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:
  o Agricultural NH₃ Emissions
  o Residential Heating Emissions
  o Onroad Mobile Emissions

• 2016: Development of the meteorology-dependent Temporal Profiles based on source-related measurements and meteorological datasets.
  o 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
  o Latest SMOKE-MOVES2014a Integration Tool
• Enhanced the meteorology dependency on mobile emissions for air quality modeling system
• Technical Challenges:
  o Slow and Most Computationally Expensive!
  o Big size of ASCII-format MOVES Emissions Factors Lookup Table files
  o Processing the limited numbers of Reference County-specific Lookup Tables
SMOKE-MOVES Integration Tool

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

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

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

• RatePerHour [grams/hour]
  o APU operation and extended idling processes
  o 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

<table>
<thead>
<tr>
<th>Sectors</th>
<th>Computing Time</th>
<th>RAM Memory Usages</th>
</tr>
</thead>
<tbody>
<tr>
<td>RPD</td>
<td>4 hours</td>
<td>10-20 GB</td>
</tr>
<tr>
<td>RPV</td>
<td>1.5 hours</td>
<td>5-10 GB</td>
</tr>
<tr>
<td>RPP</td>
<td>30 minutes</td>
<td>&lt; 1 GB</td>
</tr>
<tr>
<td>RPH</td>
<td>5 minutes</td>
<td>2 GB</td>
</tr>
</tbody>
</table>
Solutions

• Current/Possible Solutions:
  o Computational Optimization of the SMOKE-MOVES Integration tool
  o 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.
  o Convert current ASCII-formatted MOVES EF lookup tables into NetCDF format to improve the I/O speed (not implemented yet).

• Proposed Solutions:
  o Parameterization of Current ASCII-format MOVES EF Lookup Tables into Polynomial Algorithms using Best-Fitted Curve Algorithms (BFCA)
  o Store the algorithms in NetCDF format to eliminate I/O bottlenecks
  o 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]

The Emissions Inventory Conference at Baltimore, MD (August 14-18, 2017)
TOG: Gasoline-Transit Buses: Urban Unrestricted Access

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

The Emissions Inventory Conference at Baltimore, MD (August 14-18, 2017)
TOG: Gasoline-Transit Buses: Off-network Refueling [62] and All Exhaust, Evaporative, Brake and Tire [81]
NOx: Gasoline-Passenger Car: Off-network Refueling [62] and All Exhaust, Evaporative, Brake and Tire [81]
NOx: Gasoline-Transit Buses: Off-network Refueling [62] and All Exhaust, Evaporative, Brake and Tire [81]
PM2.5: Gasoline-Passenger Car: Off-network
Refueling [62] and All Exhaust, Evaporative, Brake and Tire [81]
PM2.5: Gasoline-Transit Buses: Off-network
Refueling [62] and All Exhaust, Evaporative, Brake and Tire [81]
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

The Emissions Inventory Conference at Baltimore, MD (August 14-18, 2017)
TOG: Gasoline-Transit Buses: Off-network
All Exhaust, Evaporative, Brake and Tire [81]: Weekday vs. Weekend

The Emissions Inventory Conference at Baltimore, MD (August 14-18, 2017)
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

- Significant improvement on Movesmrg computational processing time and memory usages

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

<table>
<thead>
<tr>
<th>Sectors</th>
<th>ASCII (MB)</th>
<th>CSV* (MB)</th>
<th>NetCDF* (MB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RPD</td>
<td>95-150 (77*)</td>
<td>33</td>
<td>20</td>
</tr>
<tr>
<td>RPV</td>
<td>45-100 (55*)</td>
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<td>15</td>
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<tr>
<td>RPP</td>
<td>15-50 (17*)</td>
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<td>1.4</td>
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<tr>
<td>RPH</td>
<td>&lt;1MB (.65*)</td>
<td>0.7</td>
<td>2.7</td>
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</table>

* 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:
  o CMAQ-MOVES
  o WRF-CMAQ-MOVES
  o 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

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  o Office of Air Quality Planning and Standards (OAQPS)
  o Office of Transportation and Air Quality (OTAQ)