Parameterization of MOVES Emissions Factors Lookup Tables for Air Quality Forecasting System

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Motivations

- Introduce the meteorology dependency to Korea National Institute of Environmental Research (NIER) Air Quality Forecasting Modeling System (NAQFMS)

- Targeted emissions sources:
  - Agricultural NH_3 Emissions
  - Residential Heating Emissions
  - Onroad Mobile Emissions

- 2016: Development of the meteorology-dependent Temporal Profiles based on source-related measurements and meteorological datasets.
  - Developed the polynomial algorithms for onroad mobile emissions

- 2017: Developing meteorology-sensitive gridded mobile emissions based on the polynomial algorithms using forecasted gridded ambient temperature.

Current Status

- SMOKE-MOVES Integration Tool Released on 2010
  - ○ Latest SMOKE-MOVES2014a Integration Tool

- Enhanced the meteorology dependency on mobile emissions for air quality modeling system

- Technical Challenges:
  - ○ Slow and Most Computationally Expensive!
  - ○ Big size of ASCII-format MOVES Emissions Factors Lookup Table files
  - ○ Processing the limited numbers of Reference County-specific Lookup Tables

SMOKE-MOVES Integration Tool

- RatePerDistance [grams/miles]
  - Exhaust and most evaporative emissions that happen on real roadtypes
  - Sorted By SCC (=vehicle/road/process), 16 Speed Bins and Ambient Temperature Bins

- RatePerVehicle [grams/vehicle/hour]
  - Exhaust and most evaporative emissions that occur off-network
  - Sorted By SCC, Hour of day and Ambient Temperature Bins

- RatePerProfile [grams/vehicle/hour]
  - Vapor venting evaporative emissions that occur off-network
  - Sorted By SCC, Hour of day and Min/Max Temperatures

- RatePerHour [grams/hour]
  - APU operation and extended idling processes
  - Sorted By SCC, Ambient Temperature

Current SMOKE-MOVES Integration Runs

- Around 250 Reference Counties for Continental U.S. Modeling Domains with Two Fuel Months per Each Reference County

- Size of MOVES Lookup Tables:
  - **RPD: 85-150MB,   RPV: 45-95MB,   PRP: 15-50MB,   PRH: Less than 1MB**

- Processing Optimization: Processing 7 consecutive days at a time.
  - Faster processing but requires more RAM memory
  - Processing 1 days at at time, much slower processing time
  - Tagging or source_grouping options: much more memory and slower processing time
  - More Grid Cells and more reference counties = more memory and slower processing time

Sectors	Computing Time	RAM Memory Usages
RPD	4 hours	10-20 GB
RPV	1.5 hours	5-10 GB
RPP	30 minutes	< 1 GB
RPH	5 minutes	2 GB

Solutions

- **Current/Possible Solutions:**

  - Computational Optimization of the SMOKE-MOVES Integration tool

  - Reduce the size and numbers of MOVES EF lookup tables:

    a) Aggregated Processes (Less than 15 processes)

    b) Aggregated Vehicle and Road Types

    c) Reduced optimized temperature increments

    d) Limited numbers of reference counties.

  - Convert current ASCII-formatted MOVES EF lookup tables into NetCDF format to improve the I/O speed (not implemented yet).

- **Proposed Solutions:**

  - Parameterization of Current ASCII-format MOVES EF Lookup Tables into Polynomial Algorithms using **Best-Fitted Curve Algorithms (BFCA)**

  - Store the algorithms in NetCDF format to eliminate I/O bottlenecks

  - Coupling with SMOKE and AQ models including forecasting AQ

RatePerDistance (RPD)

- Reference County:
  - Baltimore County, MD (24005)

- Vehicle Types:
  - Passenger Vehicle
  - Transit Buses

- Processes:
  - All Exhaust, Evaporative, Brake and Tire [81]
  - Refueling [62]
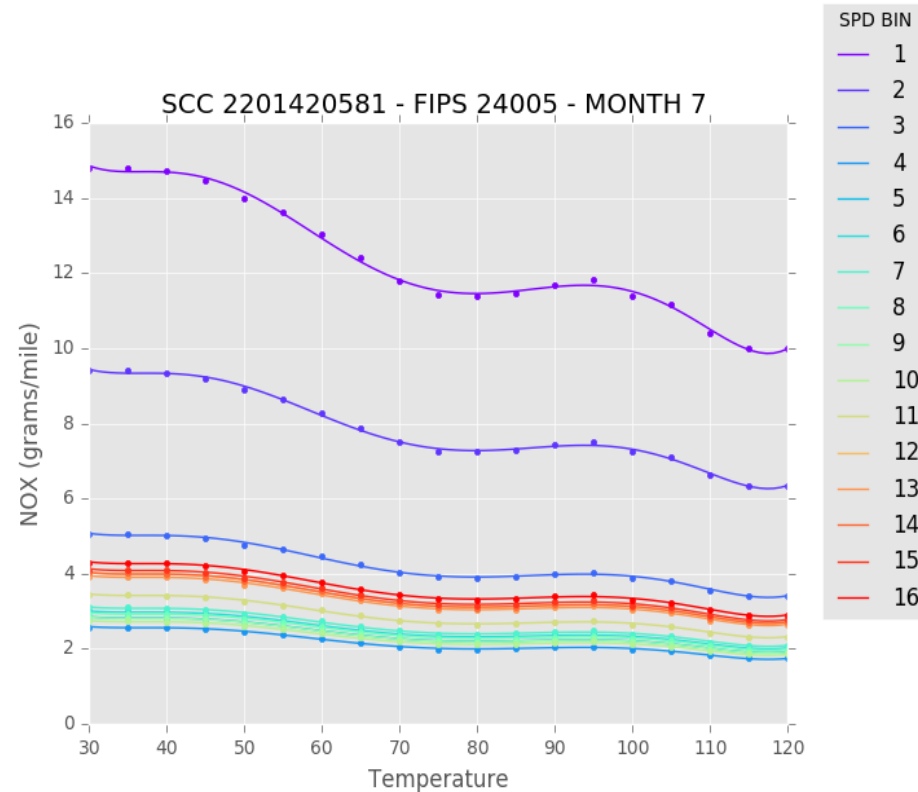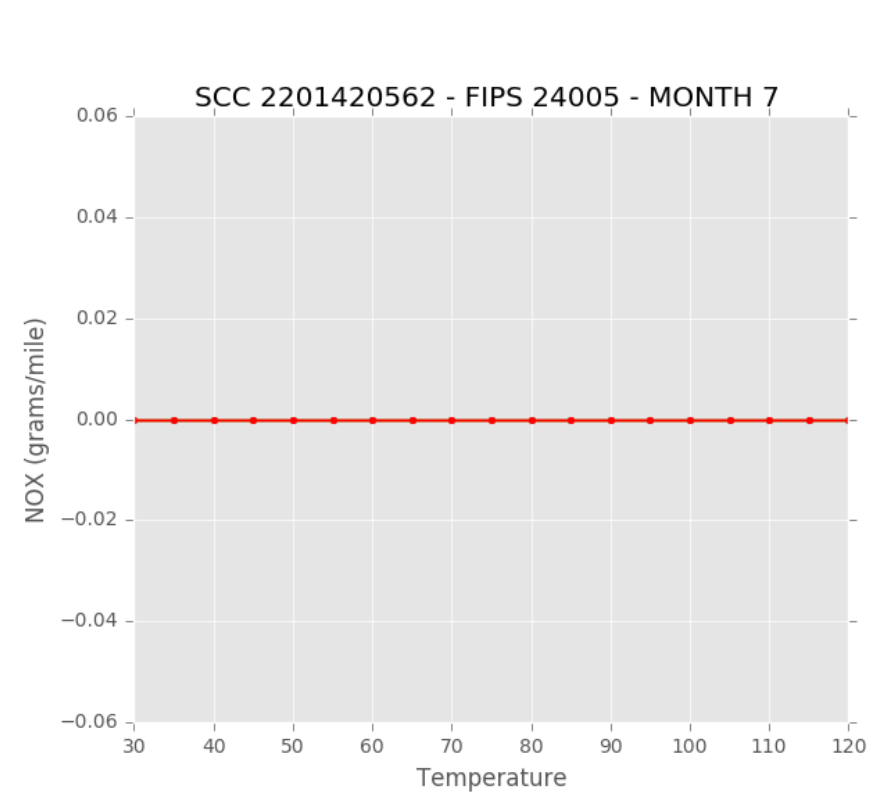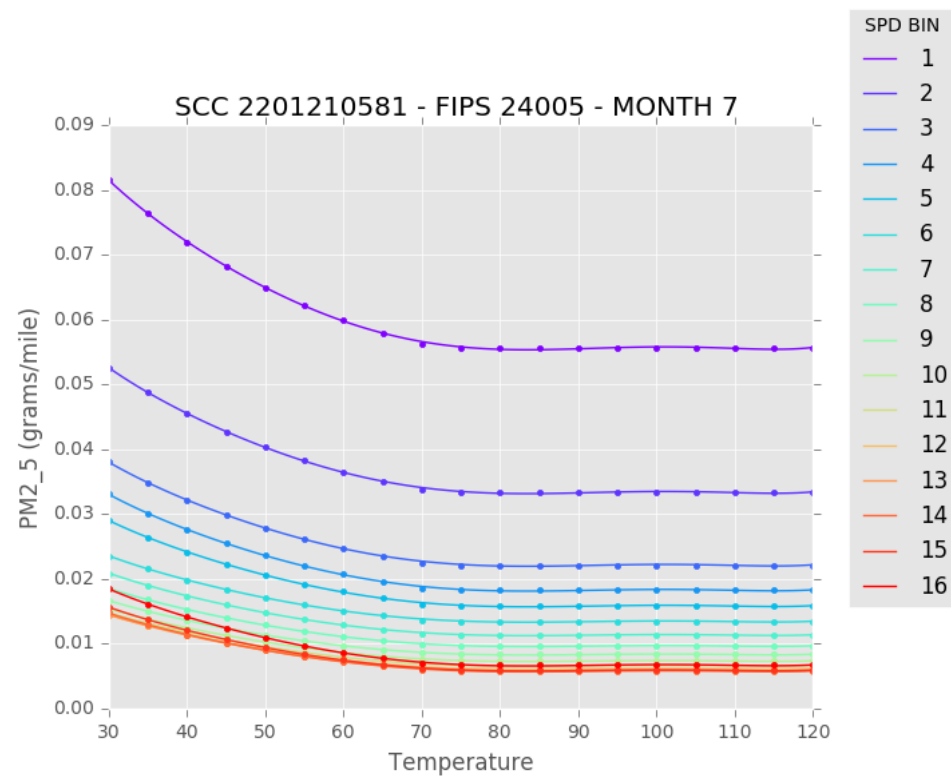
- Pollutants: TOG, NOx, PM2.5

TOG: Gasoline-Passenger Car: Urban Unrestricted Access
Refueling [62] and All Exhaust, Evaporative, Brake and Tire [81]

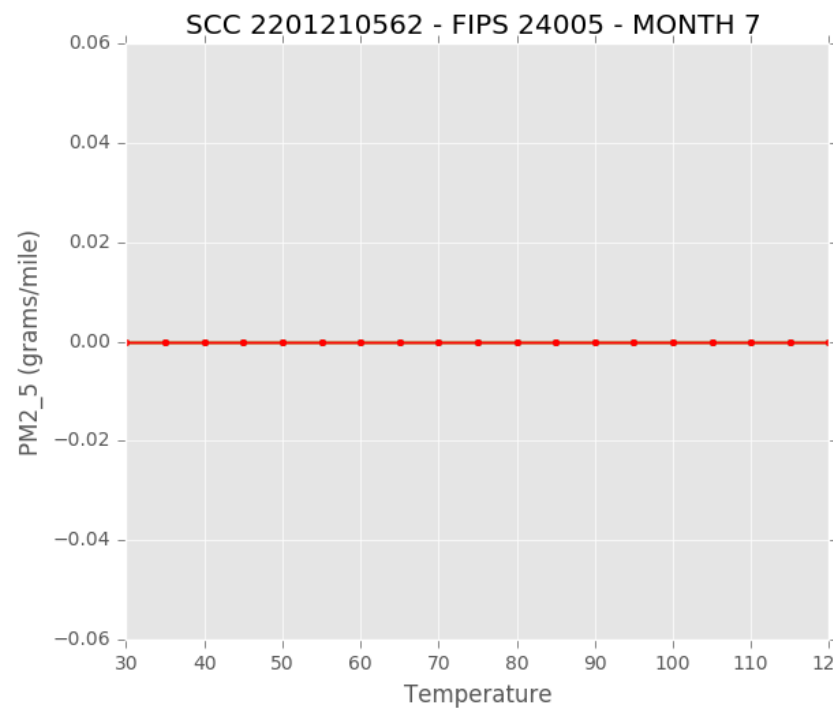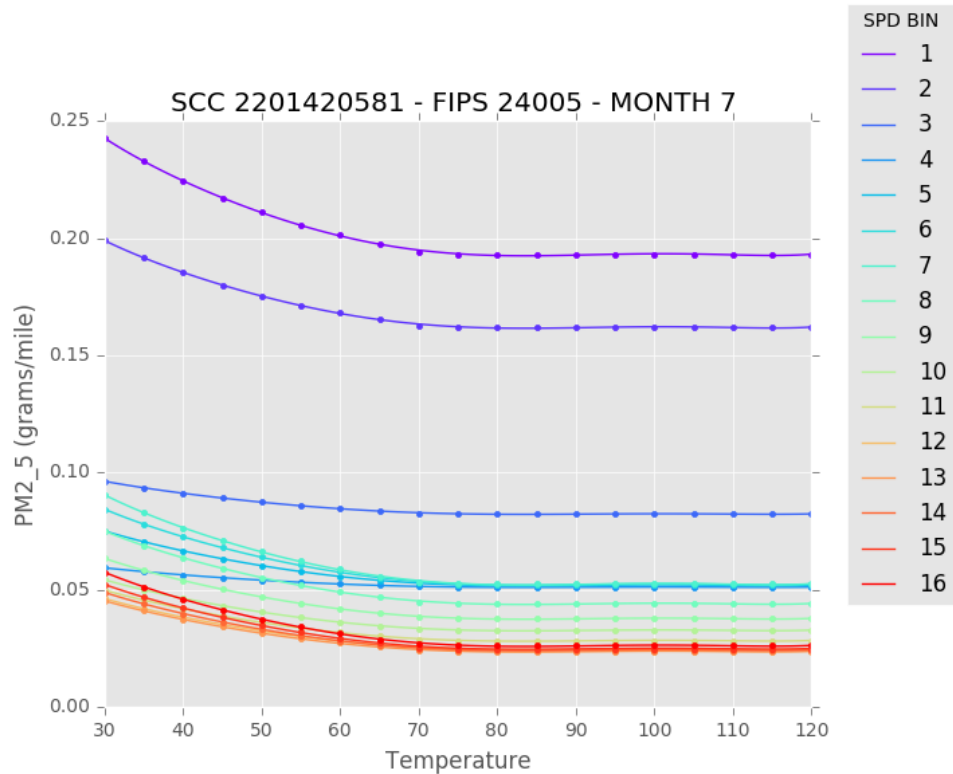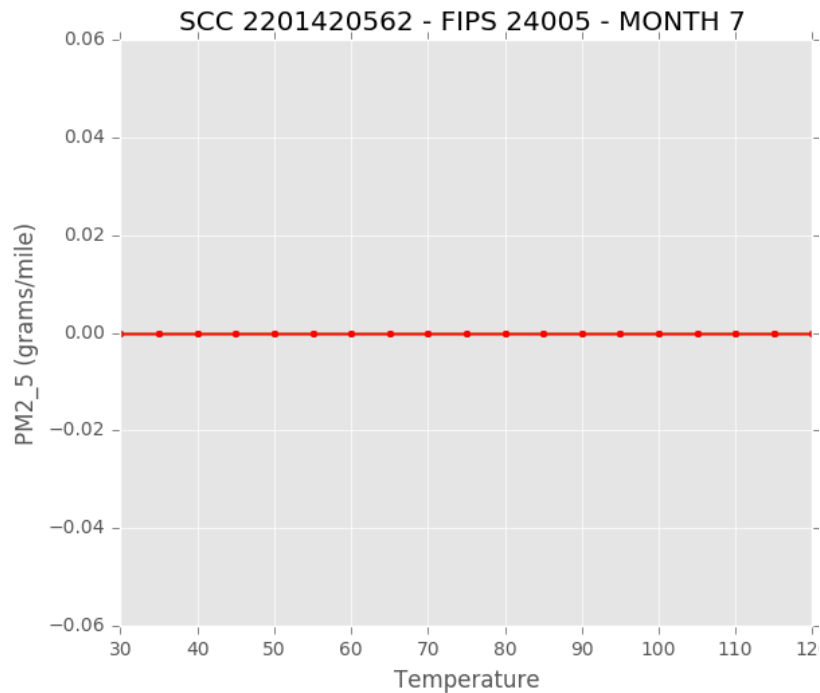# TOG: Gasoline-Transit Buses : Urban Unrestricted Access
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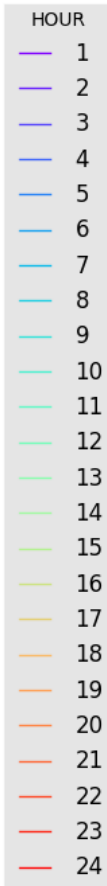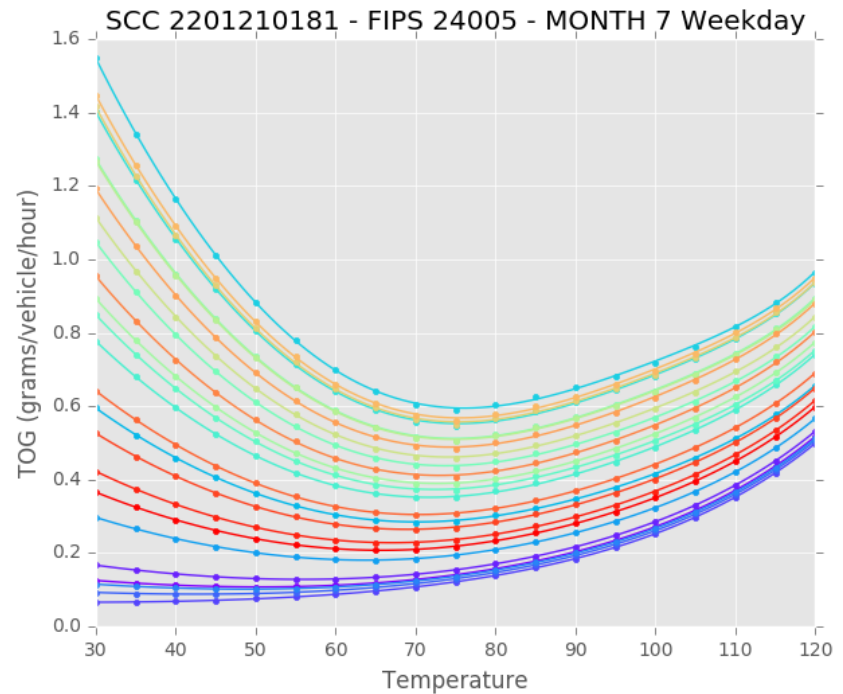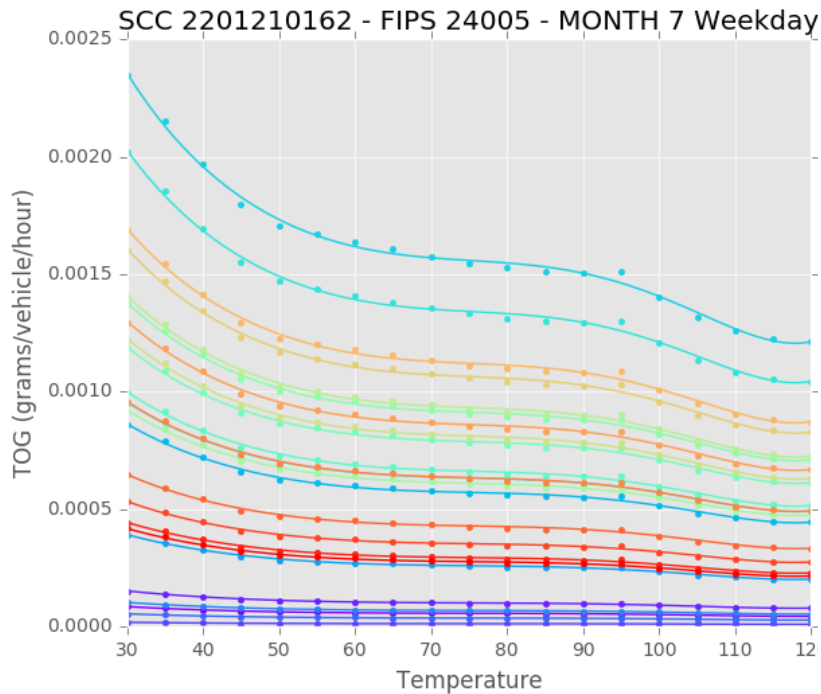## Refueling [62] and All Exhaust, Evaporative, Brake and Tire [81]
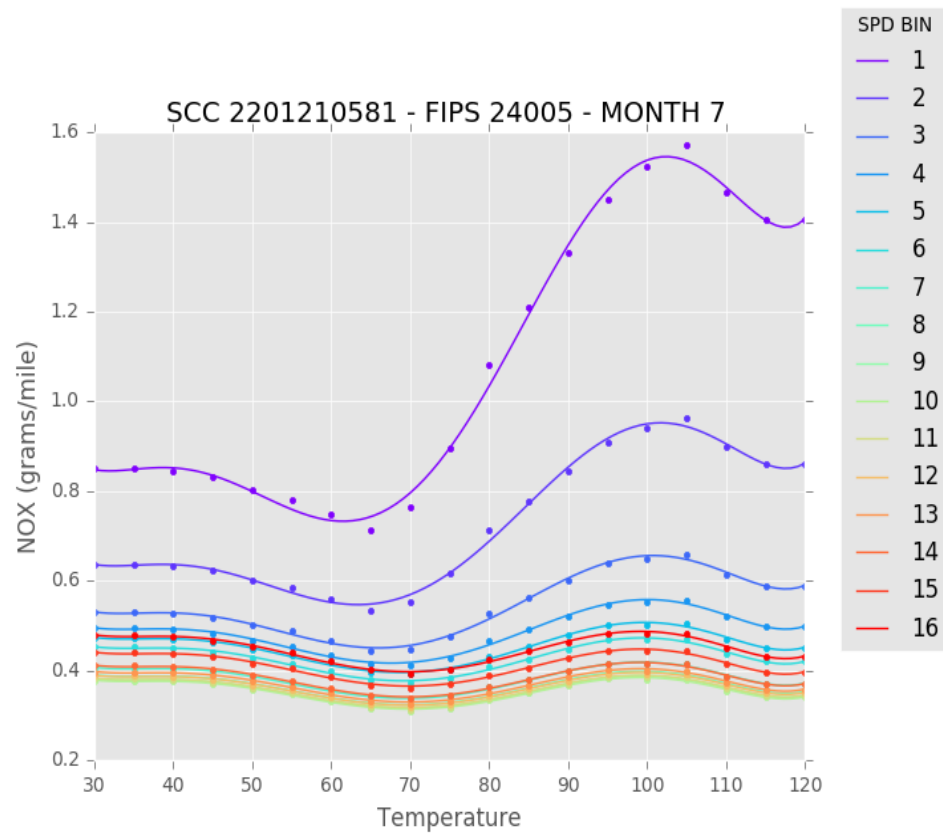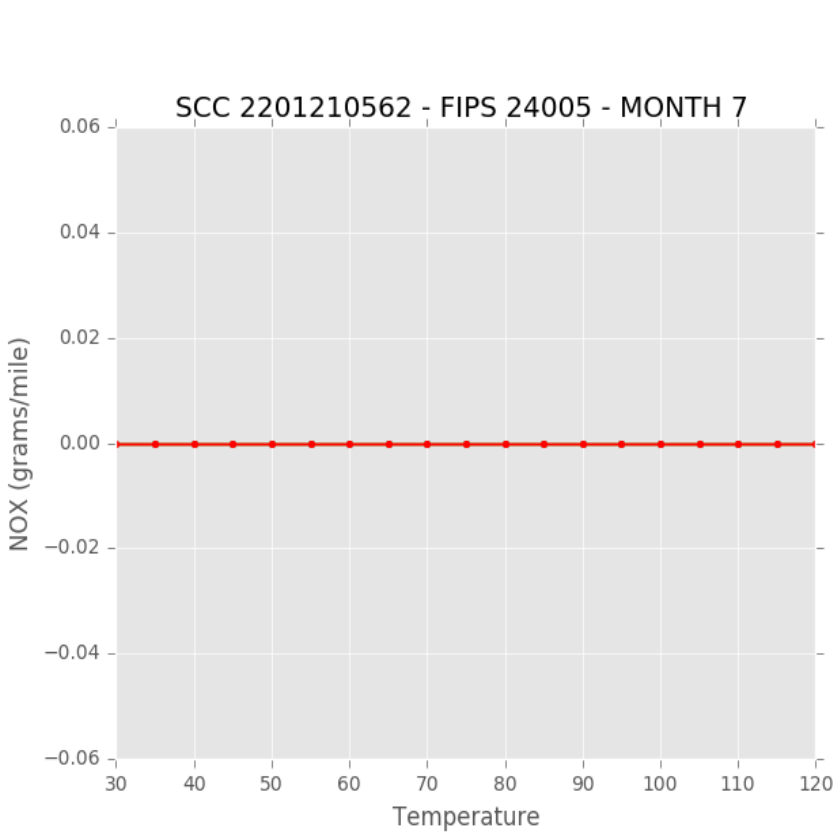
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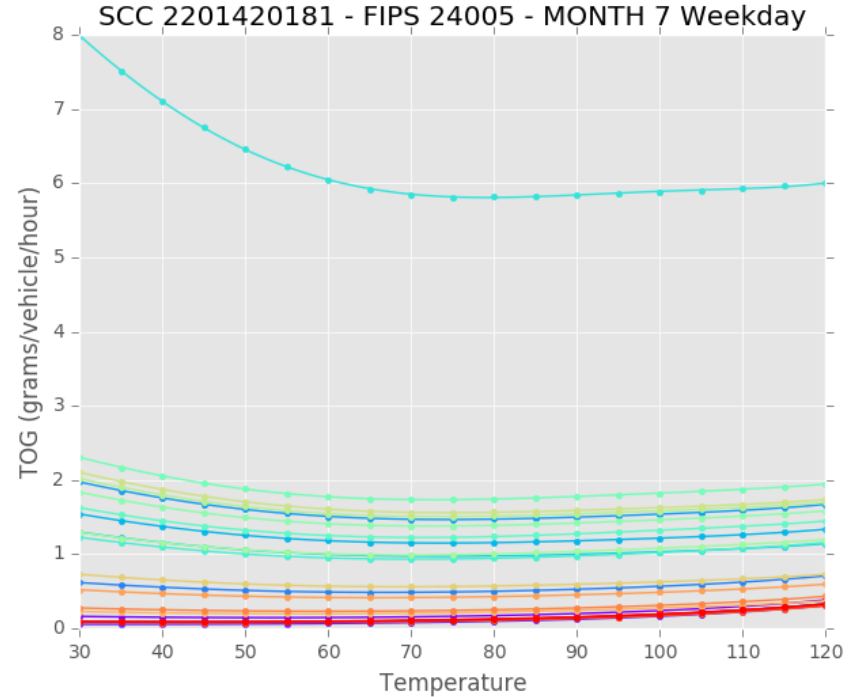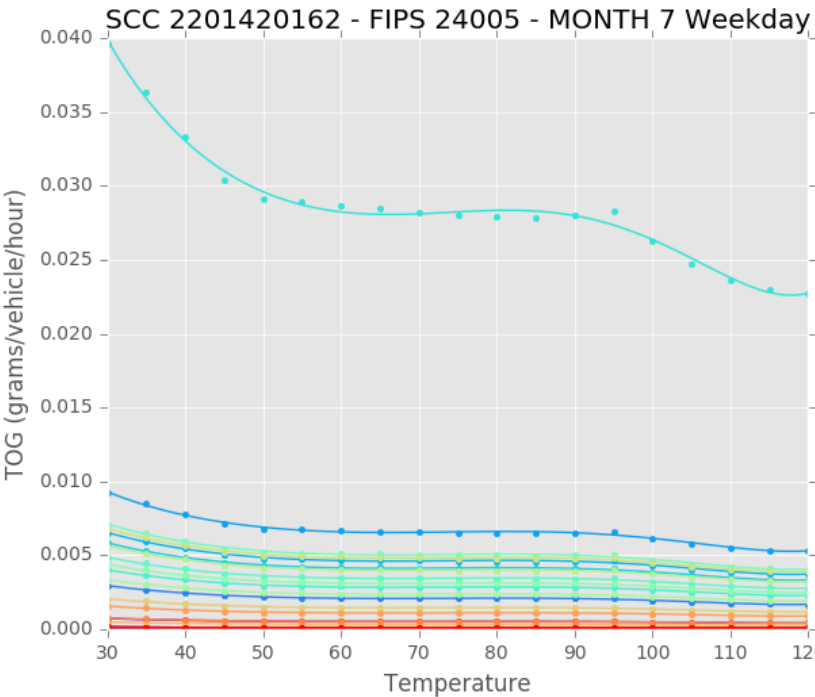## Refueling [62] and All Exhaust, Evaporative, Brake and Tire [81]

PM2.5: Gasoline-Passenger Car: Urban Unrestricted Access
Refueling [62] and All Exhaust, Evaporative, Brake and Tire [81]

PM2.5: Gasoline-Transit Buses : Urban Unrestricted Access
Refueling [62] and All Exhaust, Evaporative, Brake and Tire [81]

Rate Per Vehicle (RPV)

TOG: Gasoline-Passenger Car : Off-network
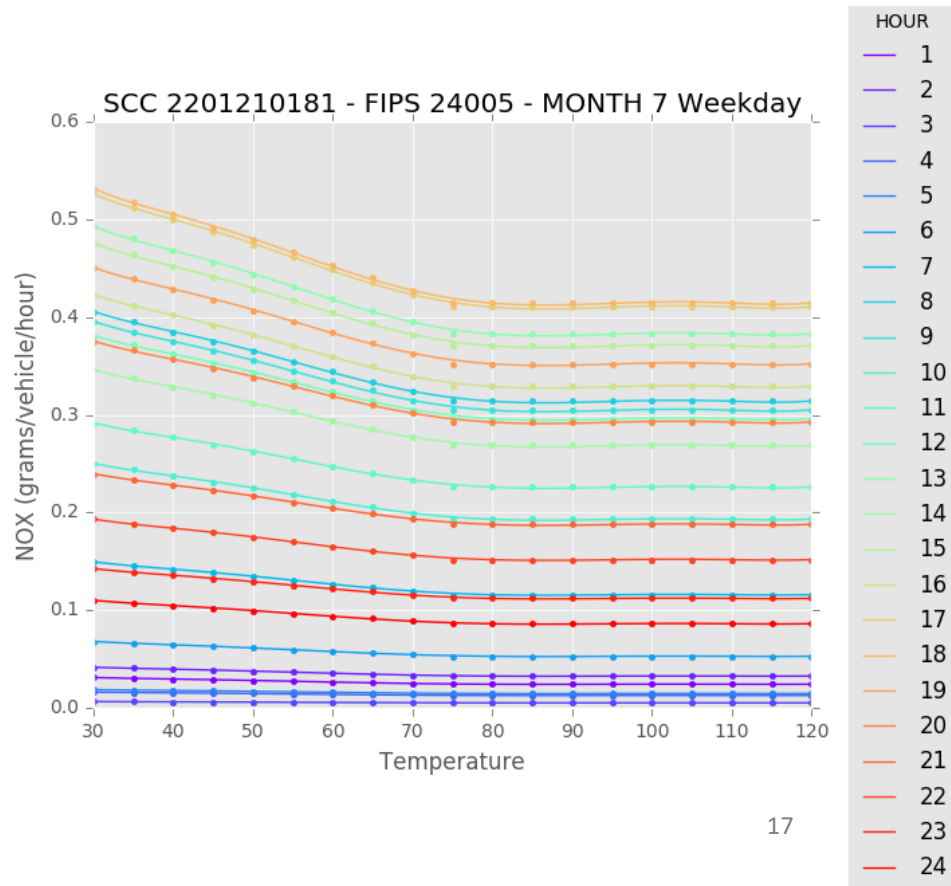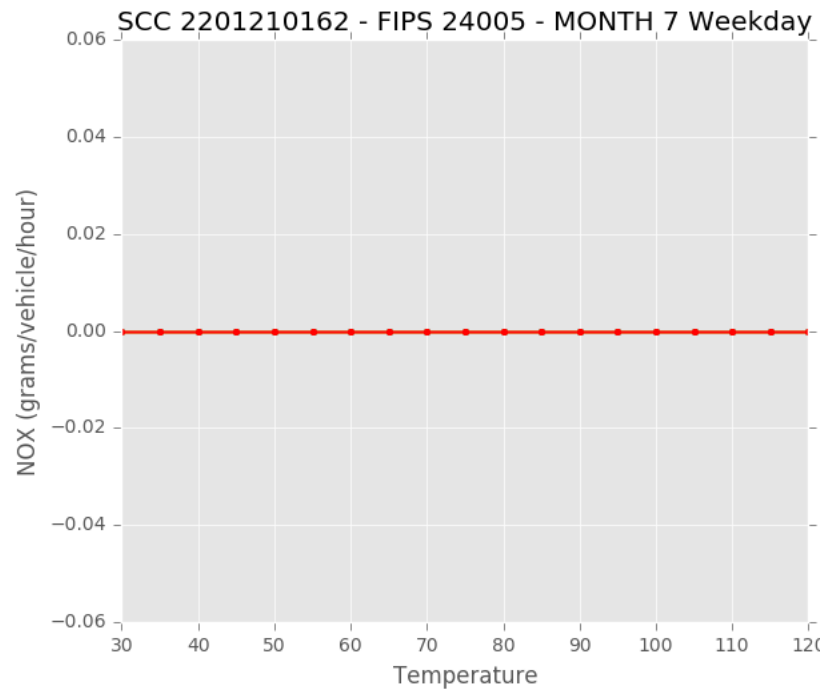## Refueling [62] and All Exhaust, Evaporative, Brake and Tire [81]

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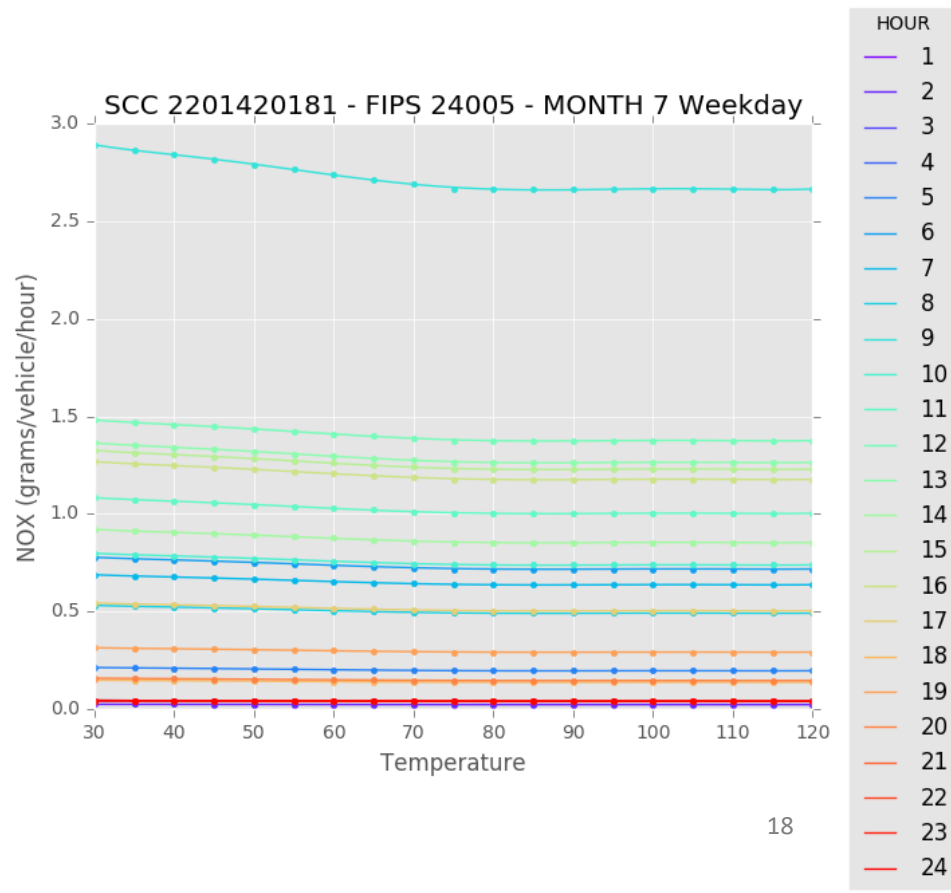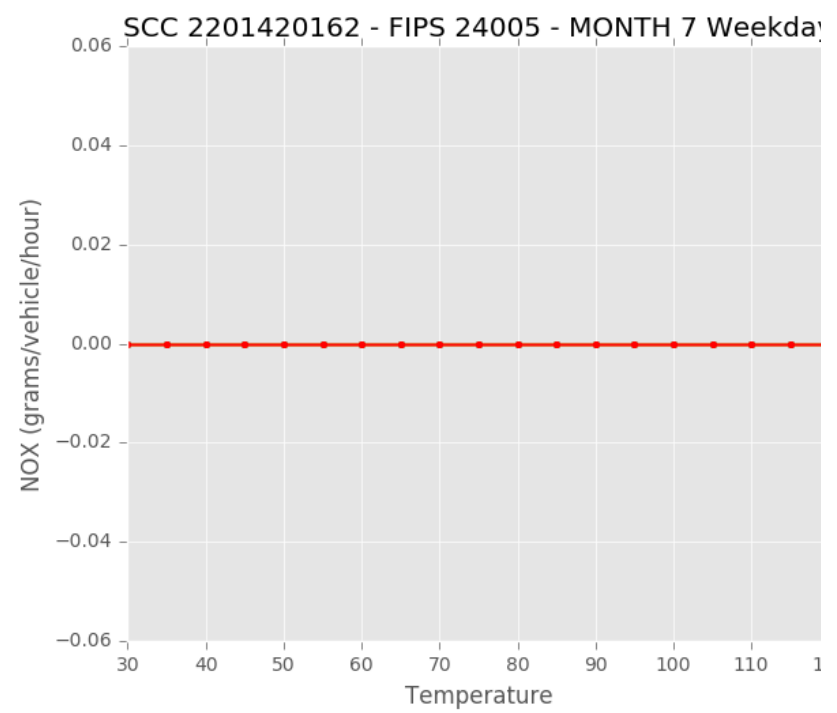## Refueling [62] and All Exhaust, Evaporative, Brake and Tire [81]

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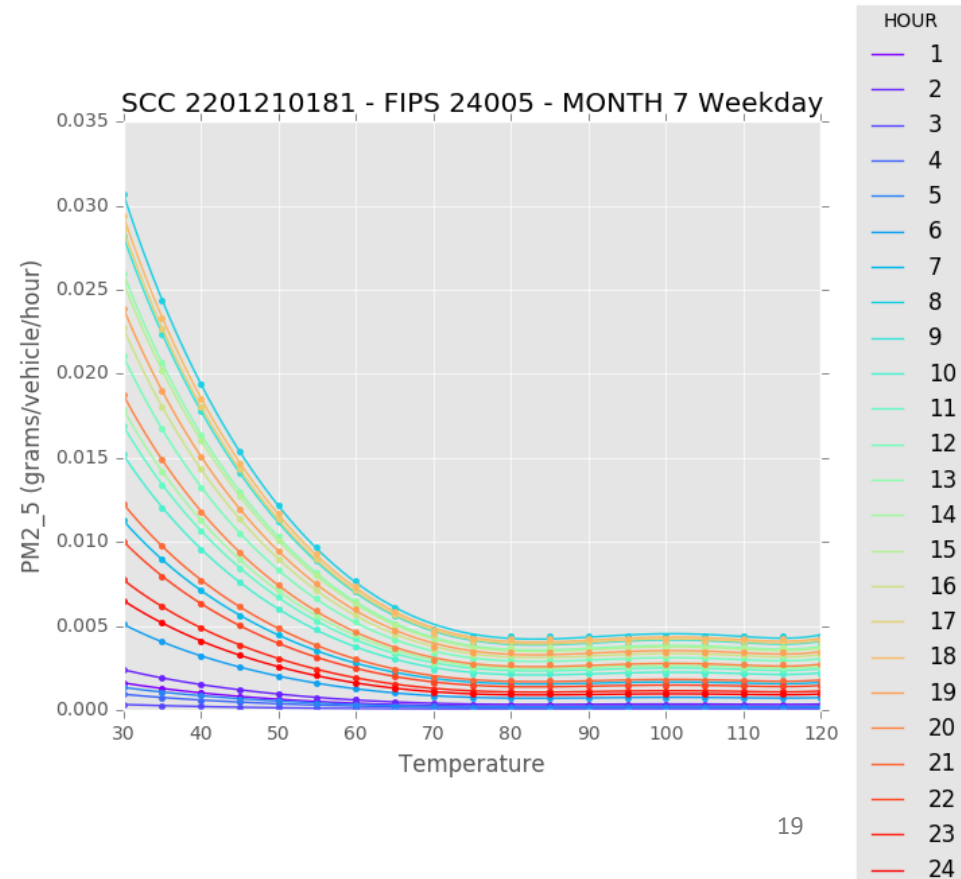## Refueling [62] and All Exhaust, Evaporative, Brake and Tire [81]
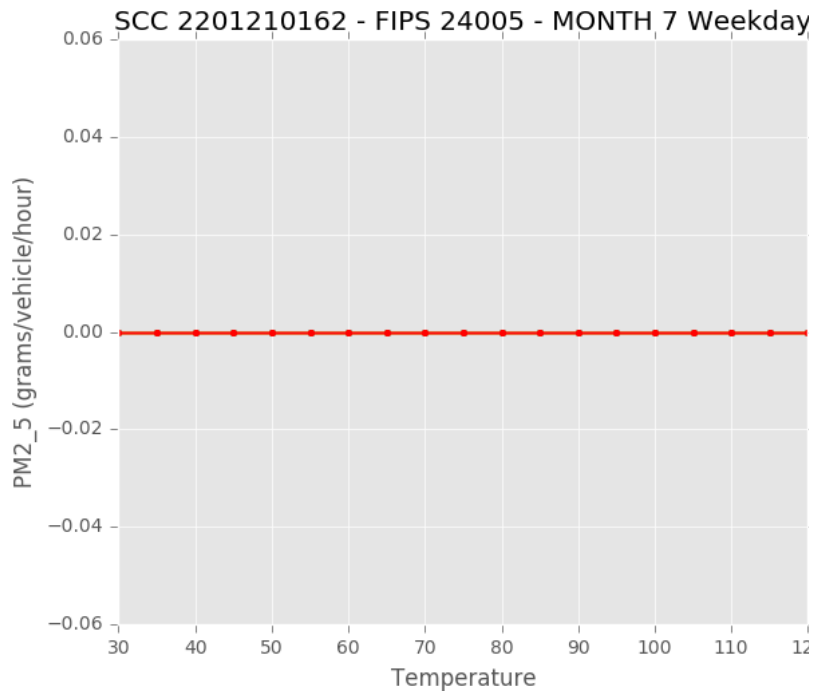
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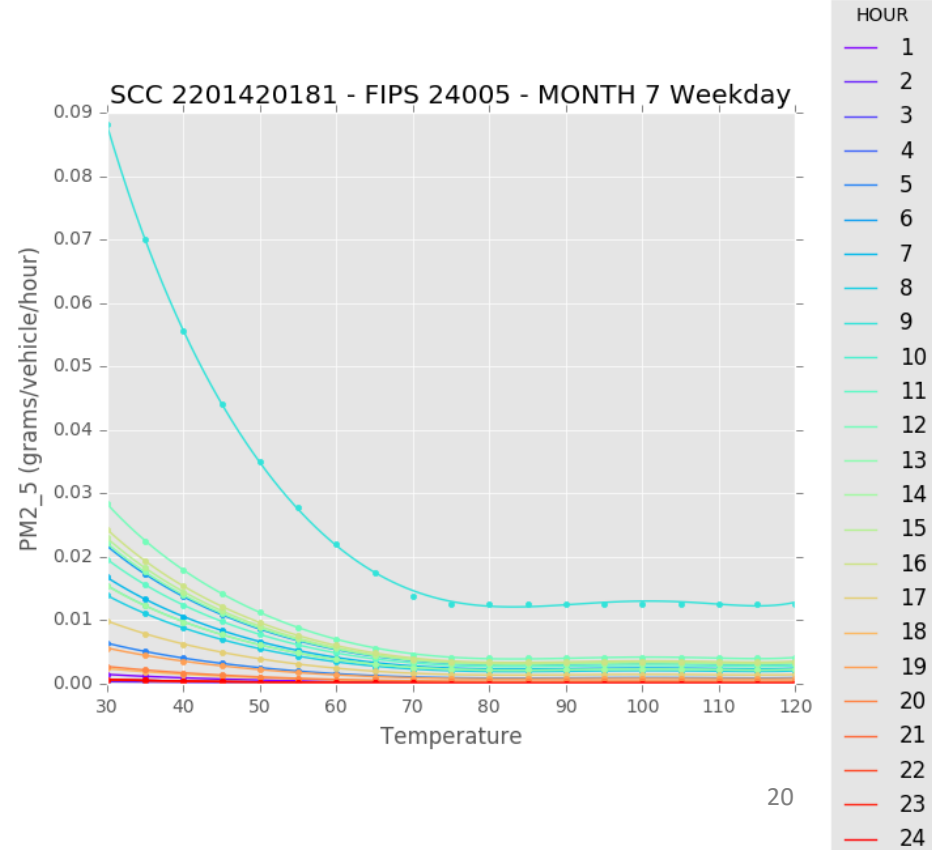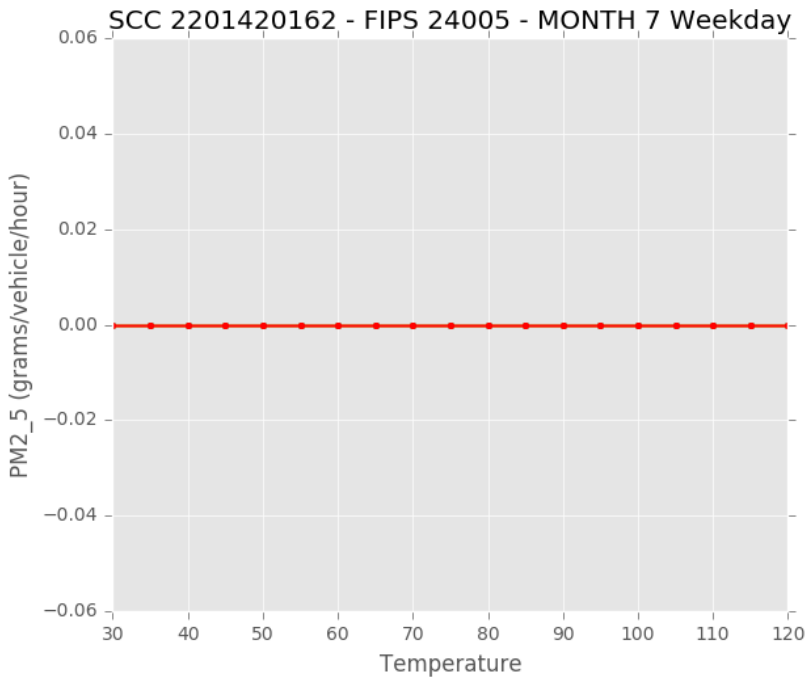## Refueling [62] and All Exhaust, Evaporative, Brake and Tire [81]

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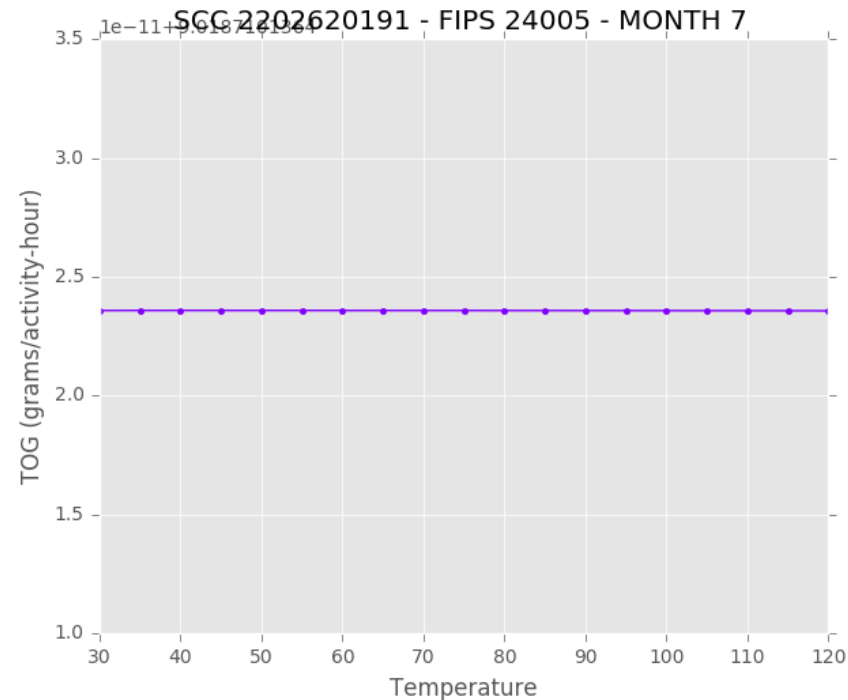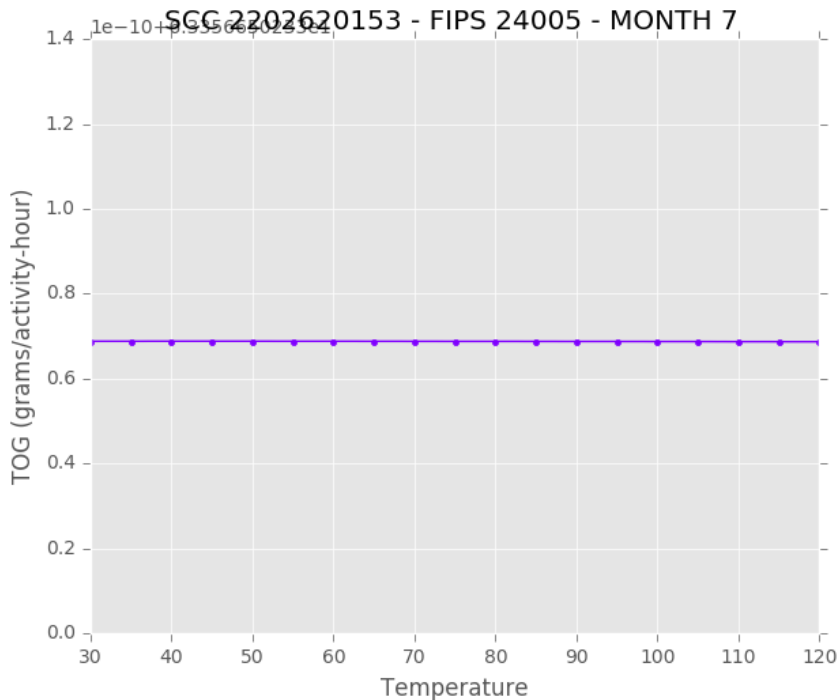# PM2.5: Gasoline-Transit Buses : Off-network
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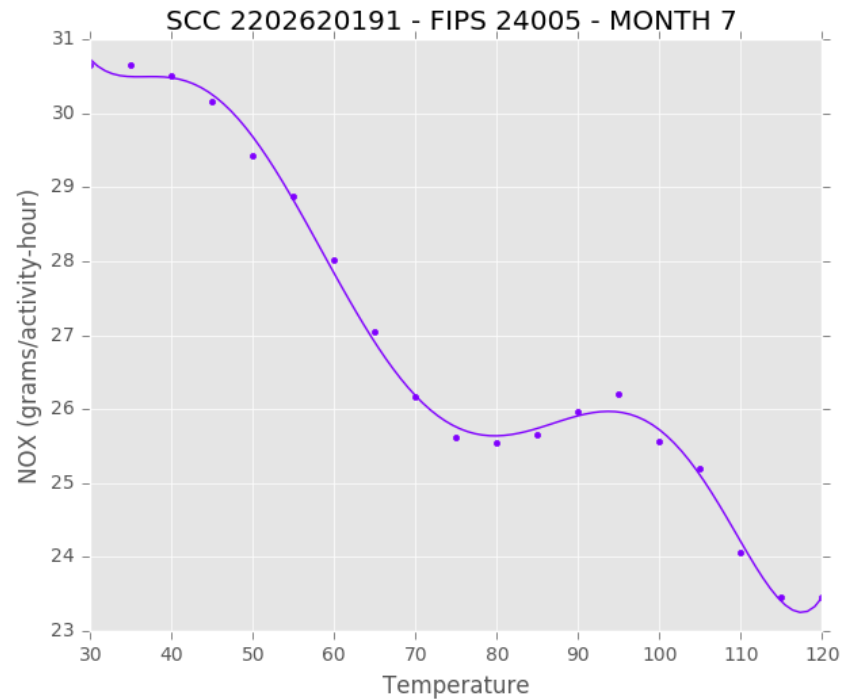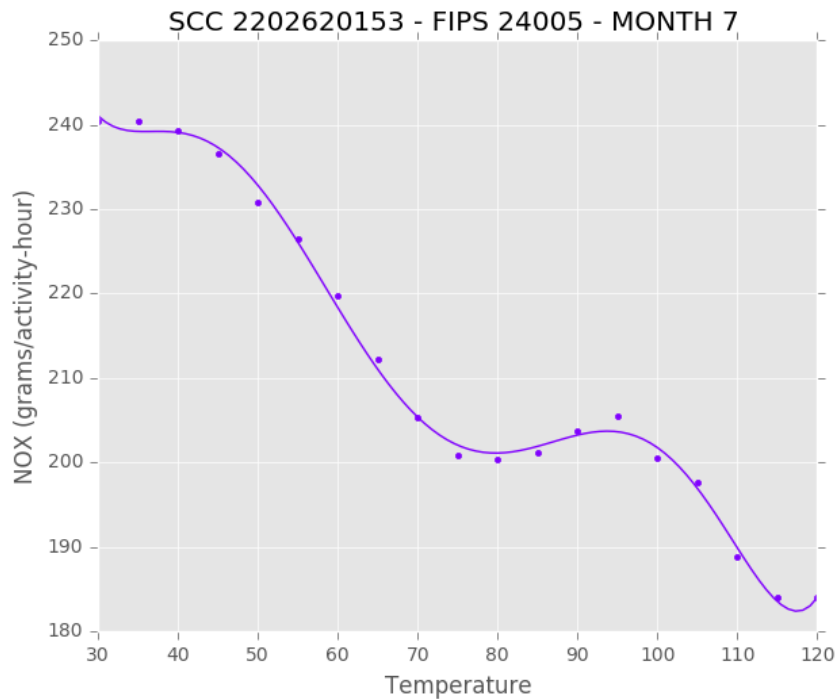
Rate Per Hour (RPH)

TOG: Diesel Long-haul Truck : Off-network
Extended Idle Exhaust [53] and Auxiliary Power Exhaust [91]

NOx: Diesel Long-haul Truck : Off-network
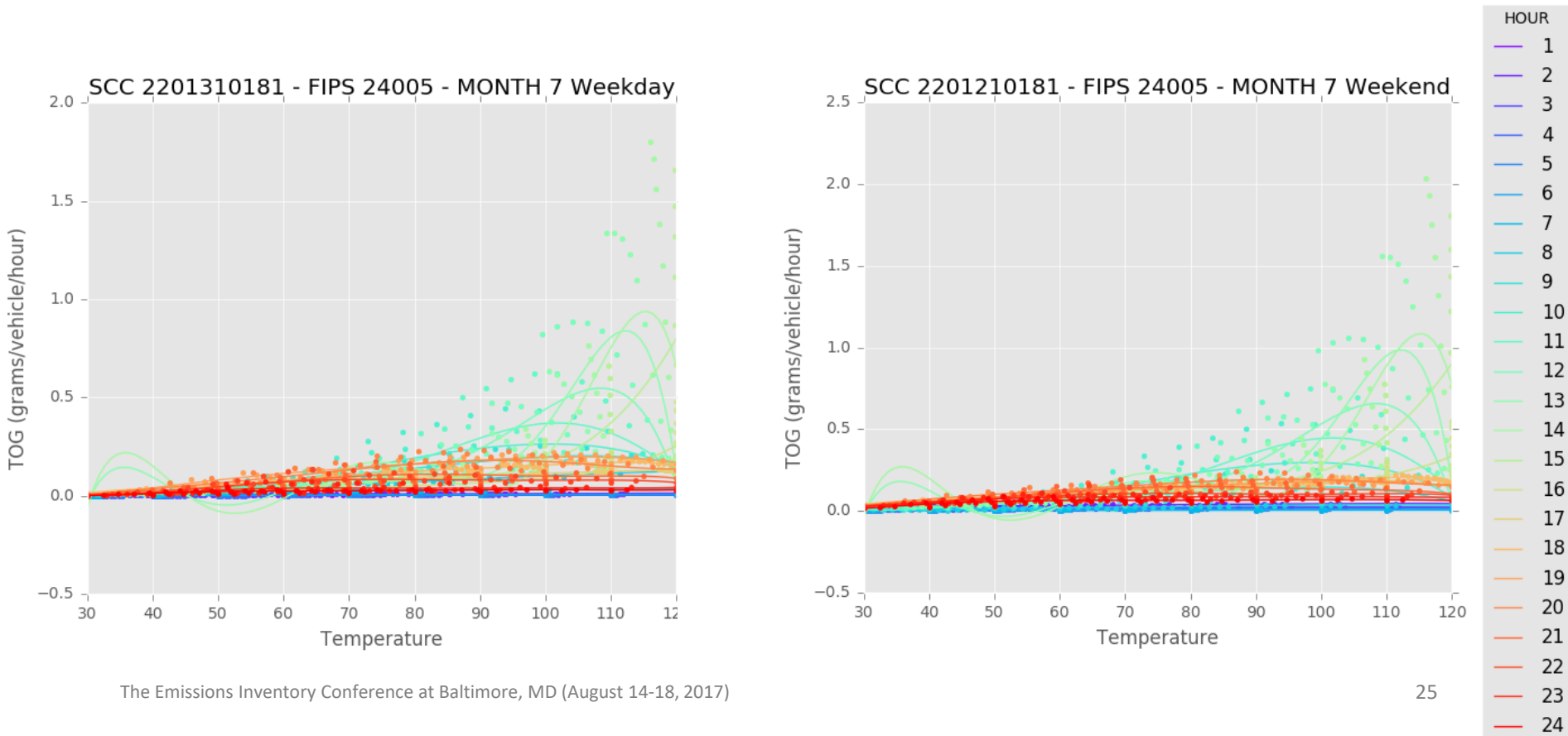## Extended Idle Exhaust [53] and Auxiliary Power Exhaust [91]
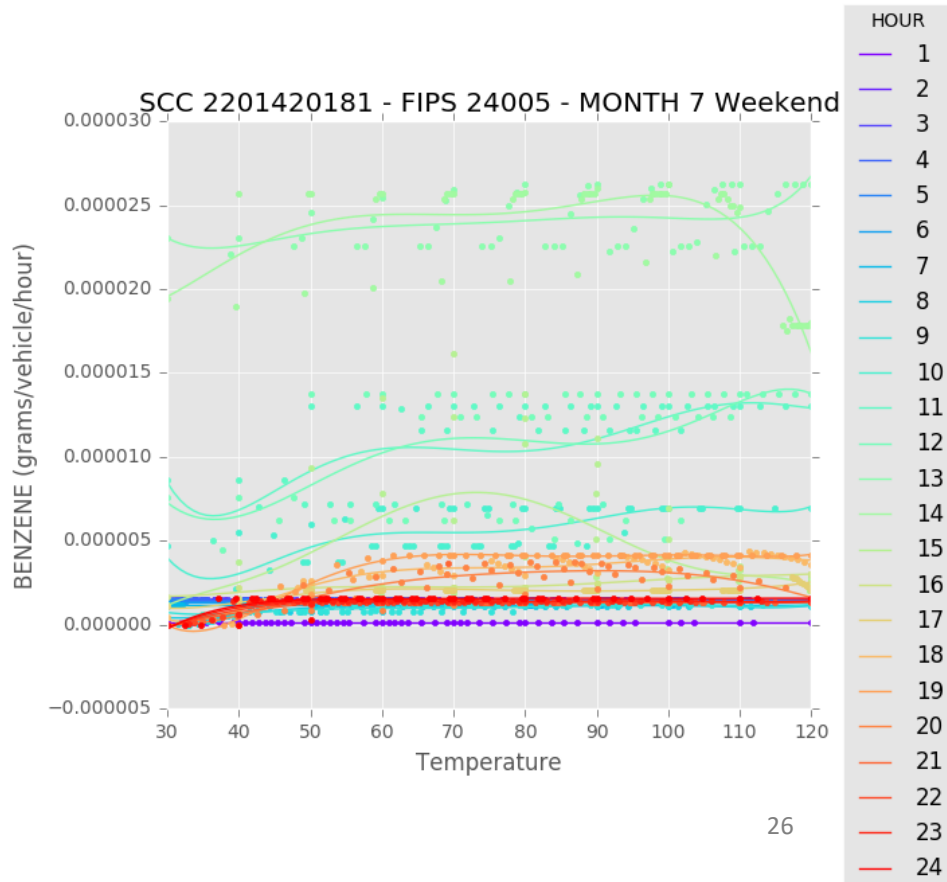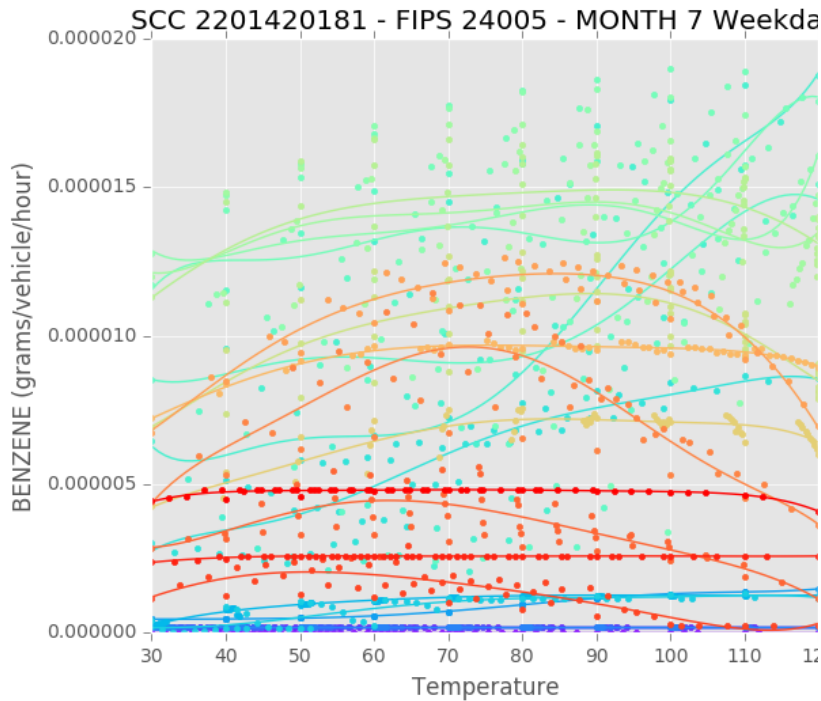
Rate Per Profile (RPP)

TOG: Gasoline-Passenger Cars : Off-network
All Exhaust, Evaporative, Brake and Tire [81] : Weekday vs. Weekend

TOG: Gasoline-Transit Buses: Off-network
All Exhaust, Evaporative, Brake and Tire [81] : Weekday vs. Weekend

File Size Comparison

- The main factors of NetCDF-format MOVES BCFA Lookup Table Size:
  - Temperature Bins
  - Number of Pollutants
  - Number of Vehicle/Road/Processes (=SCC)
  - Order of algorithms and Intercept values

- Do not expect significant changes in the size of NetCDF BFCA Lookup Tables

- <u>Significant improvement on Movesmrg computational processing time and memory usages</u>

- Increase no of MOVES BCFA lookup tables for a better accurate estimate

Sectors	ASCII (MB)	CSV* (MB)	NetCDF* (MB)
RPD	95-150 (77*)	33	20
RPV	45-100 (55*)	25	15
RPP	15-50 (17*)	2.2	1.4
RPH	<1MB (.65*)	0.7	2.7

* Size estimate is based on Baltimore reference county

Future Applications

- Integrated with current SMOKE Modeling System to reduce the computational time/memory usages, and enhance the quality of mobile emissions with more number of reference counties

- Coupled with various air quality modeling systems:
  - CMAQ-MOVES
  - WRF-CMAQ-MOVES
  - CAMx-MOVES

- BCFA by vehicle and road types can be incorporated with the other mobile emissions models that do not handle local meteorological conditions well.

Acknowledgement

- **Korea National Institute of Environment and Research (NIER)**

- **U.S. EPA**
  - ○ Office of Air Quality Planning and Standards (**OAQPS**)
  - ○ Office of Transportation and Air Quality (**OTAQ**)