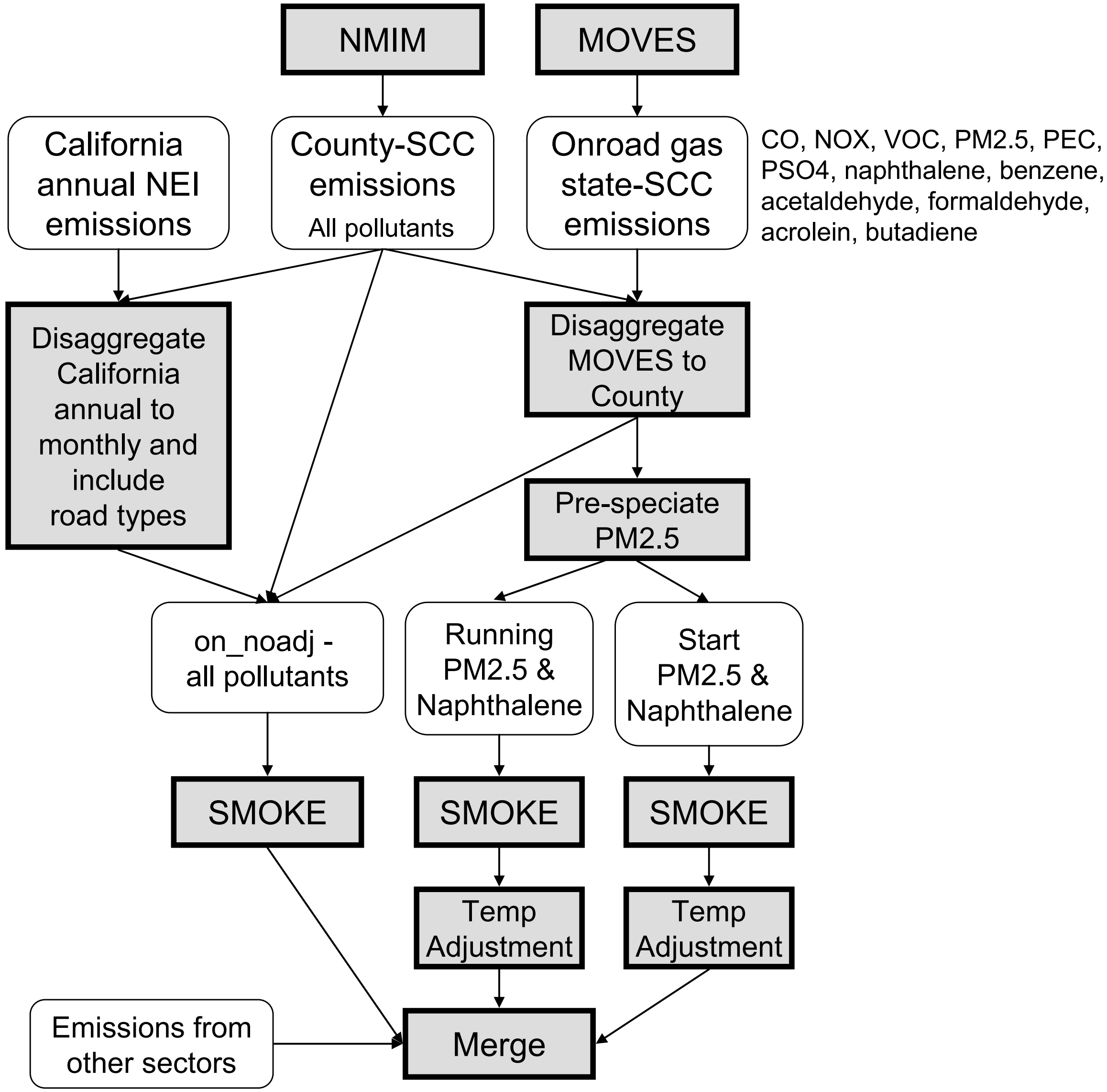
Major MOVES Updates from MOBILE

- 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
- <u>Most of the database for MOVES is national defaults or derived from them</u> (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

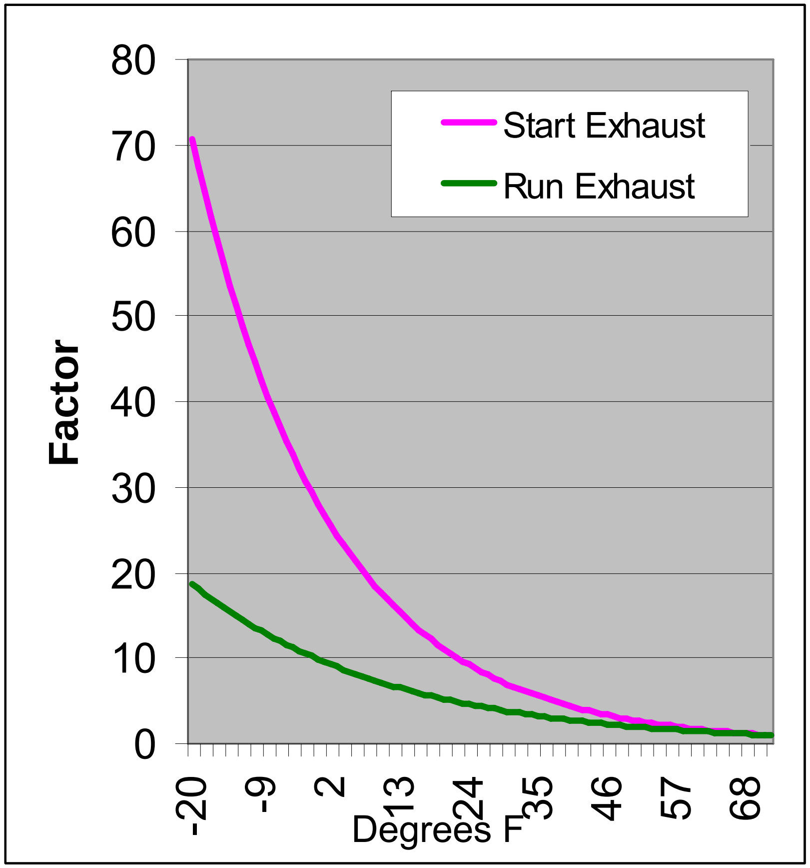
- MOVES creates emissions by state/SCC for onroad gasoline CO, NOX, VOC, $PM_{2.5}$, elemental carbon, primary sulfate, naphthalene, benzene, acetaldehyde, formaldehyde, acrolein, and butadiene
- All MOVES emissions allocated from state to county using NEI 2005 v2 (existing NMIM-MOBILE6-based approach)
- $PM_{2.5}$ 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



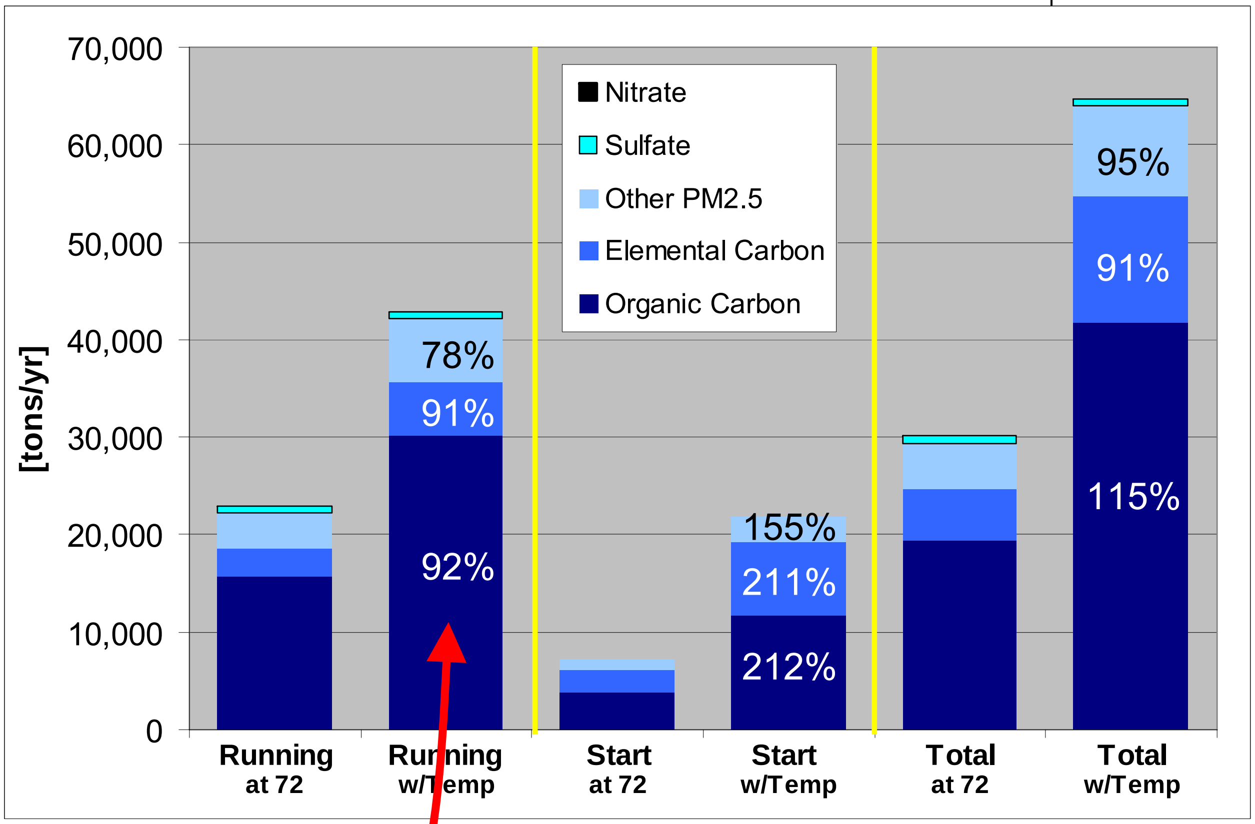
Onroad gasoline MOVES $PM_{2.5}$ Temperature Adjustments

- Factors are much higher for “start” mode (but “start” 72º 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)

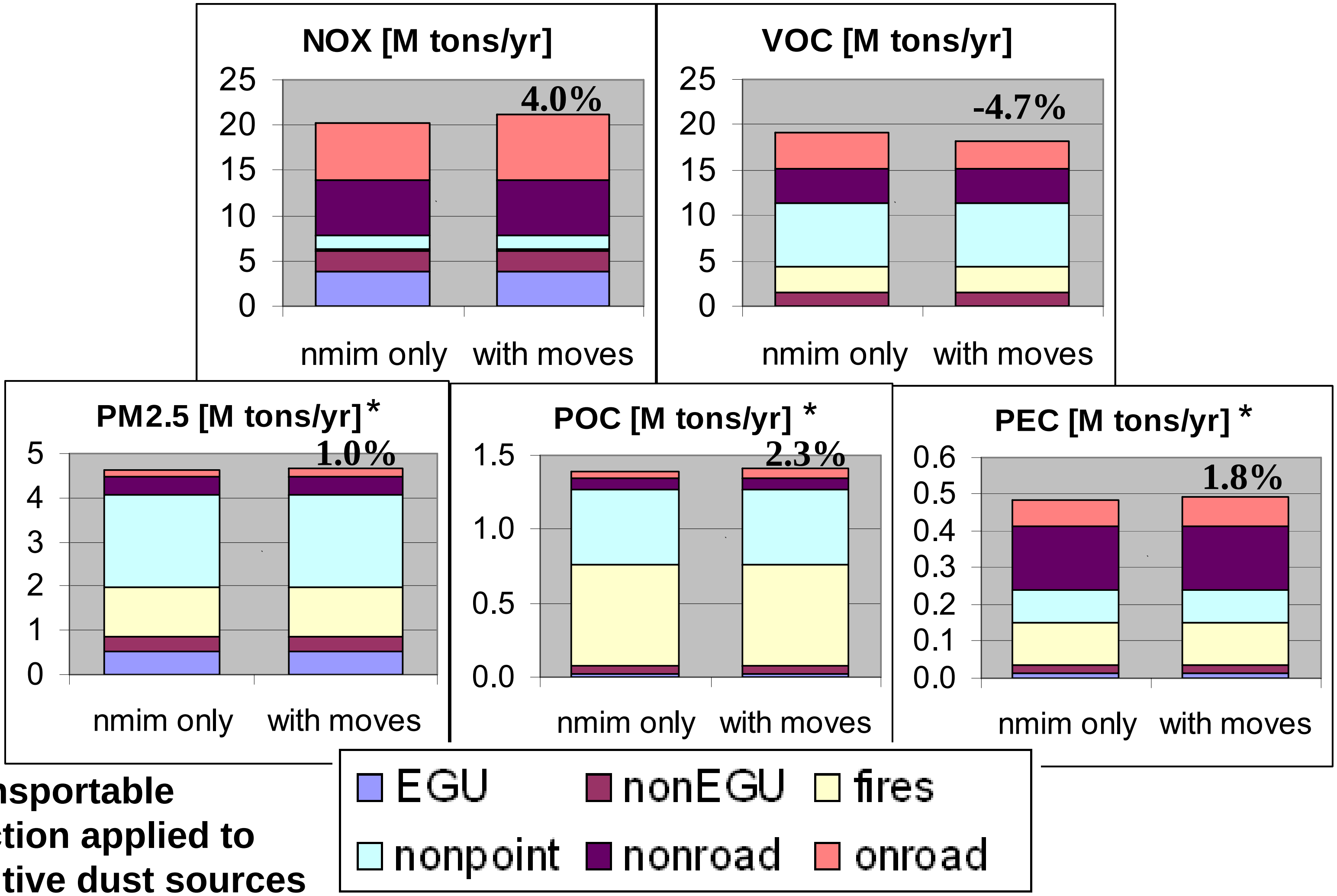
- Impacts on gasoline onroad emissions are dramatic
- Impact on "Other $PM_{2.5}$" comes from organic carbon particles (oxygen, hydrogen and other compounds) that are part of the organic carbon from MOVES
- Start emissions increase from 24% to 34% of onroad gasoline



Percentages show increase from temperature adjustment

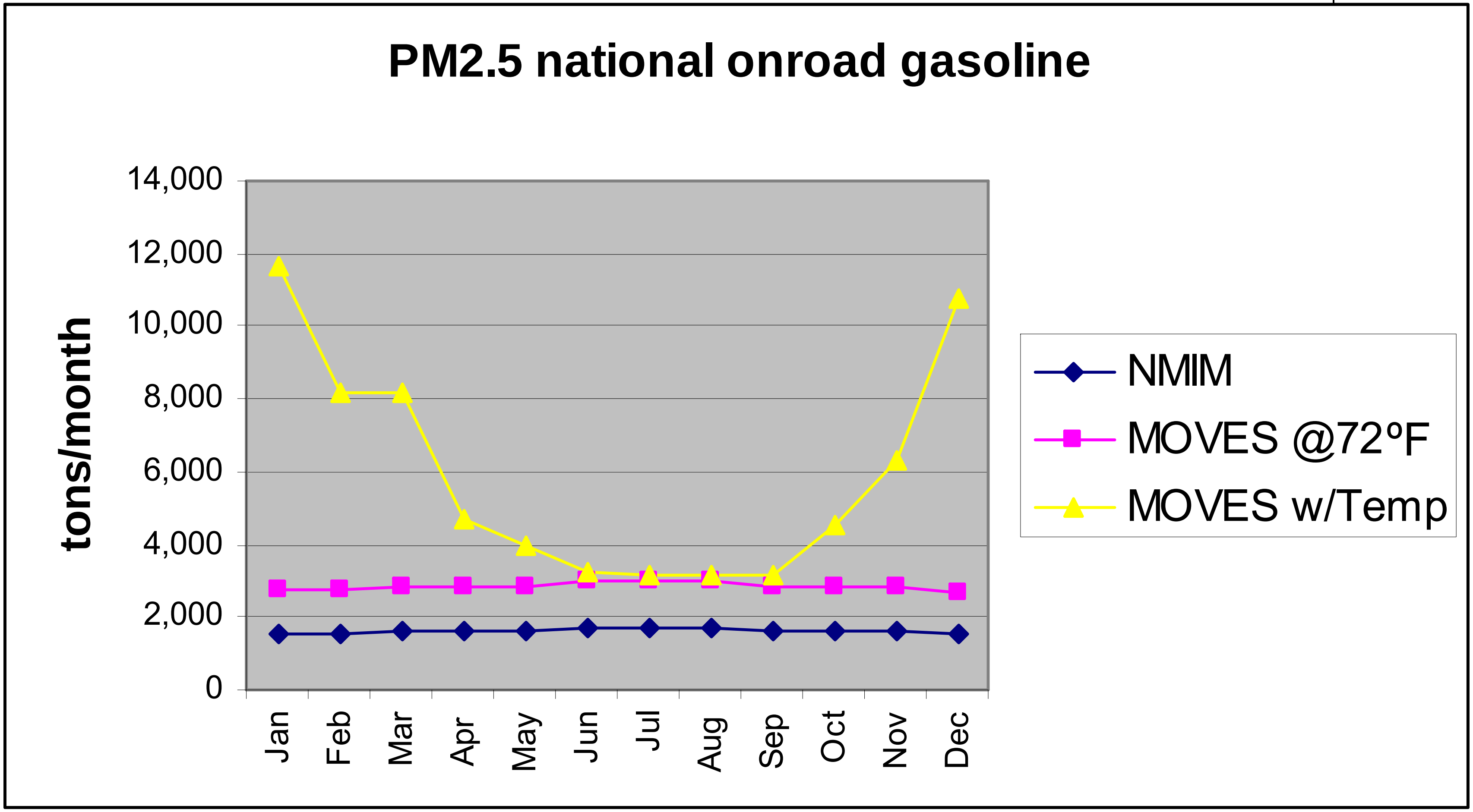
National/annual Comparison of national inventories

NMIM vs. MOVES for onroad gasoline



* Transportable fraction applied to fugitive dust sources

Impact of MOVES emissions on onroad gasoline vs. NMIM

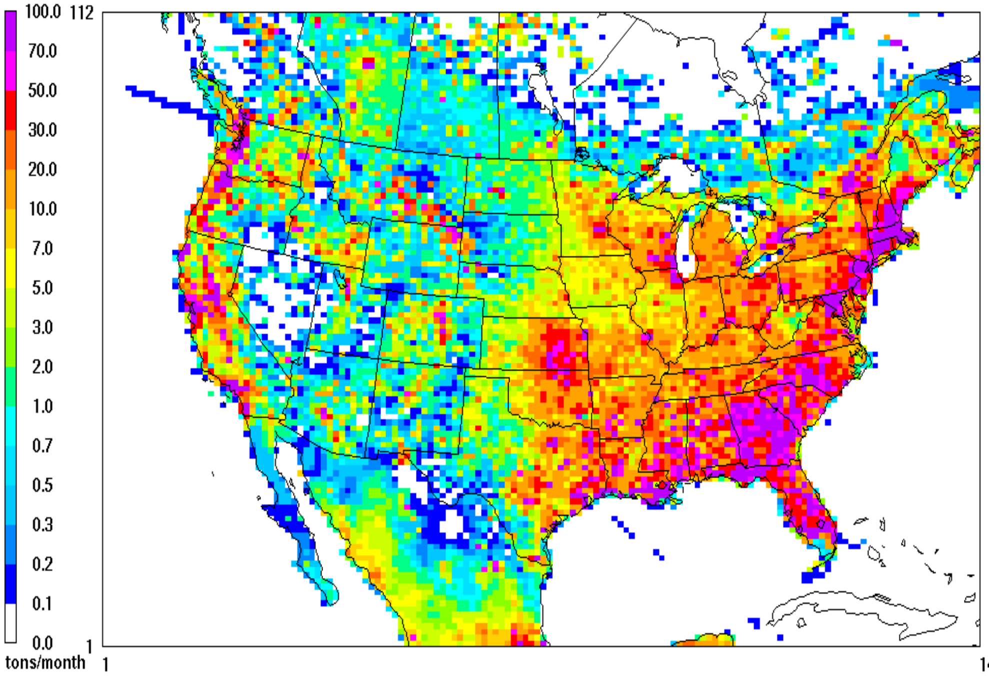


Organic Carbon Comparison

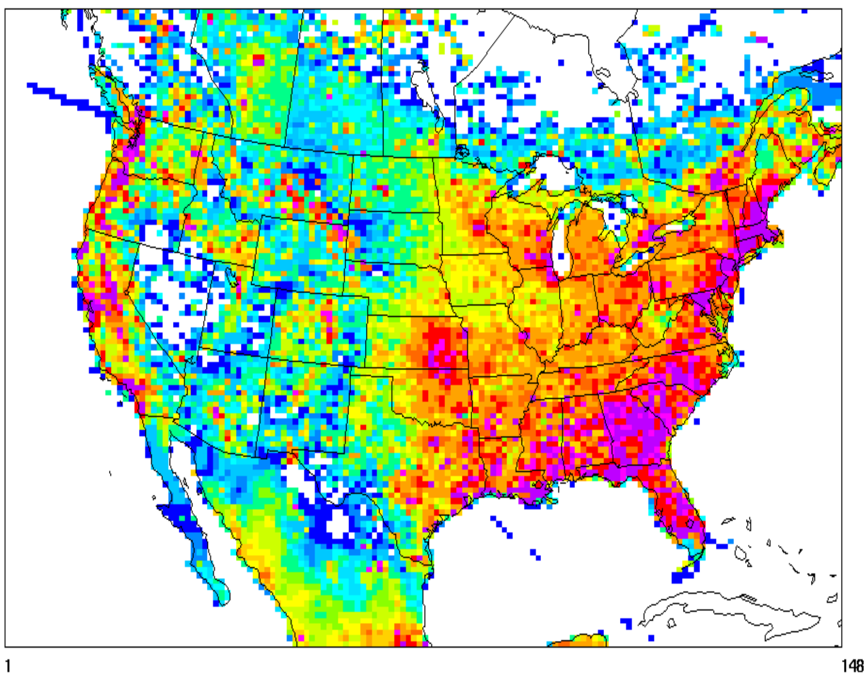
Sum over all Sectors, **January tons/month**

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

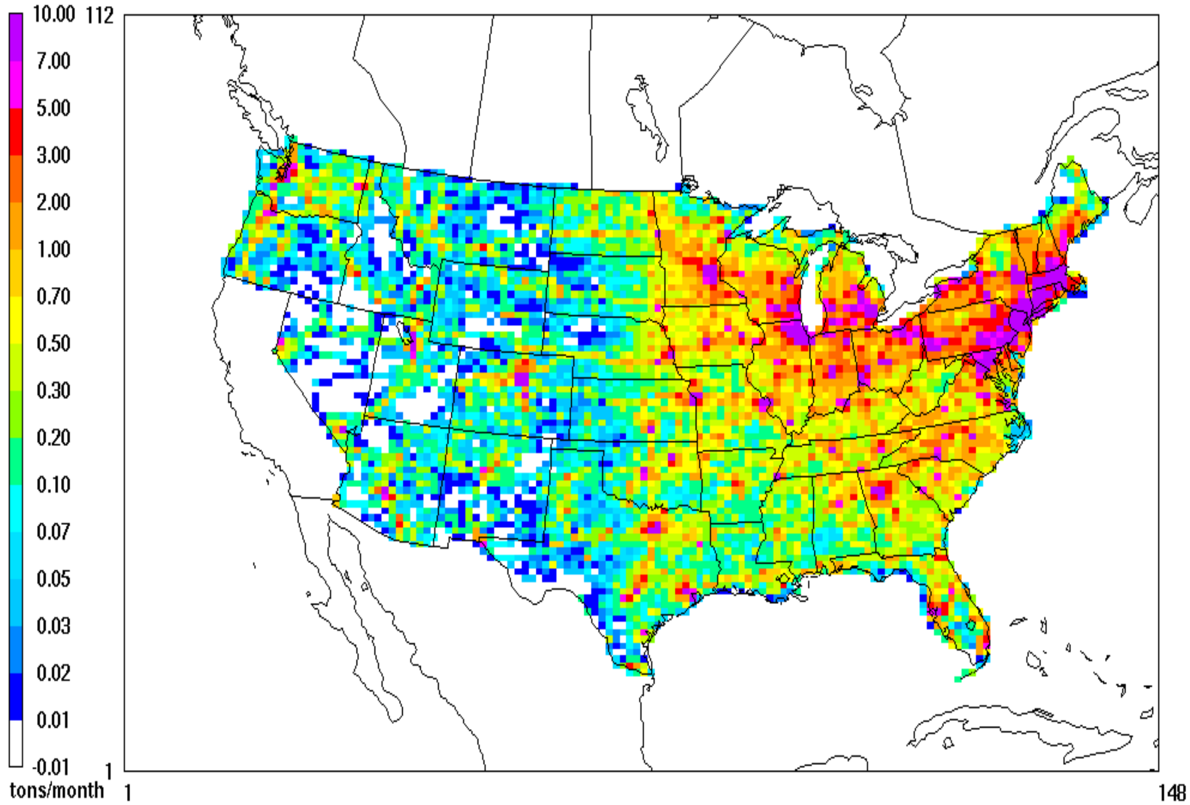


Organic Carbon Impact

<u>Sum over all Sectors</u>, **January tons/month**

All Sector **Absolute Difference**

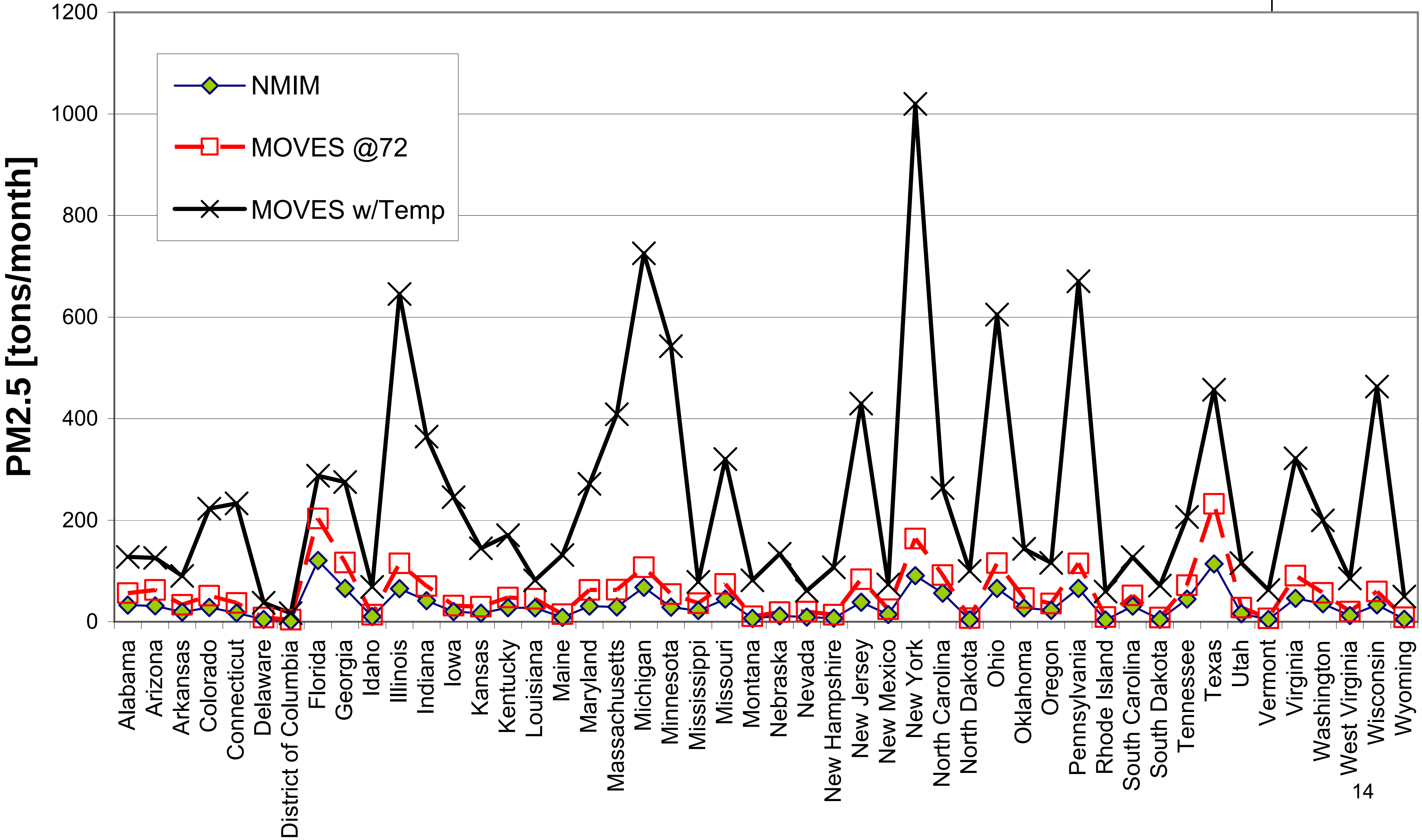
POC MOVES onroad gas minus NMIM



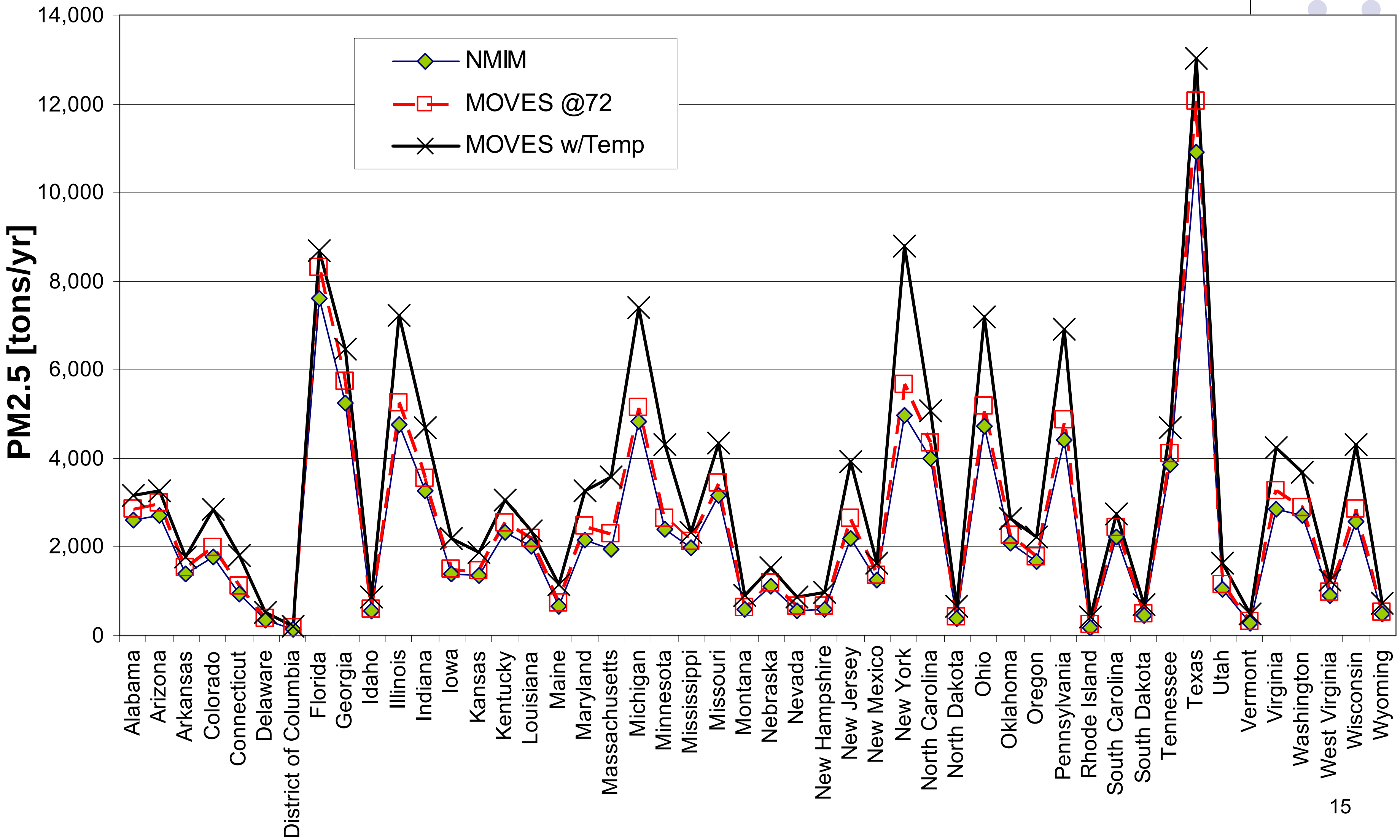
Take away:

- largest impact in large cities, particularly the cold ones.

<u>January 2005</u> $PM_{2.5}$ onroad gasoline MOVES vs. NMIM by state



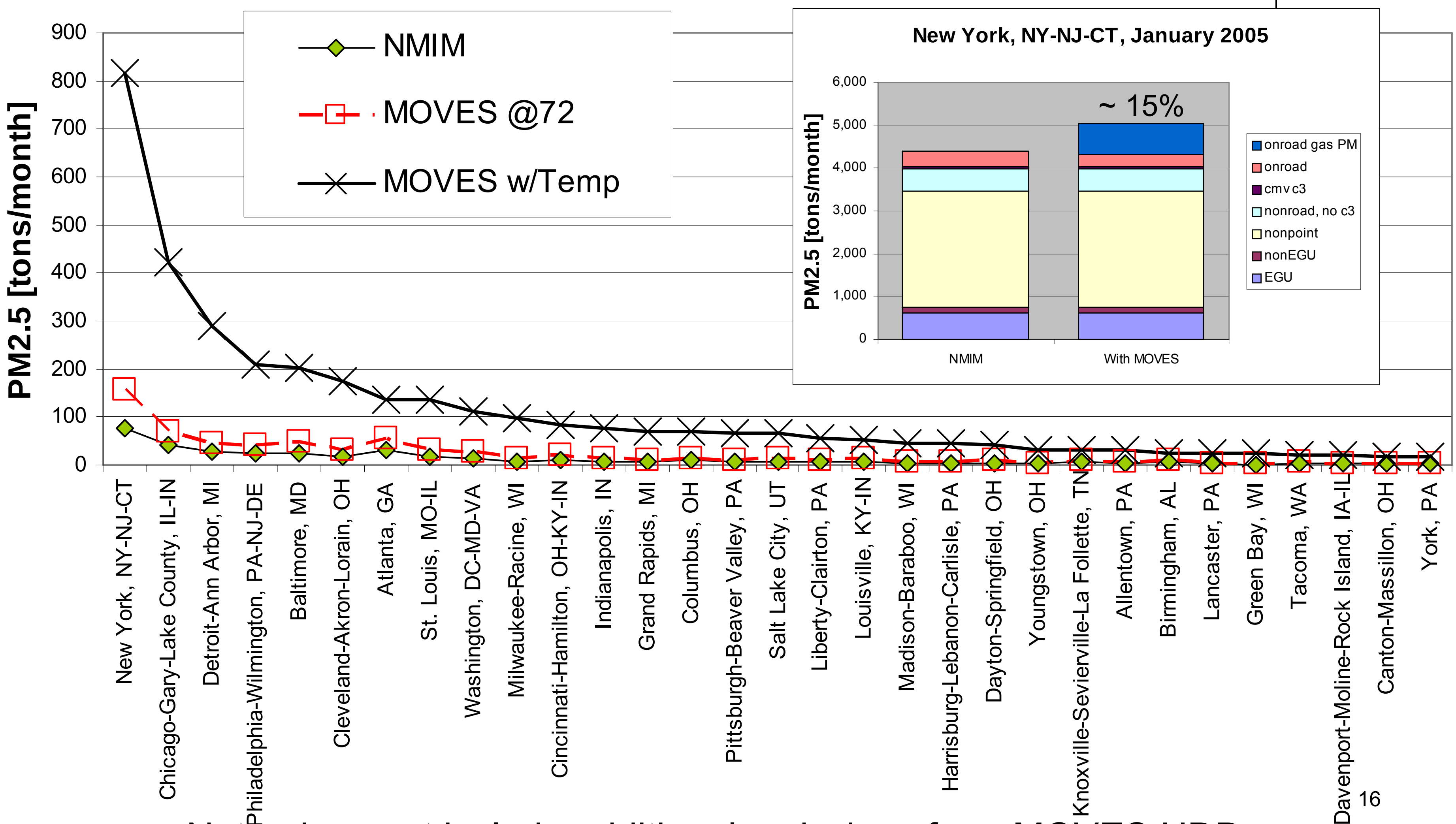
Annual 2005 $PM_{2.5}$ onroad gasoline MOVES vs. NMIM by state



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

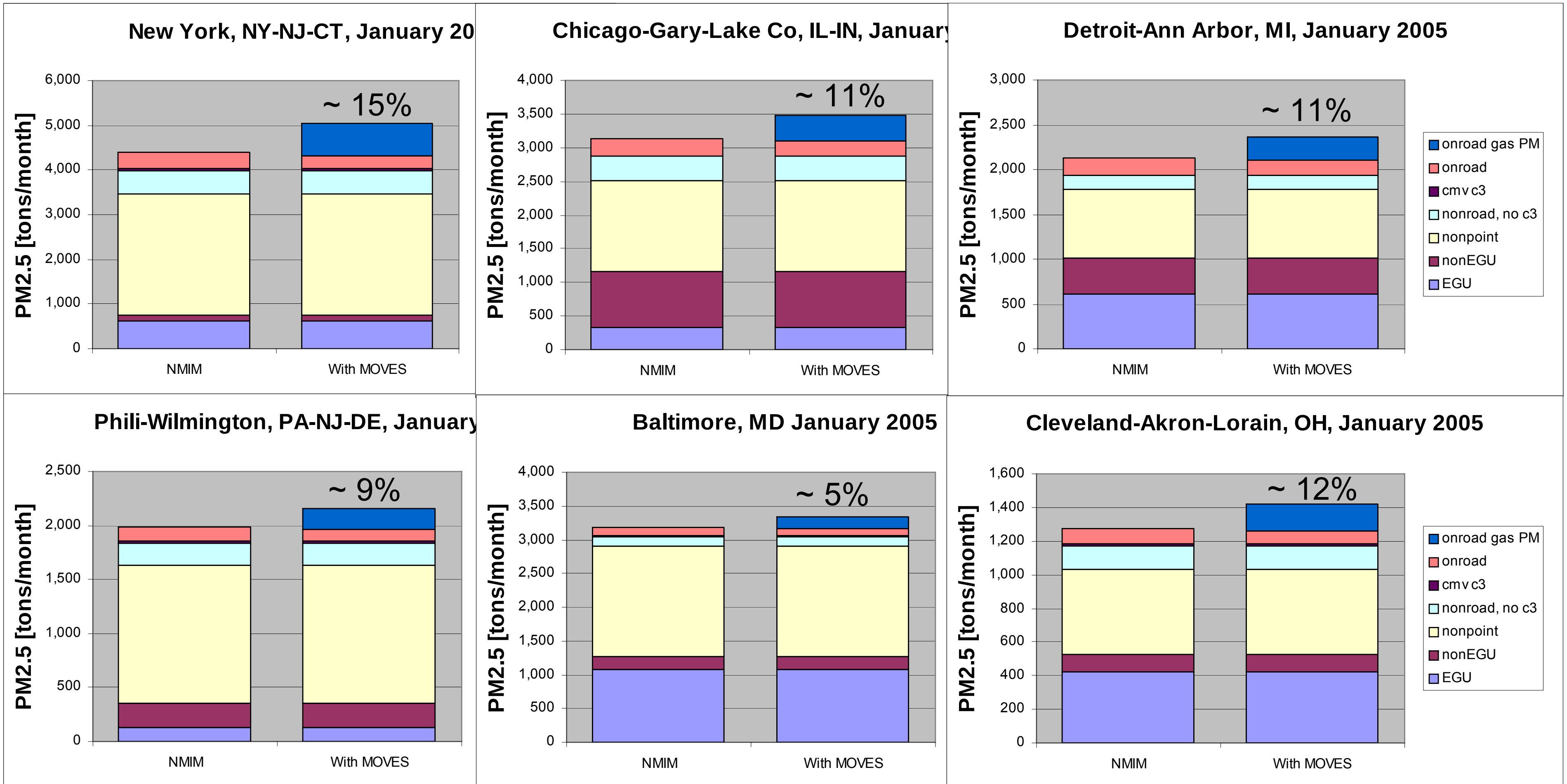


Note: does not include additional emissions from MOVES HDD

Impact across all sectors January 2005 $PM_{2.5}$ onroad gasoline

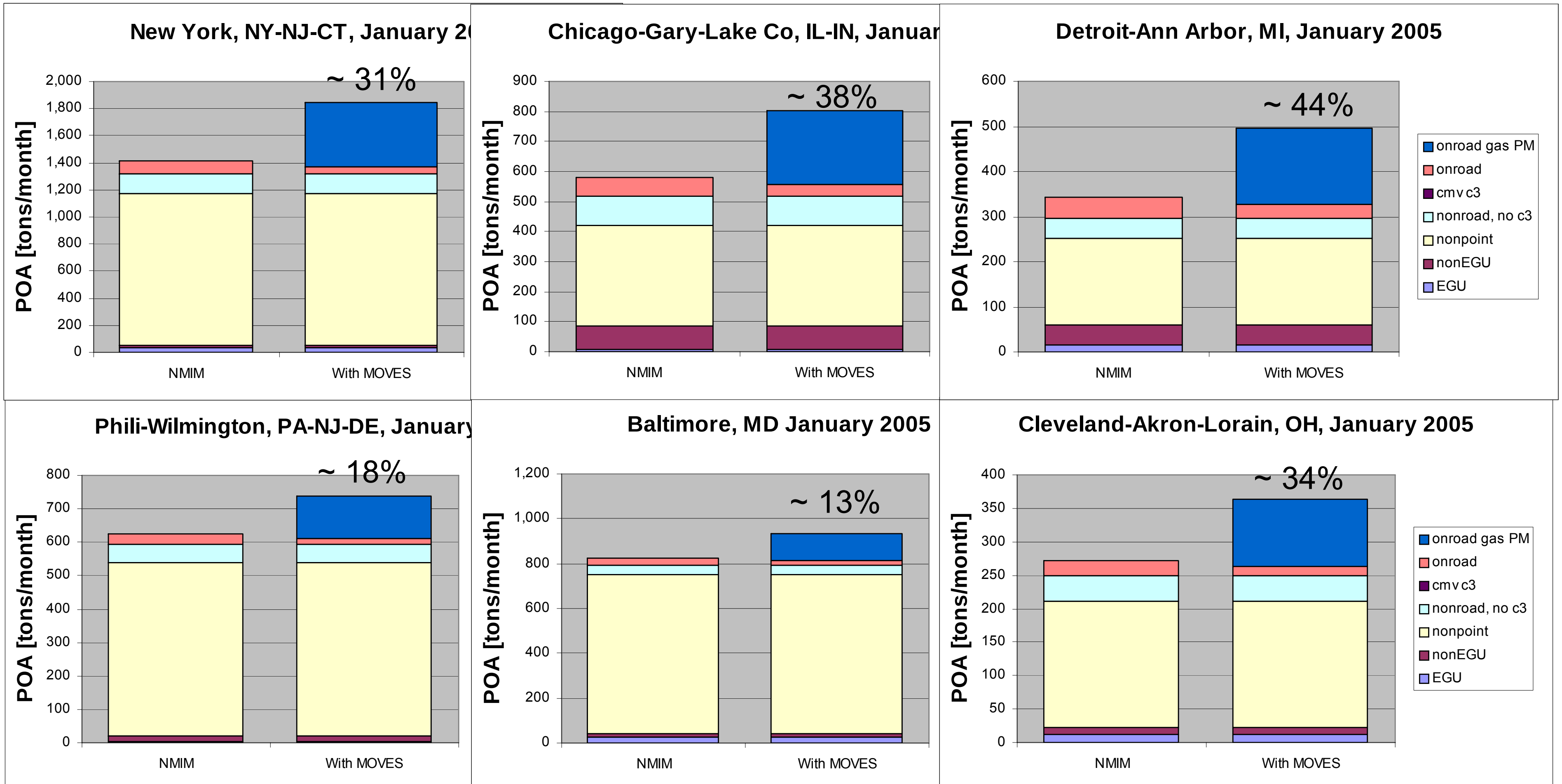
w/ MOVES onroad gas vs. NMIM by NA area

top 6 largest January MOVES $PM_{2.5}$ emissions for PM nonattainment areas



Note: does not include additional emissions from MOVES HDD

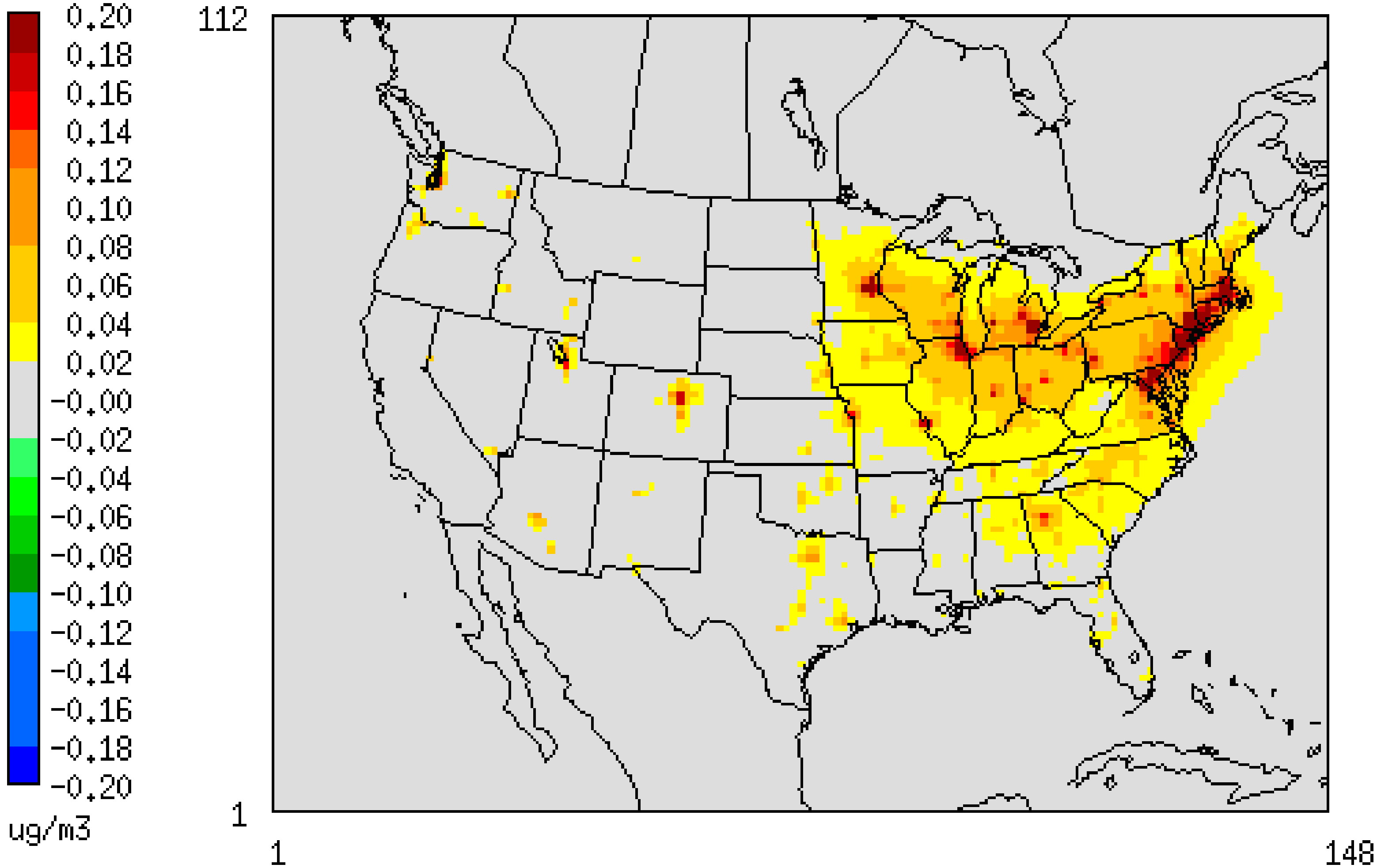
Impact across all sectors
January 2005 POC onroad gasoline
w/ MOVES onroad gas vs. NMIM by NA area
top 6 largest January MOVES $PM_{2.5}$ emissions for PM nonattainment areas



Note: does not include additional emissions from MOVES HDD

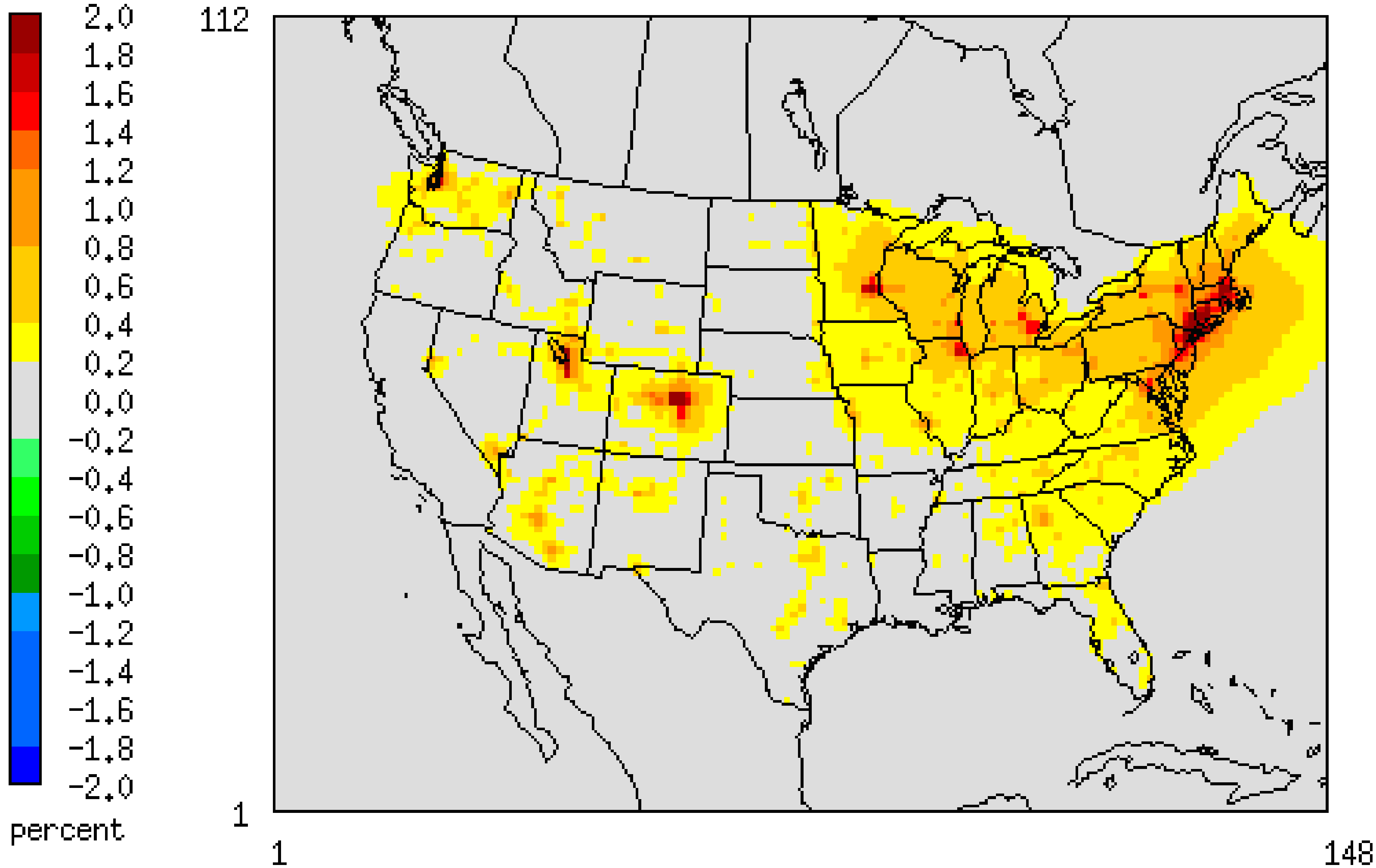
CMAQ Results

Absolute change in 2005 base case annual average $PM_{2.5}$ concentrations (MOVES – NMIM)



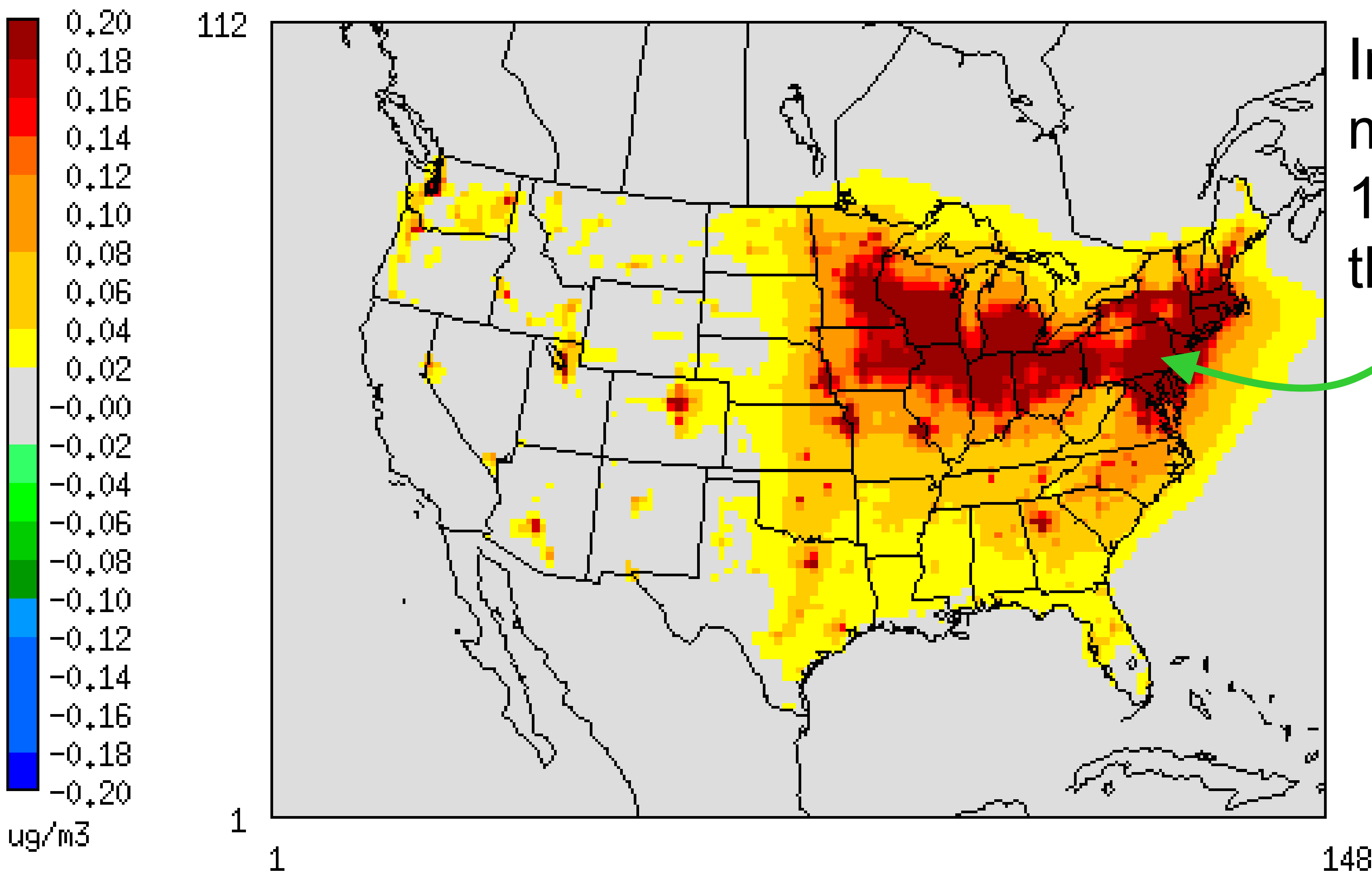
CMAQ Results

Percent change in 2005 base case annual average $PM_{2.5}$ concentrations (MOVES – NMIM)/NMIM



CMAQ Results

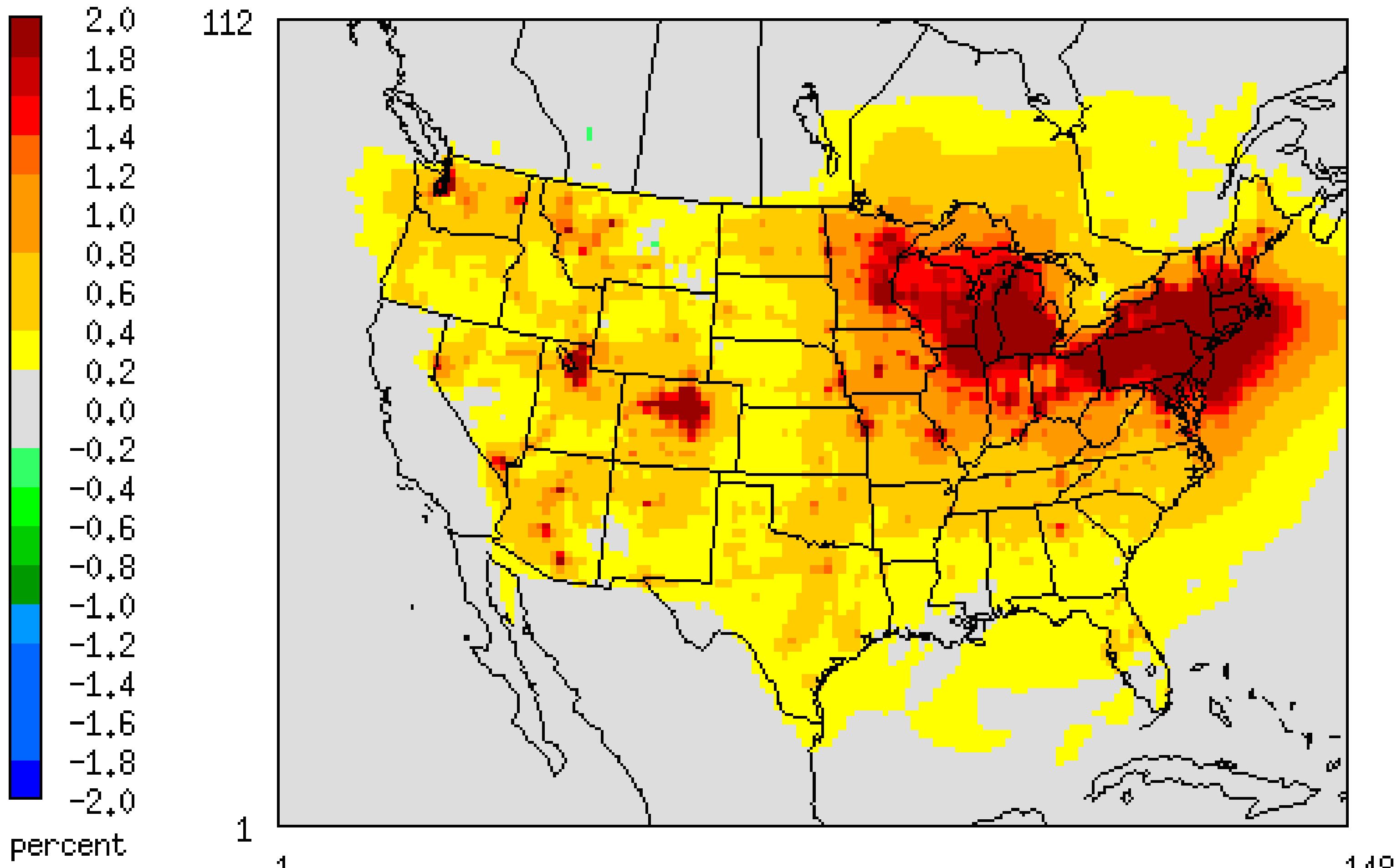
Absolute change in 2005 base case JANUARY average $PM_{2.5}$ concentrations (MOVES – NMIM)



Impacts as much as 1µg/m^3 in these areas

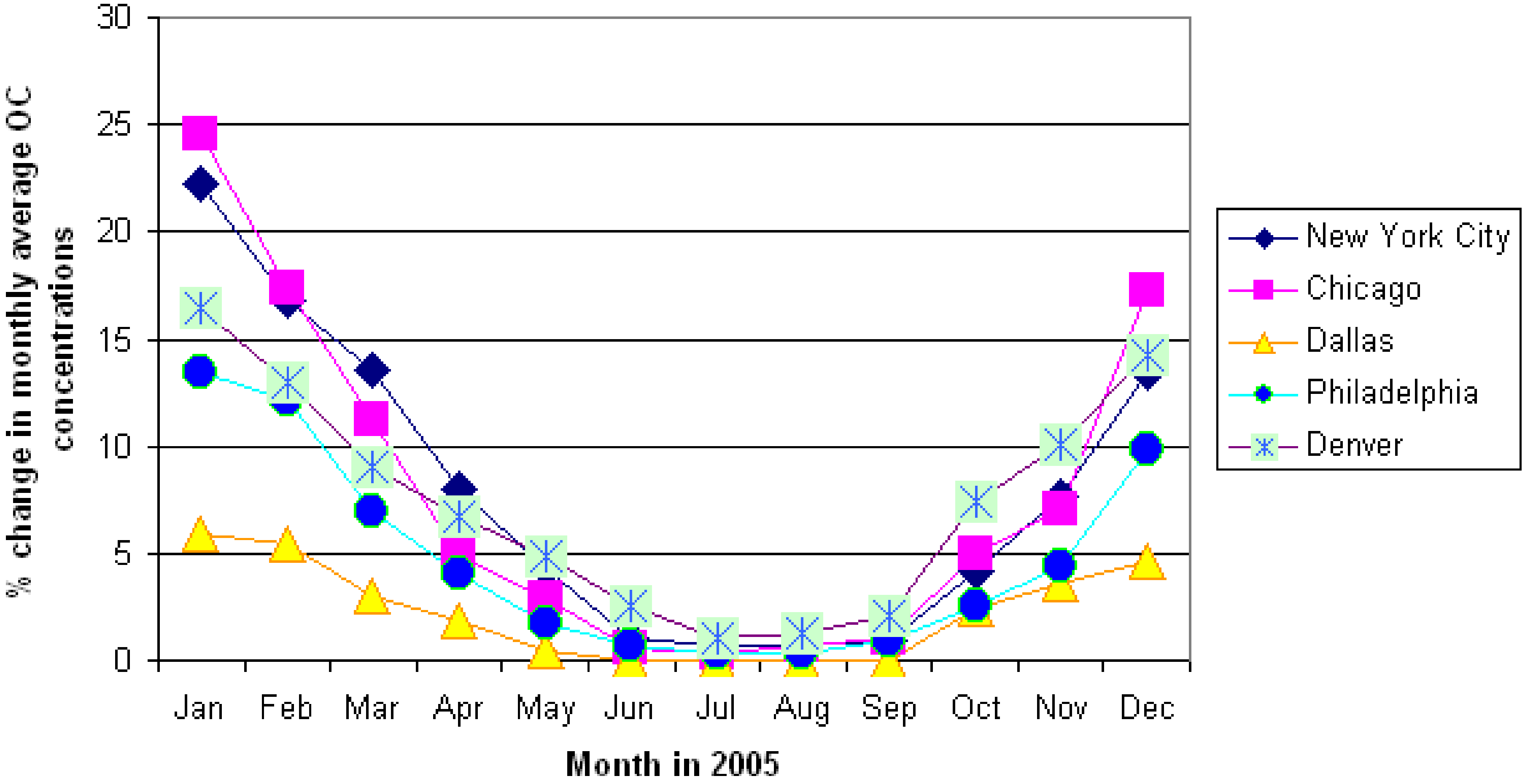
CMAQ Results

Percent change in 2005 base case <u>JANUARY</u> 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 ~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 ~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 µg/m3 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 <u>model performance</u> 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