Parameterization of MOVES-based Onroad Mobile Emission Factors Lookup Tables in SMOKE

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Background

- SMOKE-MOVES Integration Tool Released on 2010

- 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

- **304** Reference Counties for Continental U.S. Modeling Domains with Two Fuel Months per Each Reference County (Based on NEI 2014 Modeling Platform)
- **Size of MOVES Lookup Tables:**
  - **RPD: 85-150MB (66.7GB), RPV: 28-86MB (36GB), RPP: 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

Future Plans

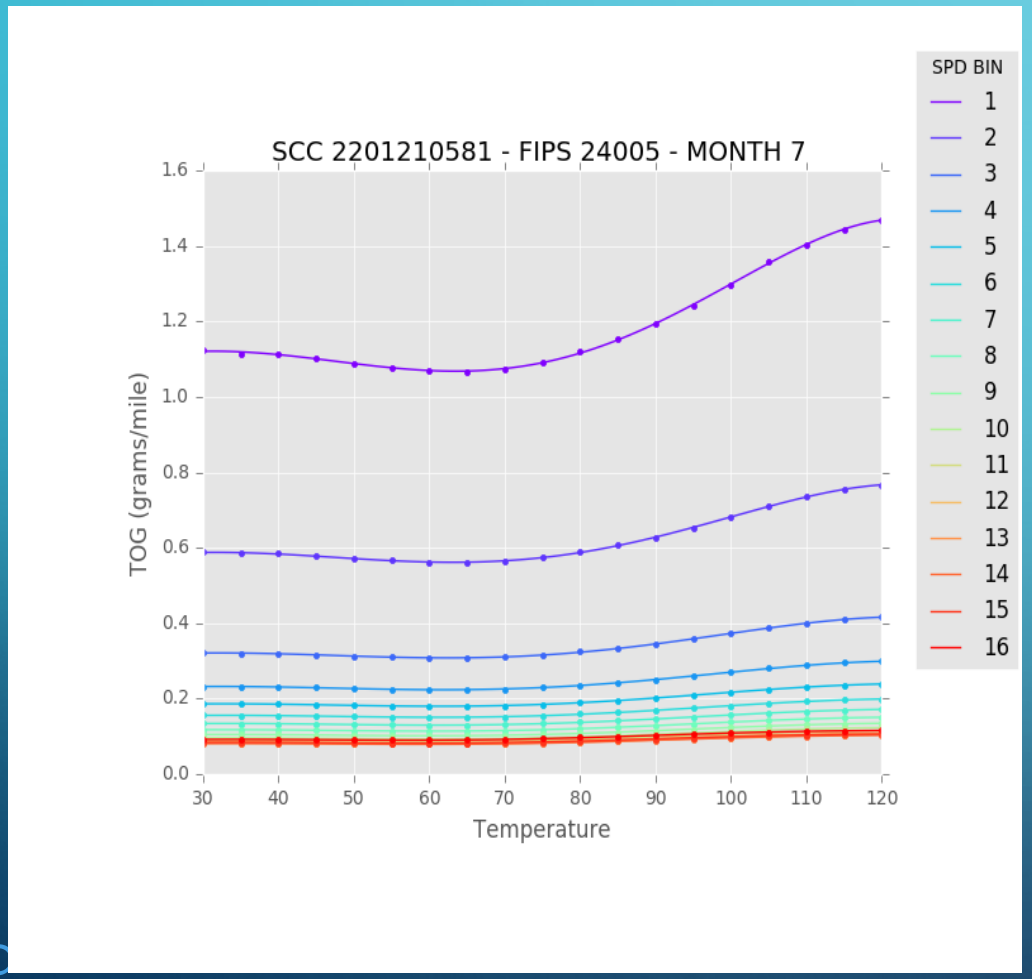
- Computational Optimization of the SMOKE-MOVES Integration tool
- Reduce the size and numbers of MOVES EF lookup tables:
  - Aggregated Processes (Less than 15 processes)
  - Aggregated Vehicle and Road Types
  - Reduced optimized temperature increments
  - Limited numbers of reference counties.
- Convert current ASCII-formatted MOVES EF lookup tables into NetCDF format

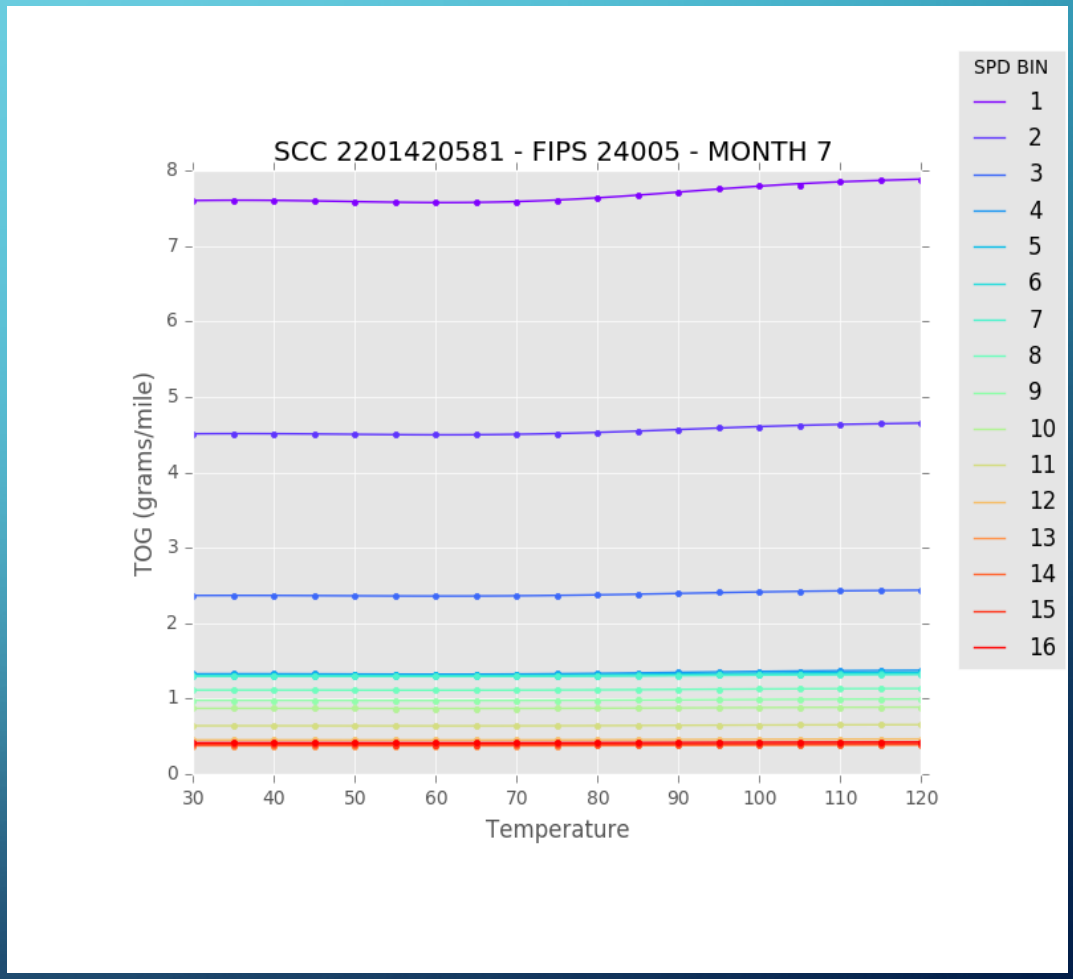
Proposed BCFA Method

- Parameterization of Current ASCII-format MOVES EF Lookup Tables into Polynomial Algorithms using **Best-Fitted Curve Algorithms (BFCA)** [**Done**]
- Store the algorithms in NetCDF format to eliminate I/O bottlenecks: [**Done**]
- Coupling with SMOKE [**Ongoing**]
- Coupling with AQ models including forecasting AQ [**2020**]

RPD TOG: Gasoline-Passenger Car(left) and Buses (Right)

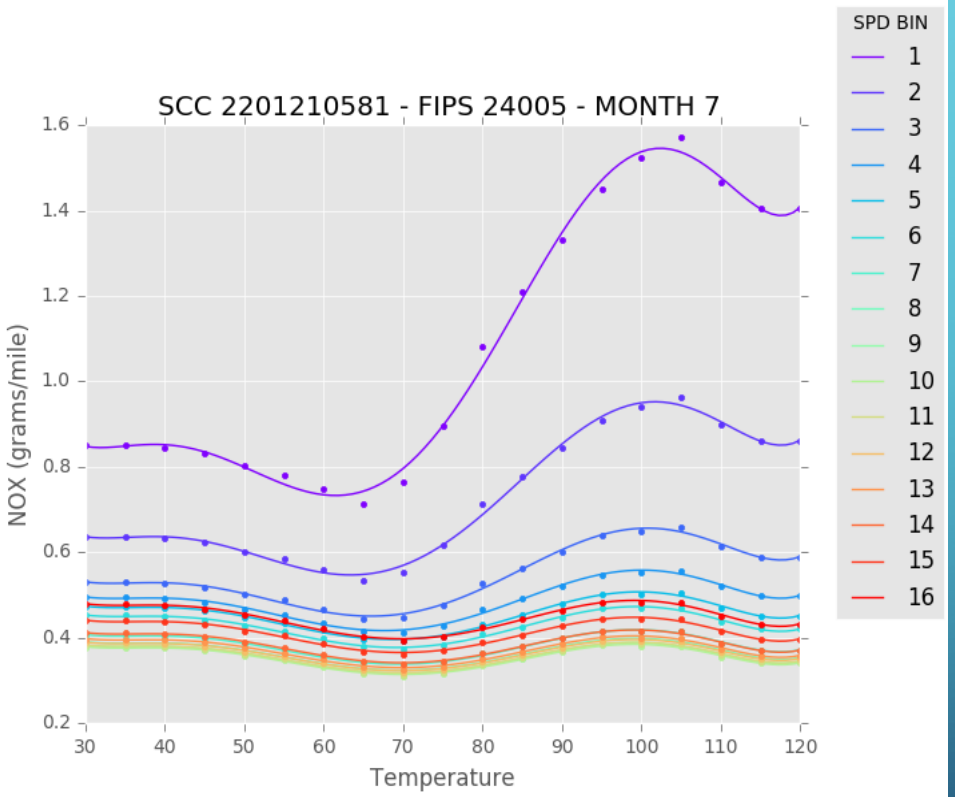
Urban Unrestricted Access
All Exhaust, Evaporative, Brake and Tire [81]

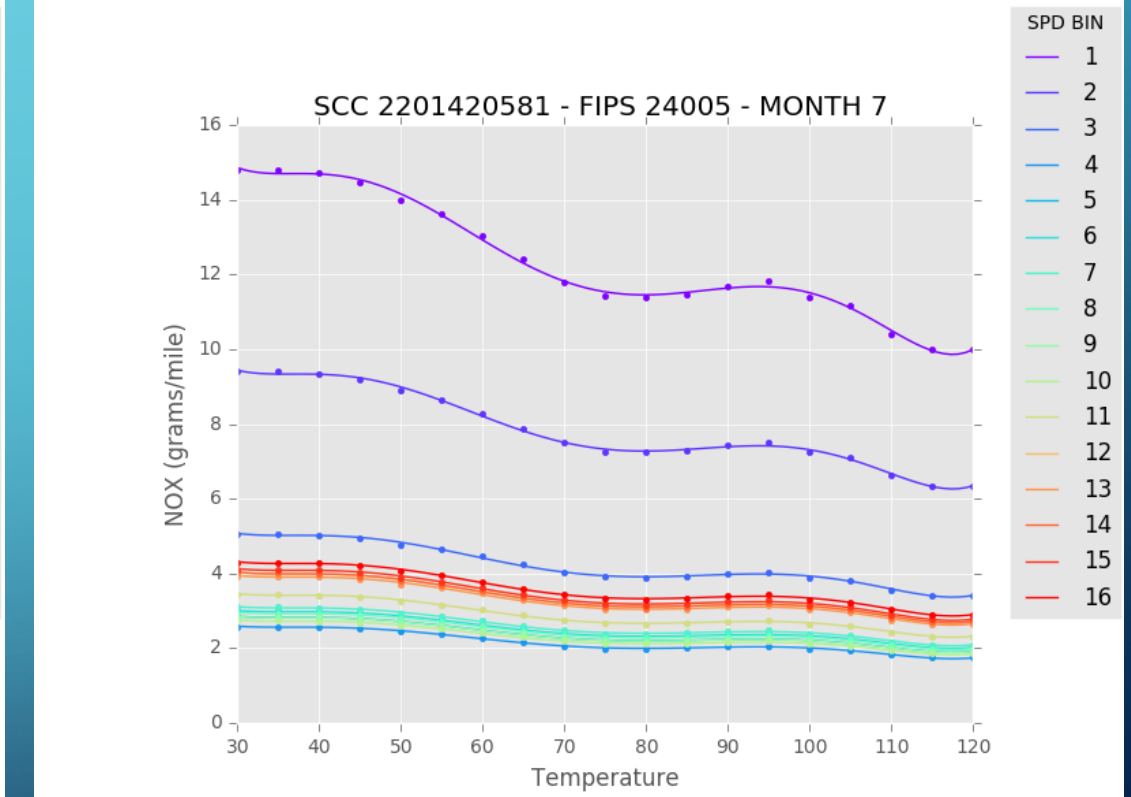




RPD NOx: Gasoline-Passenger Car(left) and Buses (Right)

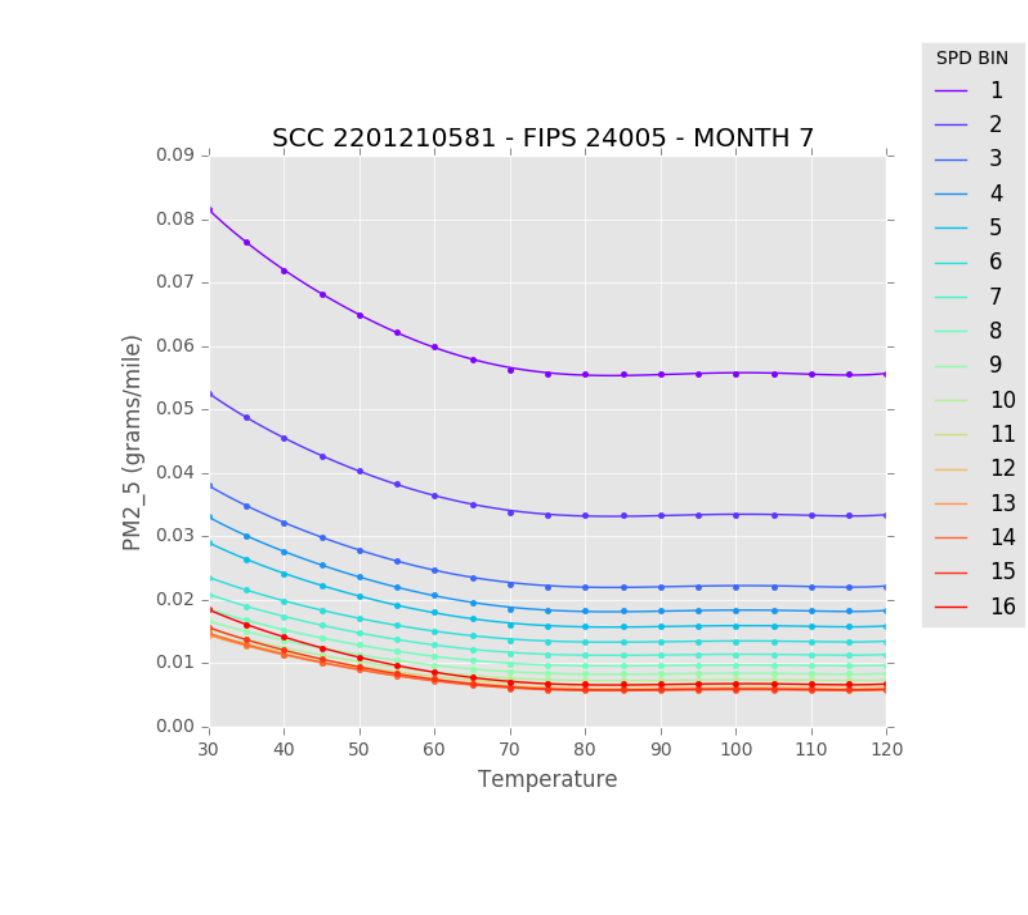
Urban Unrestricted Access
All Exhaust, Evaporative, Brake and Tire [81]

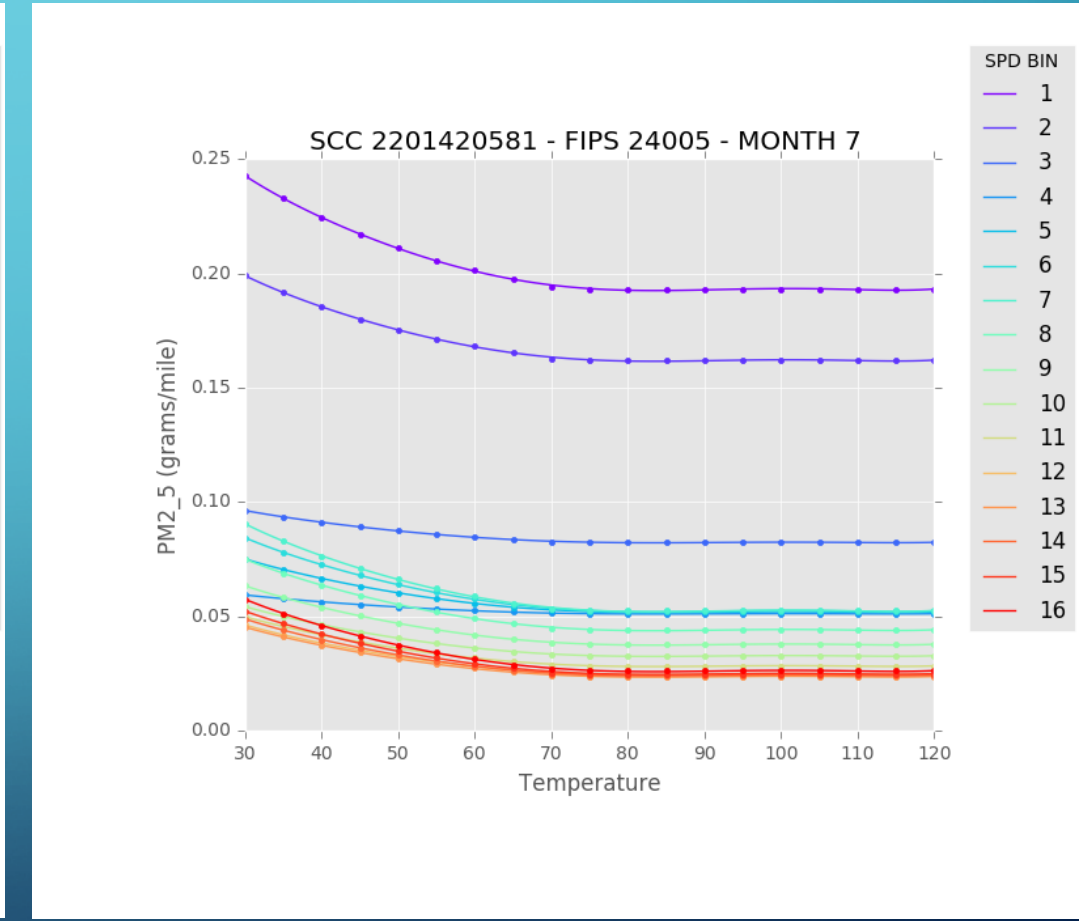




RPD $PM_{2.5}$: Gasoline-Passenger Car(left) and Buses (Right)

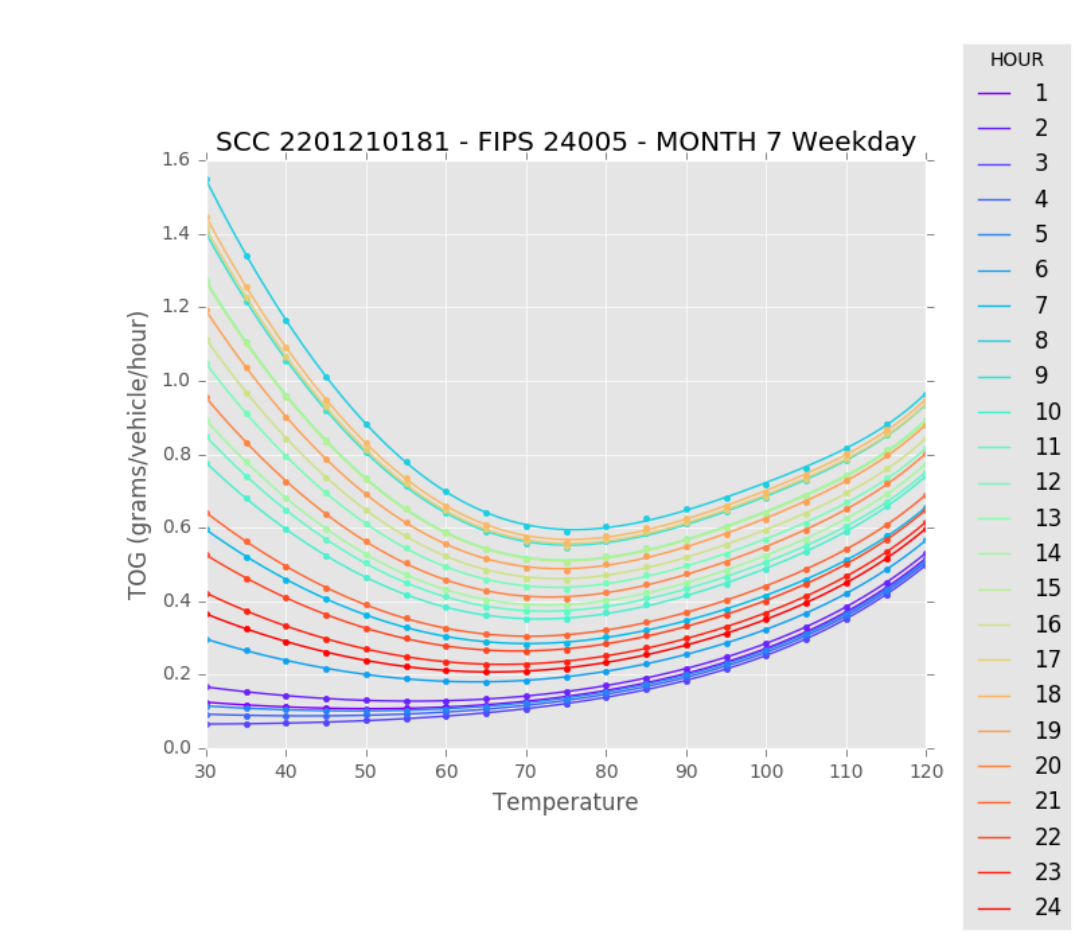
Urban Unrestricted Access
Refueling [62] and All Exhaust, Evaporative, Brake and Tire [81]

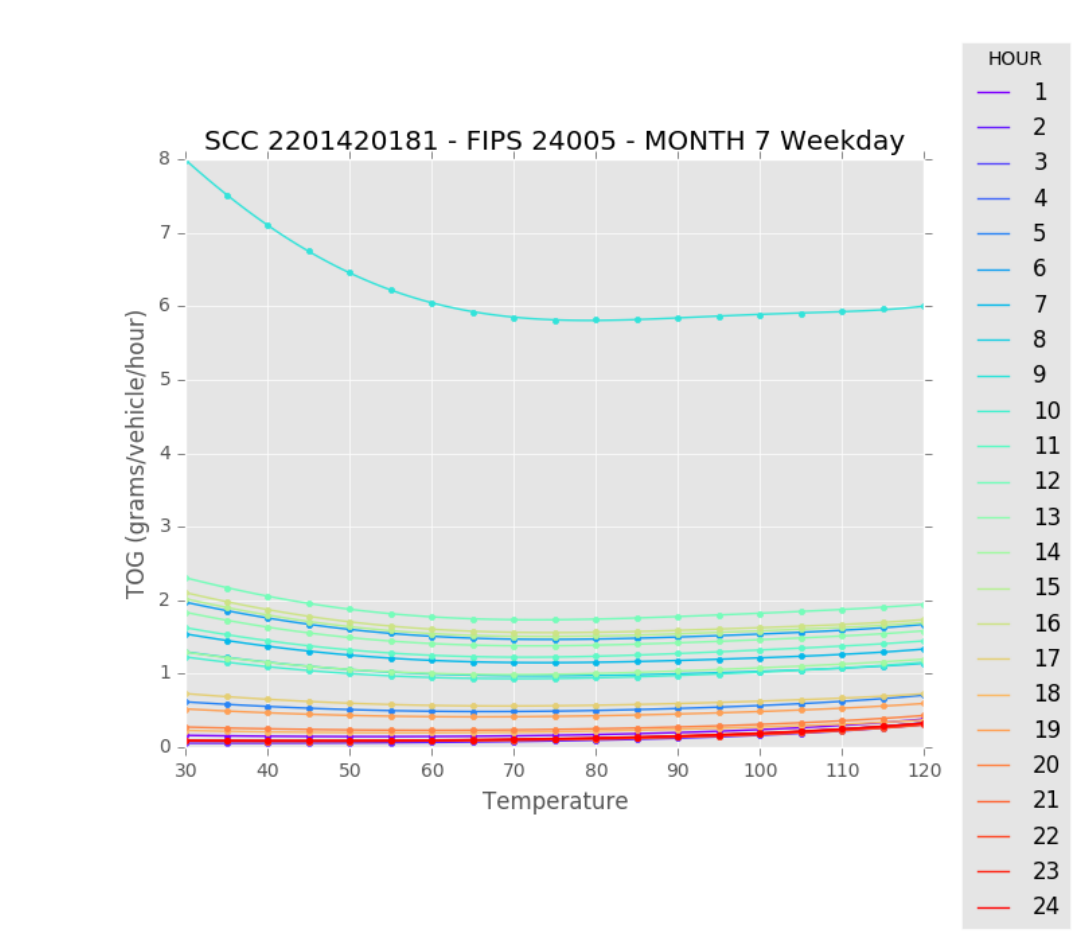




RPV TOG: Gasoline-Passenger Car(left) and Buses (Right)

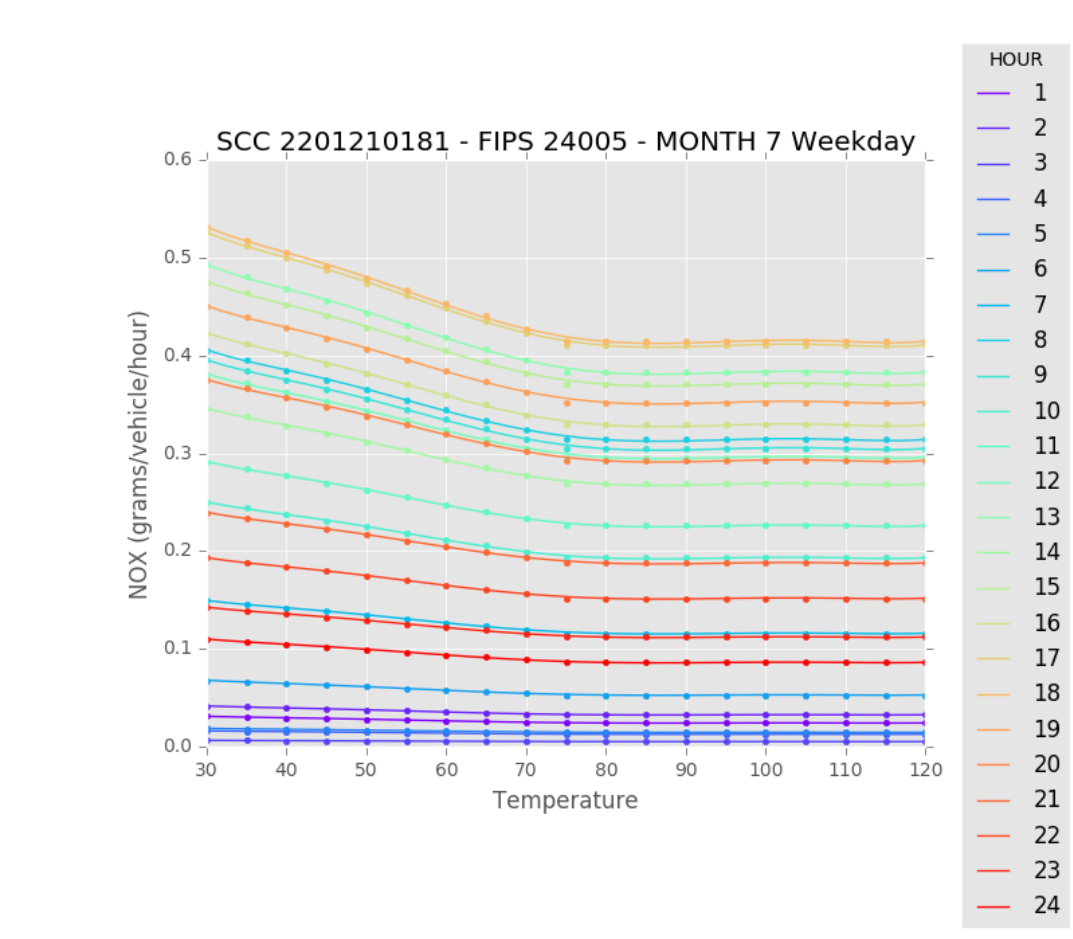
Off-network
All Exhaust, Evaporative, Brake and Tire [81]

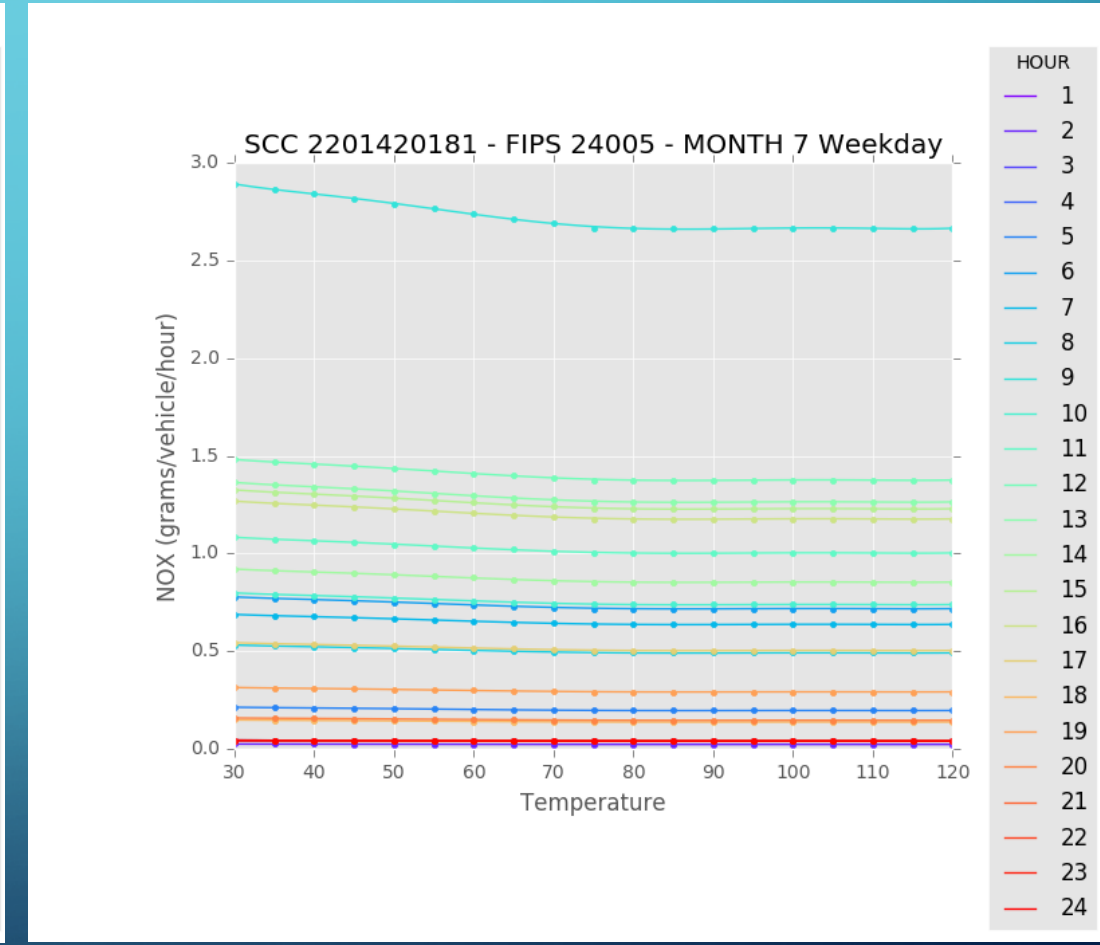




RPV NOx: Gasoline-Passenger Car(left) and Buses (Right)

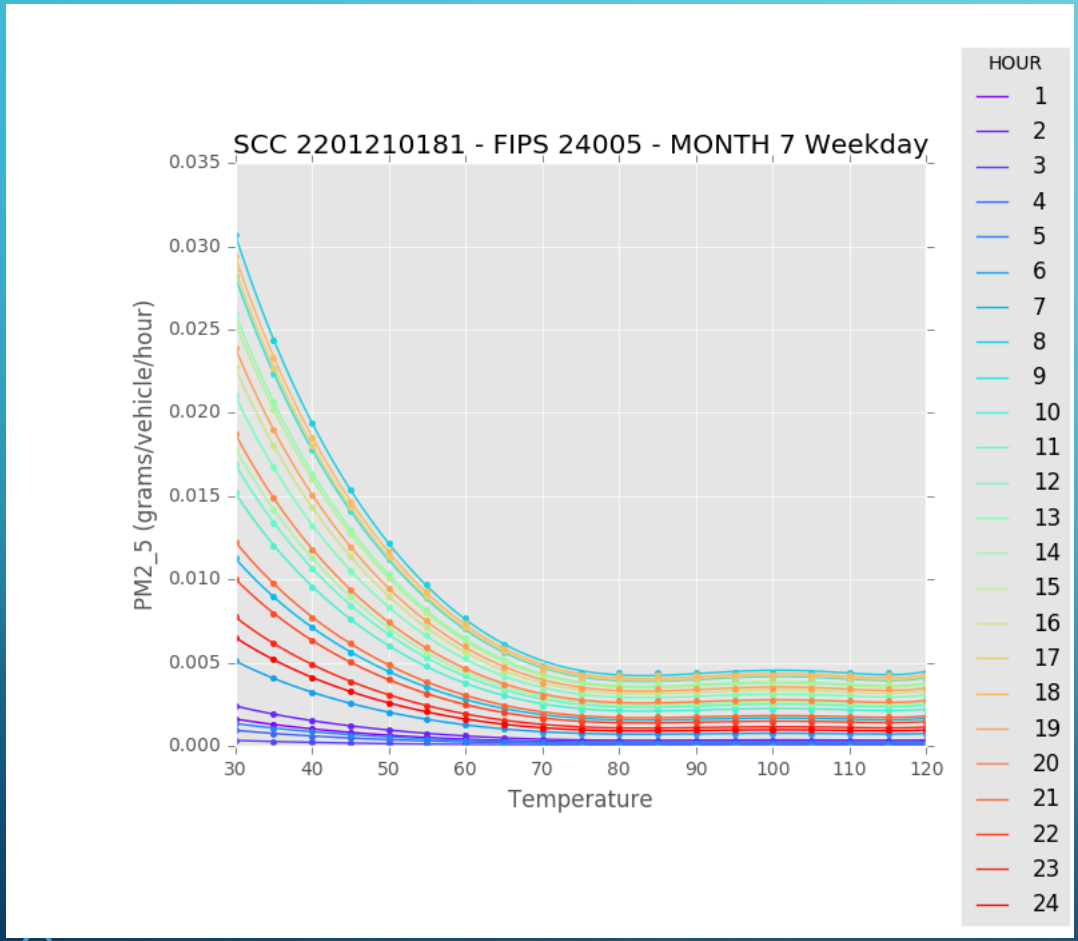
Off-network
All Exhaust, Evaporative, Brake and Tire [81]

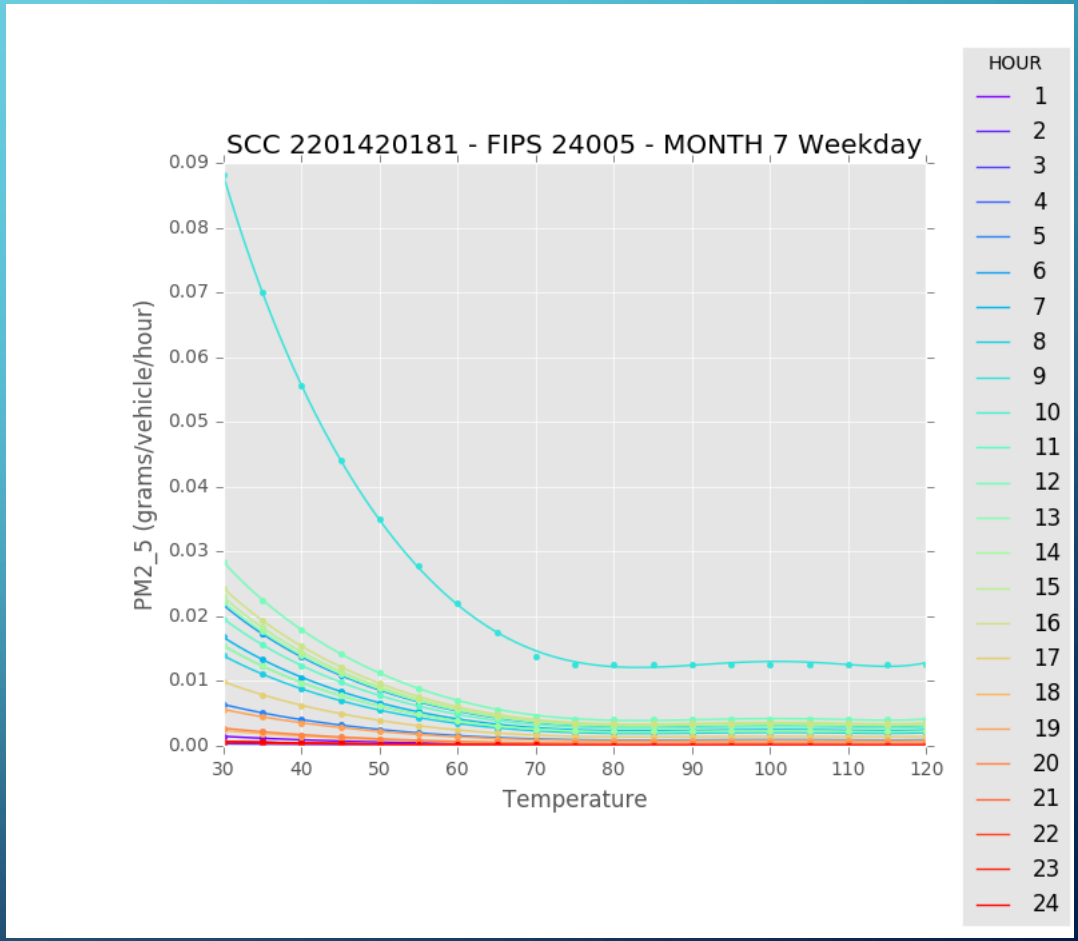




RPV $PM_{2.5}$: Gasoline-Passenger Car(left) and Buses (Right)

Off-network
All Exhaust, Evaporative, Brake and Tire [81]





Polynomial Algorithms Using BCFA Method

$$y = ax^6 + bx^5 + cx^4 + dx^3 + ex^2 + fx + g$$

MOVES BCFA NetCDF formatted Emissions Factors Lookup Table File:

- Days of Week = 7
- No of Pollutatns : 30
- No of SCC : 320
- No of Speed Bin (for RPD) : 16 Bins
- No of Hours (for RPV and RPP) : 24 hours
- Minimum Temperature for all reference Counties
- Minimum Temperature for all reference Counties
- No of Polynomial Coefficients and intercept : 7 (a, b, c, d, e, f, and g)

Sectors	ASCII (MB)	CSV* (MB)	NetCDF* (MB)
RPD	95-150 (77*)	18	4.1
RPV	45-100 (55*)	11	2.1
RPH	<1MB (.65*)	0.11	0.04

Performances

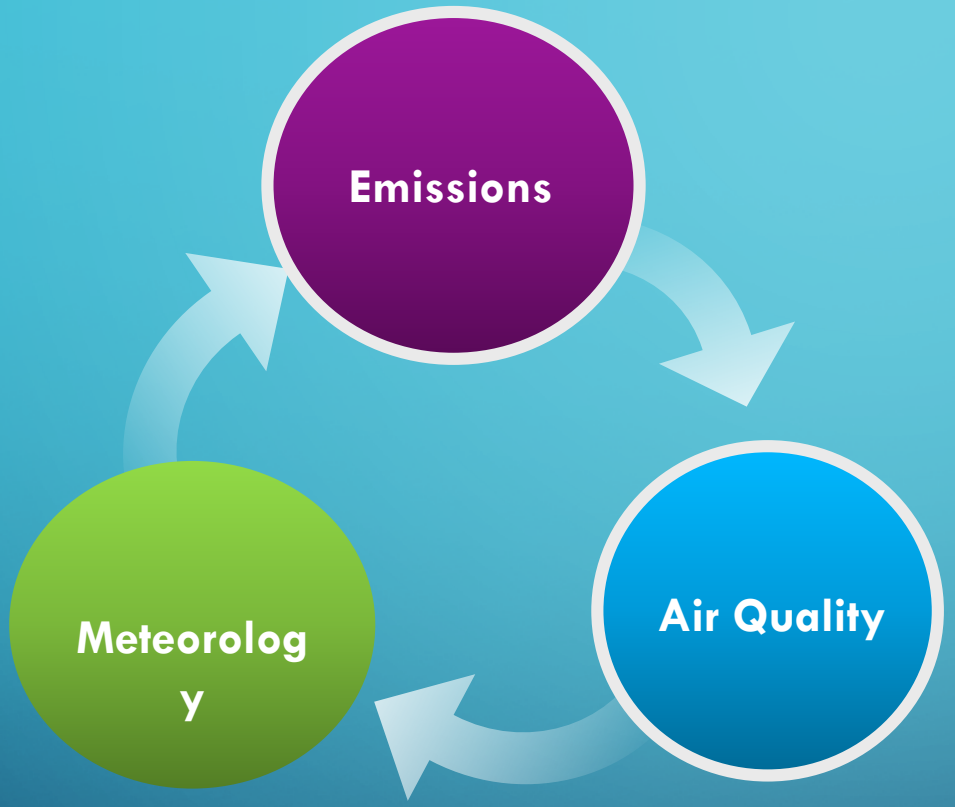
- The size of NetCDF-format MOVES BCFA Lookup Table File : **~2.5G**
  - Two Fuel Months (i.e., January and July) for 304 Reference Counties
- Significant improvement on **SMOKE-MOVES** computational processing time and memory usages:

  - Small Test Case: US12km 66*59 Domain with a Single Reference County
    - ✓ Current: 15 Seconds vs. BCFA: 5 Seconds (5 times Faster!)
  - Med. Test Case: US12km 66*59 Domain with Two Reference Counties
    - ✓ Current: 509 Seconds vs. BCFA: 20 Seconds (25 time Faster!)
  - U.S. EPA NEI Modeling Platform Case: 12US1_459X299 with full Ref. Counties
    - ✓ Current: 4165 Seconds vs. BCFA: 49 Seconds (85 times Faster!)

❖ The more no of reference counties, the better speed up of SMOKE-MOVES

❖ MOVES BCFA Lookup table approach for Humidity Dependency?

Fully Coupled AQ Modeling System



Coupled Inline Emissions

1. Biogenic
2. NH_3 Bi-directional
3. Lightning NOx
4. Sea salt
5. Windblown Dust
6. Plume Rise for Point sources
7. **MOVES Mobile Sources**

- Develop the prove of concept for coupling MOVES-based mobile emissions with air quality modeling system that can reflects the meteorology feedbacks to MOVES-based emissions for a better air quality simulation near metropolitan areas

Q&A
When?
Why?
How?
WHAT?
WHERE?
WHEN?
HOW?
WHO?
What?