# Options for Simplifying MOVES Onroad Source Types and Ramps

David Brzezinski and Darrell Sonntag

FACA MOVES Review Work Group

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# Why Simplify MOVES?

- MOVES has become more complex to fulfill needs of users

  - e.g. additional pollutants, additional detail in vehicle technologies, fuels, and vehicle activity

- However, complexity comes at a cost, including:

  - Additional inputs, and room for error

  - More difficult to update with new data

  - Less transparency

  - Increased processing/run time

- This presentation contains two suggestions we believe could simplify the model without a significant loss of accuracy

  - EPA seeking feedback from FACA

  - EPA has not made any final decisions

# Suggestion #1: Reduce the Number of Source Use Types

# MOVES Source Types

- MOVES source types are structured to correspond to activity information that is organized differently than the EPA regulatory classifications.

- All vehicles within a source type are assumed, in general, to have the same activity and age distributions.

| Source Type ID | MOVES Source Type |
|---|---|
| 11 | Motorcycle |
| 21 | Passenger Car |
| 31 | Passenger Truck |
| 32 | Light Commercial Truck |
| 41 | Intercity Bus |
| 42 | Transit Bus |
| 43 | School Bus |
| 51 | Refuse Truck |
| 52 | Single Unit Short-haul Truck |
| 53 | Single Unit Long-haul Truck |
| 54 | Motor Home |
| 61 | Combination Short-haul Truck |
| 62 | Combination Long-haul Truck |

# MOVES Regulatory Classes

- MOVES emission rates are by regulatory class.

- Each source use type is a combination of the regulatory classes.

- Altering source types does not affect regulatory class emission rates.

| regClassID | Name | Description |
|---|---|---|
| 10 | MC | Motorcycles |
| 20 | LDV | Light Duty Vehicles |
| 30 | LDT | Light Duty Trucks |
| 40 | LHD <= 10k | Class 2b Trucks with 2 Axles and 4 Tires (8,500 lbs < GVWR <= 10,000 lbs) |
| 41 | LHD <= 14k | Class 2b Trucks with 2 Axles and at least 6 Tires or Class 3 Trucks (8,500 lbs < GVWR <= 14,000 lbs) |
| 42 | LHD45 | Class 4 and 5 Trucks (14,000 lbs < GVWR <= 19,500 lbs) |
| 46 | MHD67 | Class 6 and 7 Trucks (19,500 lbs < GVWR <= 33,000 lbs) |
| 47 | HHD8 | Class 8a and 8b Trucks (GVWR > 33,000 lbs) |
| 48 | Urban Bus | Urban Bus (see CFR Sec 86.091_2) |

# Source Type Data

- EPA defaults were originally developed using the Vehicle In-Use Survey (VIUS), which has since been discontinued.

- States are asked to distribute their activity and population by source type.

- However, states have found it difficult to split the available population and activity data into the current source type groupings.

  - Personal versus commercial use.

  - Short haul versus long haul use.

  - Specialized vocations (i.e., refuse truck).

# Combining Source Types

- EPA is suggesting to combine some source types to reduce the number of needed inputs.

- Because MOVES performance (time to run) is affected by the number of source types simulated, combining source types should improve model performance.

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# Source Type Emissions

- The emissions of trucks are a function of their emission standards classification (regulatory class).

- Each source type emission rate is calculated as a weighted average of the regulatory class rates.

  – i.e., Light commercial trucks include trucks certified as light trucks and as heavy duty trucks.

- Combining source types would preserve the underlying weighting of the regulatory classes.

- Overall fleet emissions should not be affected by combining source types when default fractions are used.
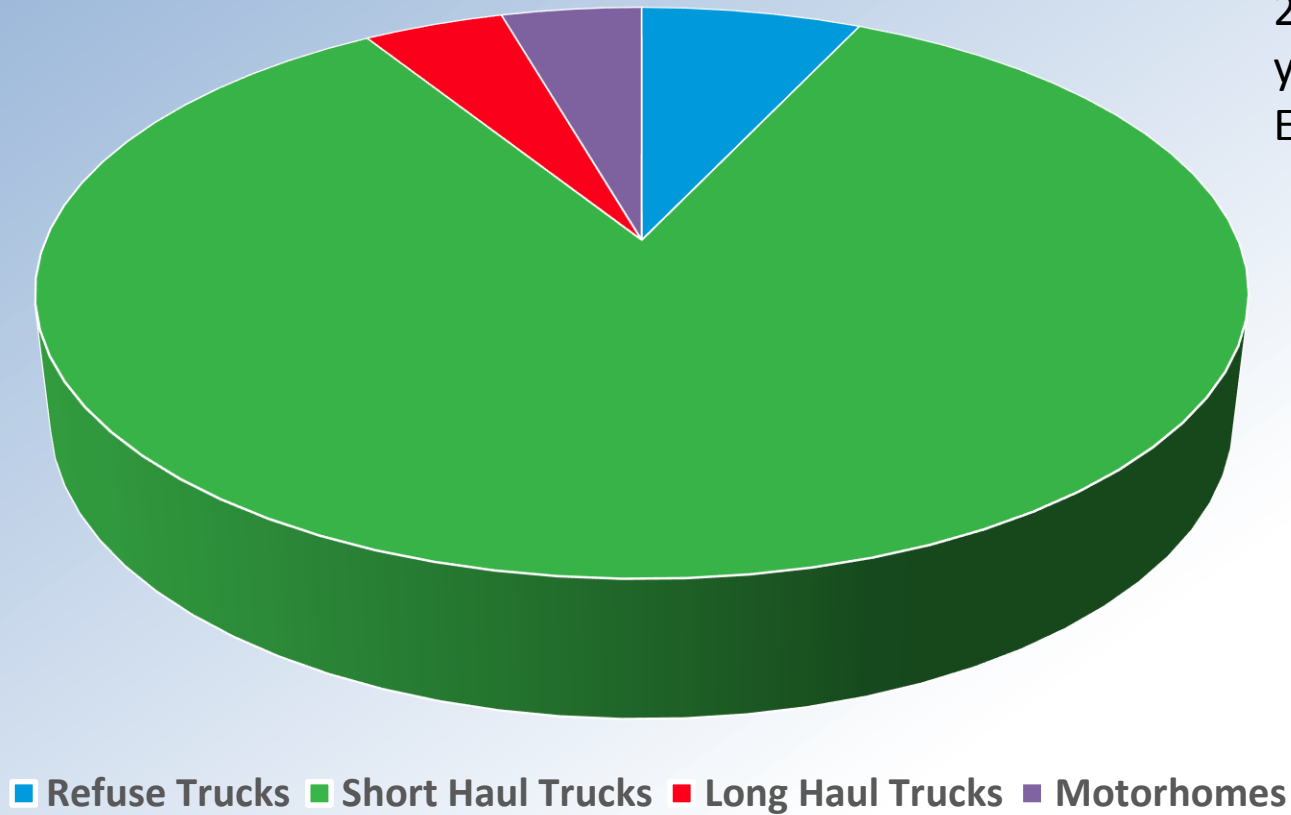
# Passenger and Commercial Light Trucks

- MOVES2014a has separate activity and emissions for the passenger and light commercial trucks (4 tire, 2 axle).

- It is difficult for states to allocate their truck population and activity to these two categories.

  - Light trucks are often used for both personal and commercial purposes.

- Note: combining light trucks will still not resolve problems with separating passenger cars from trucks.

  - Some light trucks and cars can only be identified by VIN decoding.

# Single Unit Truck Source Types



2016 Calendar year NOx Emissions

■ Refuse Trucks  ■ Short Haul Trucks  ■ Long Haul Trucks  ■ Motorhomes

# Short and Long Haul Single-Unit Trucks

- MOVES splits single unit trucks and combination trucks into two activity types:

    – Long haul (trucks that travel more than 200 miles each day)

    – Short haul (all trucks that are not long haul)

- It is difficult for states to allocate their truck population and activity to these two categories.

    – Some trucks are used for both long and short haul.

    – Economic conditions may significantly affect these categories.

# Motorhomes and Refuse Trucks

- MOVES has separate activity for motorhomes and refuse trucks.

  - Both motorhomes and refuse trucks emissions are a combination of the regulatory classes used for single unit trucks.

  - Refuse trucks have their own driving schedules for low speed (workday) operation.

- It is difficult for states to allocate their truck population and activity to these two categories.

  - It is difficult to track specific motorhome activity.

  - It is difficult to separate refuse truck operations from other truck activity measurements.

# Combining Motorhomes and Refuse Trucks into Single-Unit Trucks

- Both do not have to be combined with single unit trucks.

- Refuse trucks are likely to have local population data and have significantly different activity than other single-unit trucks.

- It would become more difficult to estimate specific emissions from motorhome and refuse trucks.

  - With some difficulty and guidance, specific emissions for motorhome and refuse trucks could still be determined using MOVES.

# Short and Long Haul Combination Trucks

- MOVES splits combination trucks into two activity types:

  – Long haul (trucks that travel more than 200 miles each day)

  – Short haul (all trucks that are not long haul)

- The short/long haul split is currently used in MOVES to estimate hotelling emissions from combination trucks.

- It is difficult for states to allocate their truck population and activity to these two categories.

  – Some trucks are used for both long and short haul.

  – Economic conditions may significantly affect these categories.

# Combination Truck Hotelling

- Only combination trucks are assumed to have hotelling activity.

- Removal of the short/long haul distinction for combination trucks would require a new mechanism for determining the appropriate amount of hotelling hours for a location.

  - Current method is the source of much criticism.

  - Changes in the current method are likely.

# Overall Effects of Changing Source Types

- Would require significant changes to MOVES default data.

  – Consolidate activity across categories.

  – Consolidate regulatory class fractions.

  – Mix of sub-classes would not vary by location.

- Should not significantly affect the overall emission inventory estimate.

  – Many areas use EPA default source type splits.

  – Custom user inputs could allow output for vehicle sub-classes when they are needed.

# Should EPA Simplify the Source Type Classifications?

- Are there technical/policy reasons to continue to:

  - model passenger and commercial light trucks separately?

  - model short/long haul single unit trucks separately?

  - model motorhomes and/or refuse trucks separately?

  - model short and long haul combination trucks separately?
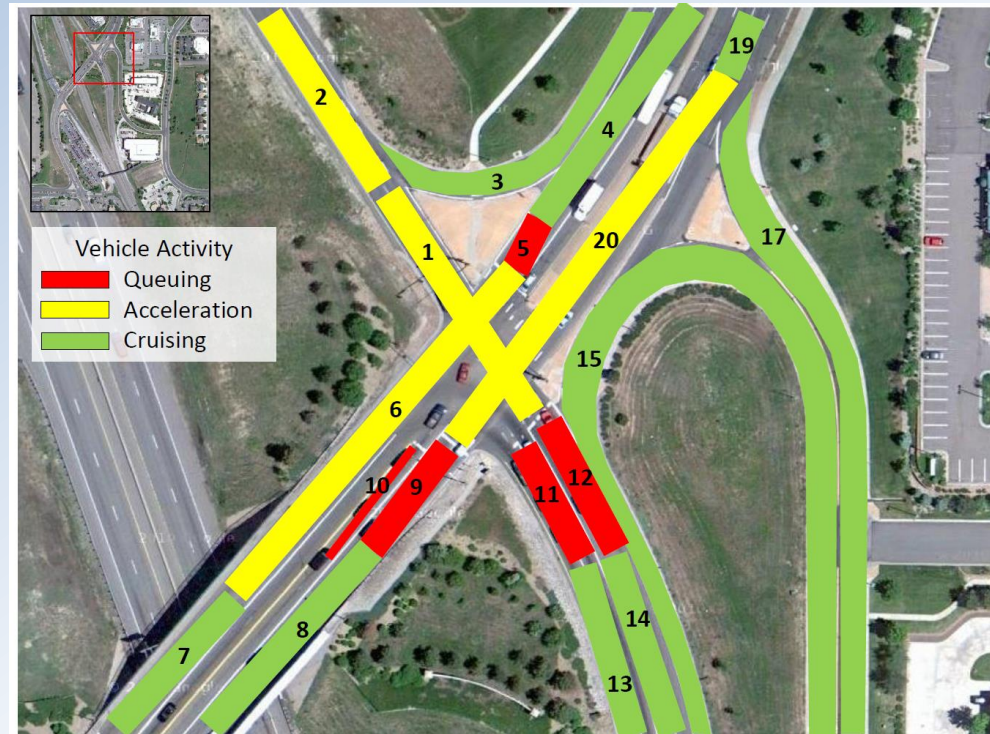
# SUGGESTION #2: REMOVE FREEWAY RAMPS FROM NATIONAL AND COUNTY-SCALE

# Background: Project-Scale

- Finest level of modeling in MOVES

- Users specify information for Individual roadway links, including:

  - Traffic volume

  - Operating mode distributions, driving cycles, or average speed

- Users can input separate driving behavior for ramps by modeling ramps as separate links

# Background: Ramps in National and County-Scale

- Ramp activity and emissions are modeled separately at county and national-scale based on the assumption that vehicle behavior and emissions are significantly different on ramps than freeway conditions

- Ramp Fractions (User Input)

  - Used to estimate the percent of time vehicles spend on ramps in Rural and Urban Restricted Access roads (roadtypeID 2 and 4)

  - National default ramp fraction derived from MOBILE6 value (8%)

- Ramp Operating Mode Distributions (Default data)

  - Varies according to the average speed of the roadtypeID 2 and 4

  - Used for estimating the behavior of ramp driving

  - Ramp operating mode distributions are based on engineering judgment

    - Contain high percentage of high power, high acceleration modes
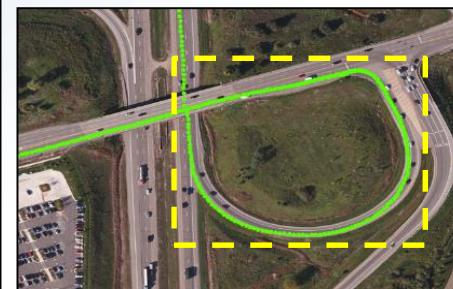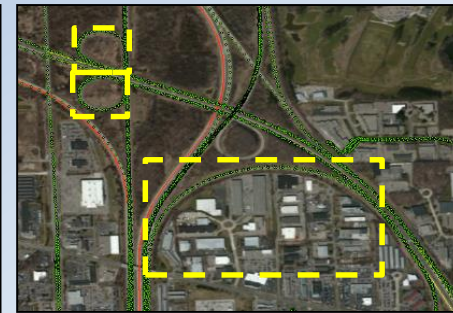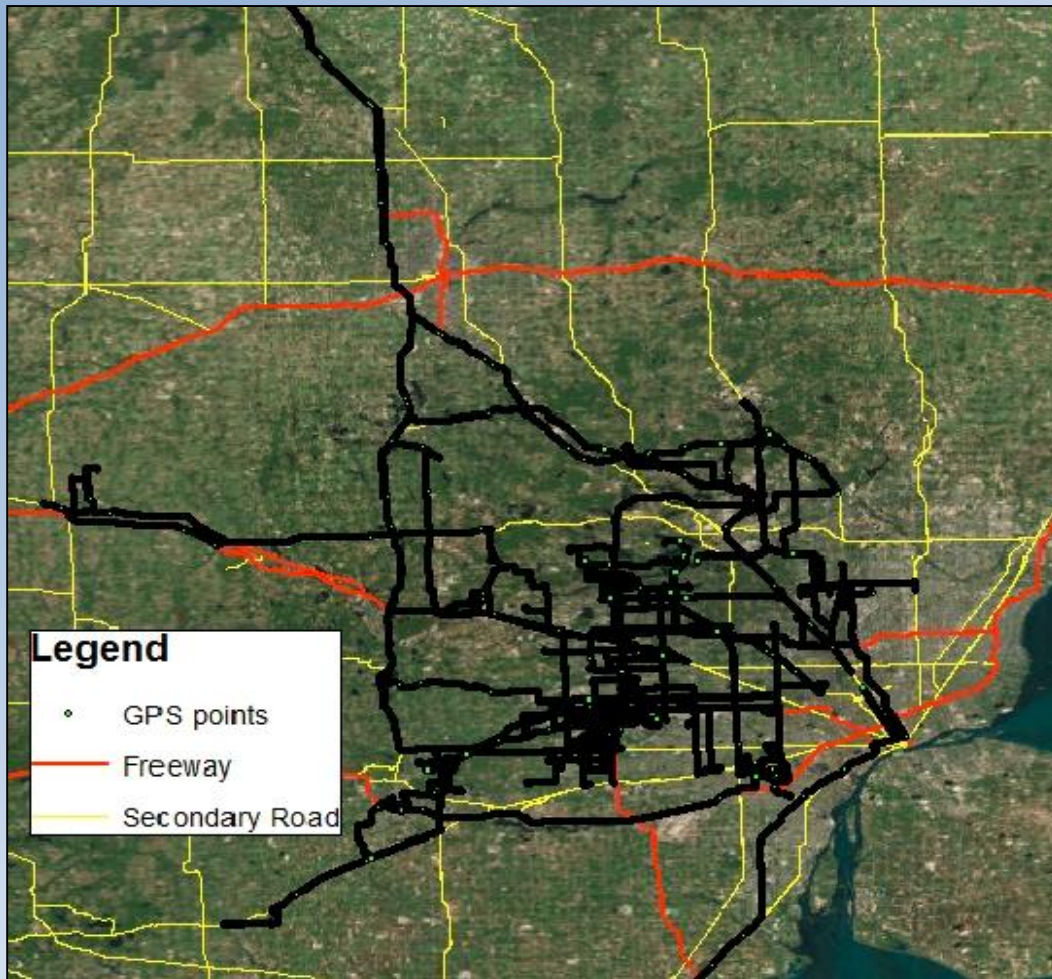
# EPA Detroit Light-duty vehicle Ramp Study

- Conducted study in 2014 to evaluate ramp activity and default MOVES ramp data
  - Not available for MOVES2014

- 10 vehicles, 10 drivers
  - Commuting trips, Aug. to Oct., 2012, in Metropolitan Detroit
  - In total of 173 hours data, in 5 Hz

- Portable Activity Measurement System (PAMS)
  - On-Board Diagnostic (OBD) module
    - time, engine rpm, **vehicle speed**, air flow rate …
  - Global Positioning System (GPS) module.
    - vehicle speed, **latitude, longitude** …

| NO | Year | Make | Series | Body | Type | Reg Class |
|----|------|------|--------|------|------|-----------|
| 1 | 2008 | Chevrolet | Malibu LTZ | 4dr Sedan | CAR | LDV |
| 2 | 2009 | Buick | Lucerne CXL | 4dr Sedan | CAR | LDV |
| 3 | 2008 | GMC | Acadia SLT(1) FWD | 4dr Cab/Sport Utility | MPV | LDT34 |
| 4 | 2009 | Chevrolet | Impala LT Sedan | 4dr Sedan | CAR | LDV |
| 5 | 2008 | Pontiac | Grand Prix Sedan | 4dr Sedan | CAR | LDV |
| 6 | 2009 | Ford | Fusion SE | 4dr Sedan | CAR | LDV |
| 7 | 2009 | Ford | Fusion SE | 4dr Sedan | CAR | LDV |
| 8 | 2009 | Ford | Fusion SEL | 4dr Sedan | CAR | LDV |
| 9 | 2007 | Buick | Rendezvous 2WD | 4dr Cab / Sport Utility | MPV | LDT2 |
| 10 | 2009 | Chevrolet | HHR | 4dr Cab / Sport Utility | MPV | LDT2 |

# Ramp Data Extraction from ArcGIS
# Total # of Ramp Traces: 270

# LDV Emission Rate Evaluation

- **Calculated Operating Mode Distributions for each ramp from the PAMS data**

- **Used MOVES in project-level to obtain emission rate of LDV for each ramp (on-ramp, off-ramp, and interchange)**

- **Input data:**
  - Operating Mode Distributions (PAMS)
  - Region: Wayne County (Detroit)
  - Time: 5:00-6:00 PM, July, 2015
  - Source type: passenger car (source type ID = 21)
  - Age distribution: 2015 national default
  - Pollutants: CO, $PM_{2.5}$, $NO_X$, $CO_2$
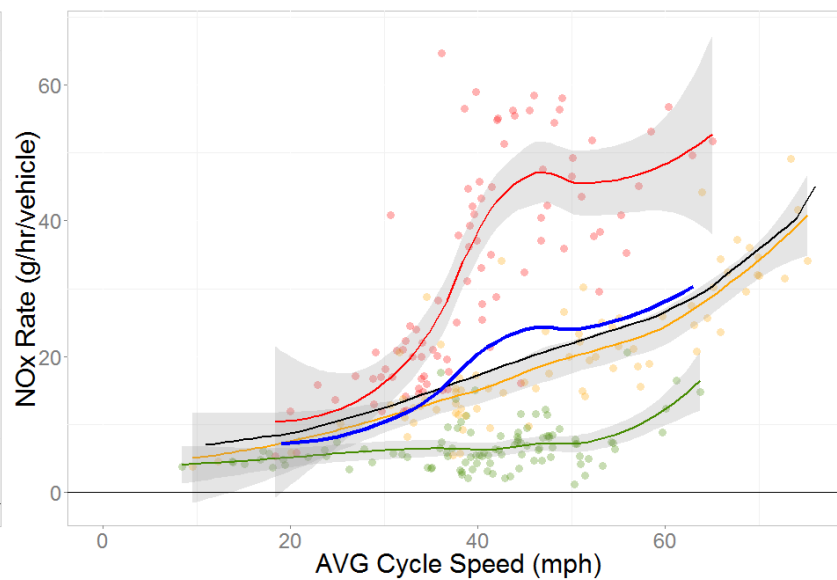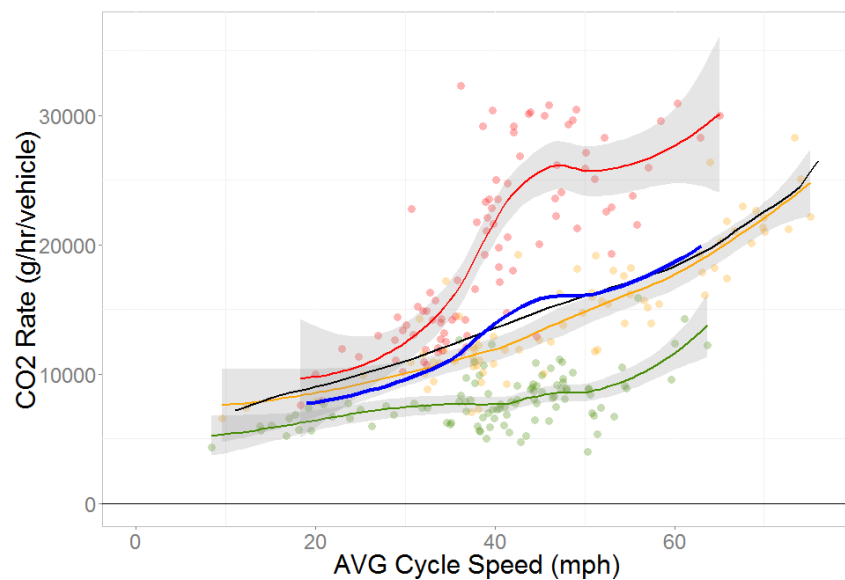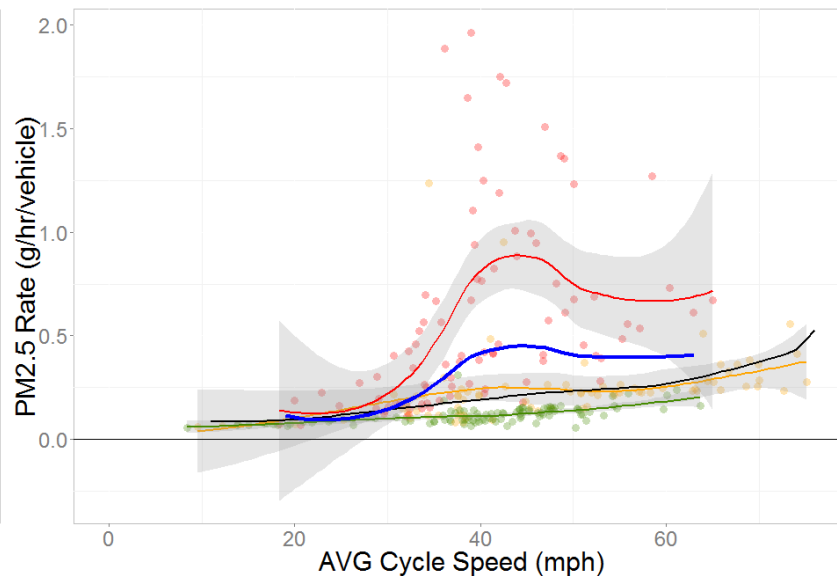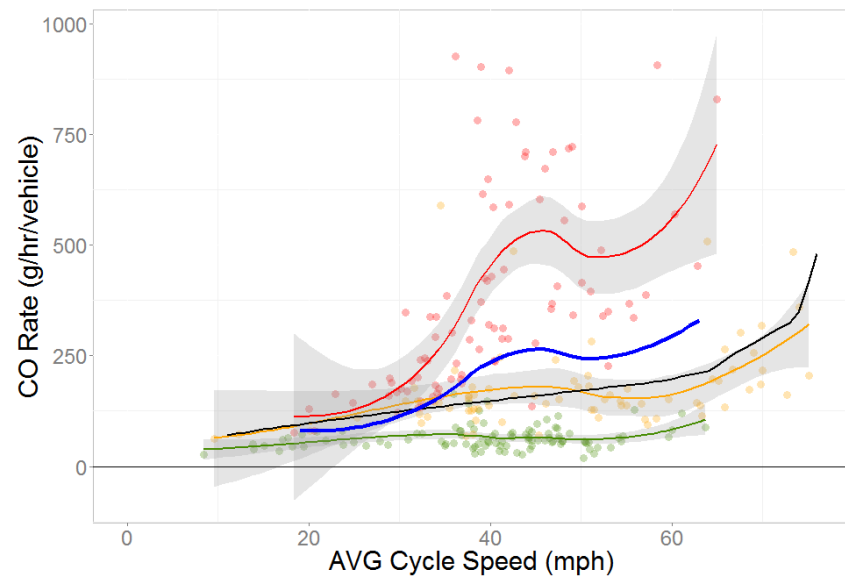
# LDV emission rates: Average of On-ramp and off-ramp emission rates ≈ MOVES highway emission rates

# of ramp traces: 270
- on-ramp: 91
- off-ramp: 102



Legend: interchange — MOVES highway — off-ramp — on-ramp — on+off ramp

# Initial Results

- Average of LDV On-ramp and off-ramp emission rates ≈ MOVES highway emission rates

  – Similar trend observed for heavy-duty transit buses

- Current ramp operating mode distributions in MOVES2014 are too aggressive

  – Too much time spend in high power, high acceleration operating modes compared to real-world ramps

  – Do not account for less acceleration noted on off-ramp and interchanges

  – Amount of braking appears reasonable

- We can simplify and improve the accuracy of MOVES by removing ramps from national and county-scale for all vehicle types

  – Would no longer require users to provide ramp fraction in county-scale

# Evaluation of Removing Ramps (1)

- We evaluated the impact of removing ramps using 60 highway trips from Detroit LD study

    – 60 highway trips, each contains on-ramp and off-ramp

    – 15 hours, 871 miles

# Evaluation of Removing Ramps (2)

Developed MOVES inputs from the 60 trip data in 2 scenarios:

- Project-Level

  – Accurate representation of the complete 60-trips in MOVES

- County-Scale (Ramps = 0)

  – Highway average speed (Ramps + Highway)

  – Ramp fraction = 0

  – Use MOVES default highway cycles

- Results:
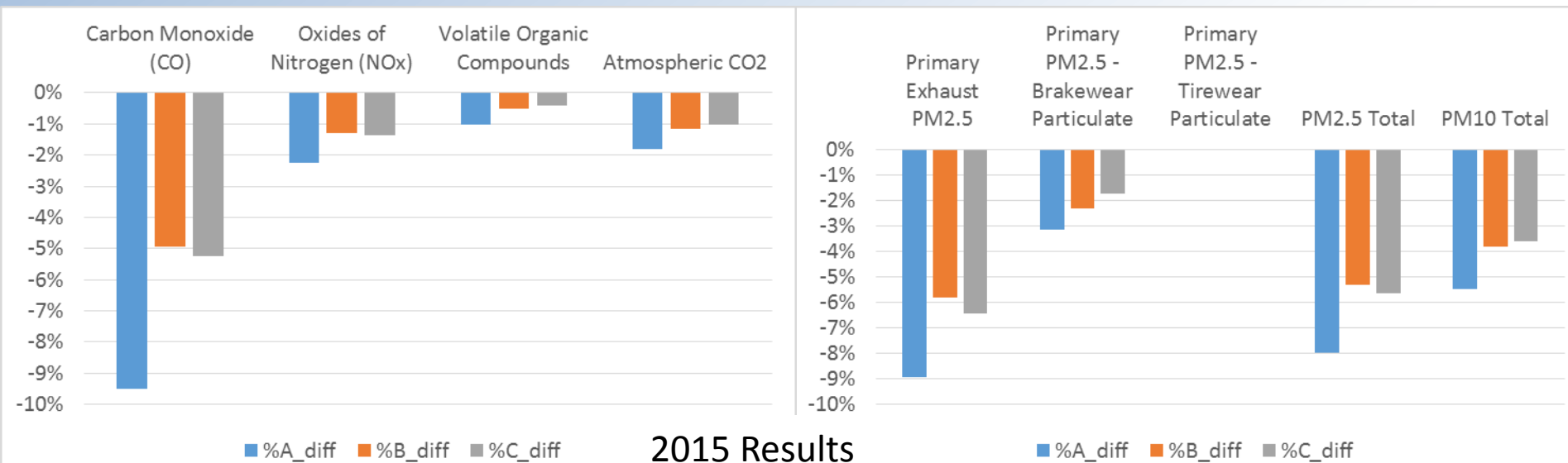
| Difference between County-scale (Remove ramps) and Project-Level | CO | NOx | CO2 | PM2.5 |
|---|---|---|---|---|
| | -1.67% | -0.53% | -0.10% | -3.17% |

  – Difference expected between using project-mode and county-scale

  – However, after removing ramps in county-scale, the results are more comparable

# What's the impact of removing ramps from a typical urban county?

- Conducted MOVES runs for 3 urban counties (A, B, and C) in 2011-2030

- Overall impact of removing ramps on 3 counties

  - 0.5-3% reductions in NOx, VOC, and CO2

  - 2-3% reductions in brake wear PM, 6-9% reductions in PM2.5 exhaust,

  - 4-12% in CO

- Larger decreases observed in the 3-county analysis than the 60-trip analysis

  - Default MOVES2014 ramp operating mode distributions are more aggressive than activity measured on ramps in the EPA Detroit study



2015 Results

# Summary

- Remove Ramps from County and National-scale

  - Increased emissions from on-ramps are largely offset by the decrease in emissions from off-ramps, which are not properly accounted for in MOVES

  - Evaluation data (60-trip analysis) confirms that removing ramps improves accuracy in light-duty exhaust emissions

  - Removing ramps for all vehicle types will lead to minor decrease in emissions, including brake wear

- Maintain Ramps in Project-scale

  - Differences between individual ramps, especially between on-ramps, off-ramps, and highway links are important

  - Ramps should be treated as individual links

  - We intend to provide light-duty op-mode distributions based on the Detroit ramp study

# Feedback?

- Are there any specific examples why users need ramp output at the county-scale?

- Any input on the recommendation for project-mode?