3508 Far West Blvd., Suite 210
Austin, TX 78731

MEMORANDUM

TO: Sarah Roberts, Alison Eyth, Janice Godfrey, US EPA

FROM: Henry Byoun, Ken Zhao, Allison DenBleyker, ERG

DATE: October 17, 2023

SUBJECT: Documentation of the 2021 CDC Run, On-road and Nonroad Sources

Description of MOVES Runs

The on-road runs require both "rates mode" MOVES runs (the primary run type) and separate "inventory mode" runs, which are necessary to allow SMOKE to perform speciation of volatile organic compounds (VOC) and particulate matter (PM).

The on-road rates run generated tables of emission factors for all pollutants, emission processes, and source category codes (SCCs), which are combinations of vehicle, fuel, road type, and emission process group. This run was performed for January and July fuel formulations, for the range of meteorological (met) conditions from 2021, and for the same representative counties as the 2020 National Emissions Inventory (NEI), except for a change in Alaska county equivalents which removed one borough (county ID 2261, *Valdez-Cordova Census Area*) which in 2019 split into two areas (county ID 2063, *Chugach Census Area*; and county ID 2066, *Copper River Census Area*).

The nonroad runs covered all pollutants and all U.S. counties, including the latest Alaska change.

Model Version and Minor Edits

ERG adapted the MOVES4 first public release, source code version 4.0.0 and default database version movesdb20230615. The minor changes included minor code changes to allow the model to run on a Linux operating system and a new default database where the only change was to the *noxHumidityAdjust* table. ERG emptied the table, which turns off the MOVES adjustment to tailpipe NO_X (and chained pollutants NO, NO_2, HONO) that the model would otherwise perform based ambient humidity stored in the *zoneMonthHour* table. ERG named the modified database to **movesdb20230615_nonoxadjust**. In the SMOKE-MOVES process, the humidity-based NO_X adjustments are instead implemented within SMOKE using hourly humidity by grid cell. This MOVES table does not impact nonroad model results or other pollutant results.

Meteorology Inputs

EPA provided 2021 meteorological (met) data for the continental US (CONUS) area and 2020 met data for the outlying areas of Alaska, Hawaii, Puerto Rico, and the Virgin Islands. ERG processed the *.txt files listed below into the many input databases each containing a *zoneMonthHour* table that drove the MOVES runs. The "PR" files contained both Puerto Rico and Virgin Islands. The met data files for the rates runs were as follows:

On-road Rates Runs:

- MOVES_DAILY_2021nei_12US1_2021001-2021365.txt (CONUS only)
- MOVES_RH_DAILY_2021nei_12US1_2021001-2021365.txt (CONUS only)
- MOVES_DAILY_2020nei_3HI1_2020001-2020366.txt
- MOVES_DAILY_2020nei_3PR1_2020001-2020366.txt
- MOVES_DAILY_2020nei_9AK1_2020001-2020366.txt
- MOVES_RH_DAILY_2020nei_3HI1_2020001-2020366.txt
- MOVES_RH_DAILY_2020nei_3PR1_2020001-2020366.txt
- MOVES_RH_DAILY_2020nei_9AK1_2020001-2020366.txt

Nonroad and On-road Inventory Runs:

- 2021nei_month_hour_for_nonroad.csv (CONUS only)
- 2020nei_month_hour_for_nonroad_3HI1.csv
- 2020nei_month_hour_for_nonroad_3PR1.csv
- 2020nei_month_hour_for_nonroad_9AK1.csv

County Databases (CDB) Inputs

The starting point for the 2021 CDBs were the representative CDBs from the 2020 NEI, with the following modifications:

- Transformed the CDBs to be compatible with MOVES4
- Made the 2 new Alaska CDBs to replace the prior Alaska CDB
- Updated the *fuelSupply*, *fuelFormulation*, *fuelUsageFraction,* and *IMCoverage* tables to use MOVES4 database values for year 2021.
- Updated *avgSpeedDistribution* to use December 2020 speeds. This is our best estimate available for speeds in 2021.
- Updated *monthVMTFraction*, *dayVMTFraction*, and *hourVMTFraction* with statewide 2021 volume counts from the FHWA, a dataset called "TMAS". The primary purpose of using TMAS in the 2021 run was to replace the month VMT distribution from 2020, which was marked by the COVID pandemic shutdowns in mid-March/April. The 2021 TMAS month VMT distribution looks more typical. We also used day/hour distributions

from the same dataset because they were available and from the correct year. See separate section on TMAS processing for more detail.

- Updated the year ID from 2020 to 2021 throughout. We retained the same VMT, population, age distribution, and AVFT from the 2020 NEI, though the year label was updated to 2021 to allow MOVES to run for 2021.

TMAS Processing

FHWA provided the large TMAS dataset via FTP for 2021 (and 2022). The format was fixed column formatted files with 1 per state and month. Several states did not provide FHWA with data, and so their directories were empty. Other states did not have sufficient data to make month-related VMT profiles (monthVMTFraction and dayVMTFraction), so ERG made substitutions for states as needed and listed Table 1. For Texas, the bus month VMT distribution was noisy and so we flattened it to set all 12 months as having equal traffic in 2021, to be more in line with other states. We note that Washington DC had complete data, but based on so few monitors the final data profiles looked noisy and unrealistic based on the low sample size. Therefore, we substituted with Maryland. Twenty states required substitutions; the other 33 used their own states' data from TMAS. The extra 3 "states" in the 53 total includes DC, PR, and VI as separate state entities.

Table 1. Twenty State Substitutions in the 2021 TMAS Dataset

Actual stateID	Actual State Abbreviation	TMAS stateID	TMAS State Abbreviation
9	CT	36	NY
10	DE	24	MD
11	DC	24	MD
21	KY	18	IN
22*	LA	22/28	LA/MS
29	MO	19	IA
31	NE	19	IA
33	NH	23	ME
35	NM	8	CO
37	NC	51	VA
41	OR	16	ID
44	RI	25	MA
45	SC	13	GA
46	SD	38	ND
47	TN	5	AR
49	UT	8	CO
50	VT	23	ME
54	WV	51	VA
56*	WY	56/30	WY/MT
72	PR	15	HI
78	VI	15	HI

*For Louisiana and Wyoming, only hourly VMT fractions were available. Louisiana's day and month VMT fractions came from Mississippi, while Wyoming's day and month VMT fractions came from Montana data.

The TMAS data was cleaned up by deleting holidays and time periods with only partial data as follows:

- Delete all records for certain holidays, as they do not exemplify typical driving conditions for their day type. Blackout days are as follows

```
000000  01 01 2021  ! New Year's Day
000000  04 02 2021  ! Good Friday
000000  05 31 2021  ! Memorial Day
000000  07 05 2021  ! July 4th Monday
000000  09 06 2021  ! Labor Day
000000  11 25 2021  ! Thanksgiving Thurs
000000  11 26 2021  ! Thanksgiving Fri
000000  12 24 2021  ! Christmas Eve
000000  12 25 2021  ! Christmas Day
000000  12 31 2021  ! New Year's Day Friday
```

  https://gaftp.epa.gov/Air/emismod/2020/ancillary_data/holidays_29apr2022_nf_v5.txt

- Delete incomplete station data.
  - Delete incomplete dates (all records for station-date combinations with fewer than 24 hours of traffic volumes).
  - Delete incomplete months (all records for any station-month combinations where there is not at least 1 complete day type [i.e., all 24 hours] for each of the 7 types: Mo, Tu, We, Th, Fr, Sa, Su).
- After cleanup, assess suitability of remaining stations to be used in the hour/day/month VMT Fraction tables
  - As long as 1 date for each of the 7 day types exists for any month, the requirement is met for a ***hourVMTFraction*** for the state. The hourVMTFraction tables does not have a month ID in the table, so not all months are required and we use what we have.
  - For purposes of ***monthVMTFraction*** and ***dayVMTFraction***, all 12 months must have all 7 day types covered, to include the station, due to presence of a month ID in those tables.

The cleaned TMAS data was then processed for each state as follows:

- Divide by the number of dates included in each day type (For example, Alabama could have a valid 3 Mondays, 1 Tuesday, etc., for a particular station. Here we would divide the volumes for that station-7daytype combination as follows: Mondays by 3, Tuesdays by 1, and so on. The goal is to have equal weighting of 1 day volume total per type represented).
- Add label for the MOVES day types (5=weekday, 2=weekend day) based on the 7 day types. This new label is hereafter "dayID."
- Add label to map the 13 TMAS vehicle classes into 7 MOVES source type groups according to Table 2 and summarized below in sub bullets.

- Group TMAS Class # 5,6,7 together as Single Unit Trucks
- Group TMAS Class # 8,9,10,13 together as Combination Short-haul Trucks
- Group TMAS Class # 11,12 together as Combination Long-haul Trucks
- Everything else (TMAS Class # 1,2,3,4) is 1-to-1

Table 2. Mapping of TMAS Vehicle Classes to MOVES Source Type Group

TMAS Class	TMAS Class Description	Unique Profile #	MOVES source type group name	MOVES source type(s)
1	Motorcycles	1	Motorcycles	11
2	Passenger Cars	2	Passenger Cars	21
3	Other 2-Axle, 4-Tire, Single-Unit Vehicles	3	Light Duty Trucks	30s (31,32)
4	Buses	4	Buses	40s (41,42,43)
5	2-Axle, 6-Tire, Single-Unit Trucks	5	Single Unit Trucks	50s (51,52,53,54)
6	3-Axle, Single-Unit Trucks			
7	4-or-More Axle, Single-Unit Trucks			
8	4-or-Less Axle, Single-Trailer Trucks	6	Combination Unit Short-haul Trucks	61
9	5-Axle, Single-Trailer Trucks			
10	6-or-More Axle, Single-Trailer Trucks			
11	5-or-Less Axle, Multi-Trailer Trucks	7	Combination Unit Long-haul Trucks	62
12	6-Axle, Multi-Trailer Trucks			
13	7-or-More Axle, Multi-Trailer Trucks	6	Combination Unit Short-haul Trucks	61

- For ***hourVMTFraction***, sum hourly traffic volumes over stations/lanes/etc. to the level of state, MOVES source type group 1-7 (see Table 2), dayID, hourID, volume. Normalize the hourly volumes by dayID total volumes, matching on state/sourcetypegroup/dayID.
- For ***dayVMTFraction***, sum traffic volumes over hours/stations/lanes/etc. to the level of state, MOVES source type group, monthID, dayID, volume. Normalize the volumes using totals across the dayIDs 5 and 2. Put another way, each dayID pair of volumes should sum to one (1) by state, MOVES source type group 1-7 (see Table 2), and monthID.
- For ***monthVMTFraction***, sum traffic volumes over hours/stations/lanes/etc. to the level of state, MOVES source type group, 7 day types, and volume. Compute the average volumes to reflect an equal weighting of the 7 day types. Scale up from the statewide average day volumes to month total using the number of days in the month (i.e., 30, 31, or 28 days). This calculation estimates the would-be volume at the month total level without requiring the station/monitor to be operational 24/7. The approach assumes all Mondays are equal to each other, etc. *We could refine for next time (2022) to include the holiday impacts on the month totals consistent with what SMOKE does which is to assume a typical Sunday volume for any traffic-impacted holiday*. Accounting for the for variations between 28,30,31-day lengths is consistent with the MOVES approach. Finally, normalize by annual totals (sum over the scaled month totals), so each profile sums to one (1) across the twelve months.

- Format the results for MOVES using a script and apply “seeding”. Seeding is a process that turns zero (0) values into small value (e.g., 1e-15), a step which ensures the output emission rate tables are complete.

Post-Processing Scripts

The names of the applied post-processing code for the 2021 runs were as follows:

Rates On-road

- aq_cb6_saprc_20220825
- nata_20220825

Inventory On-road

- invmode_speciation_movesdb20230615_nonoxadj

Nonroad

- nr_speciation_20221207
- nraq_20191204