THE INTEGRATION APPROACH OF MOVES AND SMOKE MODELS

Development of Drivers and Post-Processing Scripts to Incorporate MOVES2010 Emission Factors with the SMOKE Modeling System

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Developments of Meteorological pre-processor and SMOKE Enhancements to incorporate MOVE2010 emission factors for a regional modeling

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ABSTRACT

The successful use of the MOVES2010 emission factor calculations for a regional modeling requires careful planning and a clear understanding of emission rates calculation in MOVES2010. To reduce the time and effort required of the user for this process, and to help the user obtain more accurate modeling results, EPA initiated this work to integrate the MOVES2010 and SMOKE models.

The first part of the integration was to develop the meteorological data preprocessor that prepares spatially and temporally average temperatures and relative humidity to provide the meteorological conditions for both the MOVES2010 and SMOKE models. The next part was to develop the MOVES2010 driver and post-processing scripts to help users to setup and run MOVES2010 model efficiently to generate lookup tables of emission rates for all emission processes for SMOKE. The last part was to develop how to process those MOVES2010 lookup tables through SMOKE to create hourly gridded and speciated input files for a regional air quality modeling.

This paper describes (1) how the meteorological data are prepared, so that MOVES2010 and SMOKE can read and use them for their modeling, (2) how the raw data from the MOVES2010 lookup tables are parsed, sorted and condensed, and (3) how the MOVES2010 lookup tables are processed through SMOKE modeling system using average/real-time hourly gridded meteorology data. When user estimates on-roadway running emission processes, county-total VMT and average speed inventory are used as an input to use the 'RatePerDistance' lookup table. However, SMOKE requires county-total vehicle population by vehicle type as input to use the 'RatePerVehicle' and 'RatePerProfile' lookup tables for off-network and parked vapor venting emissions processes, respectively.

INTRODUCTION

MOVES2010 is the U.S. Environmental Protection Agency's (EPA) MOtor Vehicle Emission Simulator 2010 model. The purpose of MOVES2010 is to provide an accurate estimate of emissions from mobile sources under a wide range of user-defined conditions. It helps the user answer "what if" questions, such as "How would particulate matter emissions decrease in my state on a typical weekday if truck travel were reduced during rush hour?", or "How does the total hydrocarbon emission rate change if my fleet switches to gasoline from diesel fuel?"

An important feature of MOVES2010 is that it allows users to choose between (1) the "Inventory" calculation type, which provides emission rates in terms of total quantity of emissions for a given time period; and (2) the "Emission Rate" calculation type, which gives emission rates in terms of grams/mile or grams/vehicle/hour. For large-scale emissions modeling such as that needed for regional- and national-scale air quality modeling projects, it is desirable to use the "Emission Rate" calculation type, which populates emission rate lookup tables that can then be applied to many times and places, thus reducing the total number of MOVES runs required.

The approach for running MOVES for SMOKE relies on the concept of representative "reference counties" and "reference months." The concept of "reference county" refers to running MOVES for a single county, which is the reference county, to represent itself and other counties that share the same MOVES input parameters and thus have the same emission rates for any given speed, temperature and humidity. A "reference month" similarly refers to a representative fuel month's MOVES run that contains the temperatures that occur in neighboring months as well as the reference month. The mapping of calendar months to a reference month should be assigned on the basis of shared fuel parameters, because it is the interaction of fuel and temperature that is important. For example, an average-hourly temperature of 70°F may occur in some hour of any day in each of four months: May, June, July and August. If those four months share the same fuel properties (i.e. summer fuel) then an emission factor will be determined for just the reference month, reducing by a factor of four the number of calculations that MOVES needs to perform.

The successful use of the MOVES "Emission Rate" calculation type requires careful planning and a clear understanding of emission rates calculation in MOVES. To reduce the time and effort required of the user for this process, and to help the user obtain more accurate modeling results, UNC and ENVIRON created a tool called the SMOKE-MOVES integration tool (Baek and DenBleyker, 2010). This tool consists of a set of scripts that automate the proper use of the "Emission Rate" calculations for the purpose of estimating mobile-source emissions for air quality (AQ) modeling. The SMOKE-MOVES tool provides three major functions:

I. Meteorological data preprocessor:

- The meteorological data preprocessor program (MET4MOVES) prepares spatially and temporally averaged temperatures and relative humidity data to set up the meteorological input conditions for MOVES and SMOKE using the Meteorology-Chemistry Interface Processor (MCIP) output files.

II. MOVES model processing:

- The MOVES driver script creates data importer files and the MOVES input file (runspec), which specifies the characteristics of the particular scenario to be modeled.

- The MOVES postprocessing script formats the MOVES emission rate lookup tables for SMOKE.

III. SMOKE model processing:

- The new SMOKE post-processing program (MOVESMRG) estimates emissions from on-road mobile sources based on MOVES-based emission rate lookup tables and meteorology data from MET4MOVES.
- Creates hourly gridded speciated air quality model-ready input files.
- Produces various types of reports for users.

This user's guide describes the major functions of the SMOKE-MOVES integration tool.

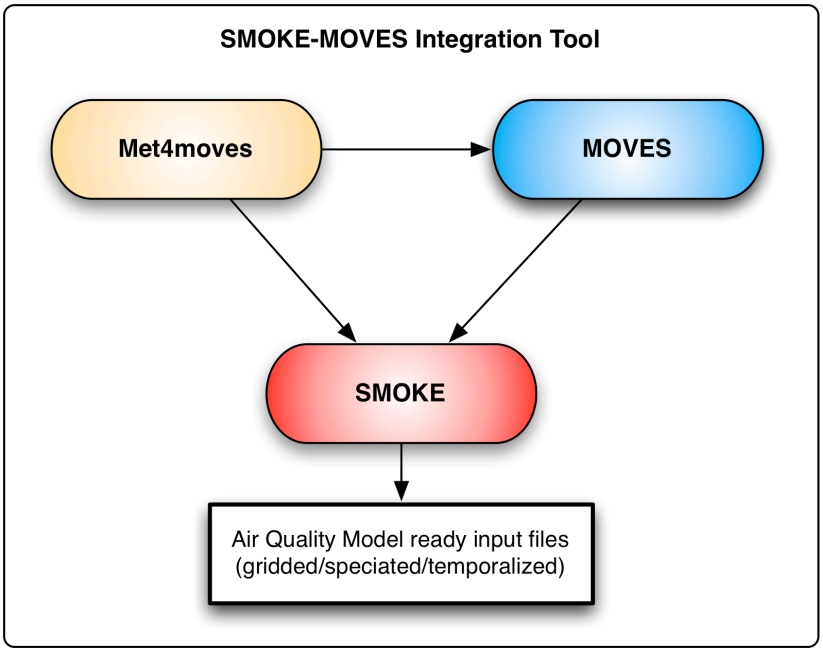

Figure 1. Flow diagram of overall SMOKE-MOVES integration tool.

SMOKE-MOVES INTEGRATION TOOL

1 Metrological Data Processing

With the specified "reference county" and "reference (= fuel) month" approach for temperature and RH calculation for MOVES and SMOKE modeling systems, MET4MOVES uses hourly min/max temperatures and averaged RH over the spatial region that includes all of the inventory counties in a county group over the user-defined modeling period. The current version of MET4MOVES supports only the monthly averaging method (versus daily or episodic) to create min/max temperatures and averaged RH for all inventory counties in the county group(s). MET4MOVES determines the min/max grid cell temperatures and associated RH for both SMOKE and MOVES, and computes average 24-hour temperature profiles for use in MOVES.

The 24-hour temperature profiles are averaged over a user-specified time period and grid cells for all reference counties. For the MOVES model driver scripts, MET4MOVES outputs monthly average RH, min/max temperatures, and 24-hour temperature profiles in local time for all reference counties into one output file. For the SMOKE model, MET4MOVES outputs county-specific min/max temperatures and averaged RH values in local time for every inventory county and averaging period in the modeling inventory.

2 MOVES Model Processing

MOVES emission rate tables are organized into three tables, depending on emission mode or process and whether the vehicle is parked or in motion. The approach to running MOVES for SMOKE is unique for each emission rate table listed in Table 1. A complete inventory must use the emission rates from all three tables.

Table 1. MOVES2010 Organization of Emission Processes into Emission Rate Tables

Emission Rate Lookup Table	Units	SMOKE ProcesID	Emissions Process
RatePerDistance	Gram/mile	EXR	Running Exhaust
		CXR	Crankcase Running Exhaust
		TIR	Tire Wear
		BRK	Brake Wear
		EVP	On-road Evaporative Permeation (roadTypeID=2,3,4,5)
		EFL	On-road Evaporative Fuel Leaks (roadTypeID=2,3,4,5)
		EFV	On-road Evaporative Fuel Vapor Venting (roadTypeID=2,3,4,5)
RatePerVehicle	Gram /vehicle /hour	EXS	Start Exhaust
		CXS	Crankcase Start Exhaust
		EVP	Off-network Evaporative Permeation (roadTypeID=1)
		EFL	Off-network Evaporative Fuel Leaks (roadTypeID=1)
		CEI	Crankcase Extended Idle Exhaust
		EXT	Extended Idle Exhaust
RatePerProfile	Gram /vehicle /hour	EFV	Off-network Evaporative Fuel Vapor Venting (roadTypeID=1)

The RatePerDistance table emission factor units are grams/mile and are from emission processes from vehicles operating in the running condition, as opposed to stationary. The RatePerDistance emission factors are independent of both day type (weekday/weekend) and hour of day. They only depend on speed, temperature and humidity. Sixteen speed bins shown in Table 2 are hard-coded in the MOVES model. Temperature and humidity conditions are determined from the output of the meteorological preprocessor MET4MOVES.

Table 2. MOVES2010 Default Speed Bins

Speed Bin ID	Bin Speed (mph)	Description of Sped Bin
1	2.5	speed< 2.5mph
2	5	2.5mph ≤ speed < 7.5mph
3	10	7.5mph ≤ speed < 12.5mph
4	15	12.5mph ≤ speed < 17.5mph
5	20	17.5mph ≤ speed <22.5mph

6	25	22.5mph ≤ speed < 27.5mph
7	30	27.5mph ≤ speed < 32.5mph
8	35	32.5mph ≤ speed < 37.5mph
9	40	37.5mph ≤ speed < 42.5mph
10	45	42.5mph ≤ speed < 47.5mph
11	50	47.5mph ≤ speed < 52.5mph
12	55	52.5mph ≤ speed < 57.5mph
13	60	57.5mph ≤ speed < 62.5mph
14	65	62.5mph ≤ speed < 67.5mph
15	70	67.5mph ≤ speed < 72.5mph
16	75	72.5mph ≤ speed

The RatePerVehicle and RatePerProfile table emission factors have units of grams/vehicle/hour. These emissions are emitted during the parked operation of vehicles. MOVES2010 contains assumptions of parked vehicle activity and engine start activity that depend on hour of day and distributions differ between weekdays and weekends. The RatePerVehicle table includes all parked emissions except the emission process Off-Network Evaporative Fuel Vapor Venting, which resides in its own table, RatePerProfile. RatePerProfile exists separately from RatePerVehicle because Evaporative Fuel Vapor Venting emission rates depend not only upon the current hour temperature, but also the previous hours' temperatures.

MOVES2010 automatically computes emission factors for each of the default speed bins at every hour of the day for the RatePerDistance Table. Since the RatePerDistance emission factors are independent of hour, it is not important which temperature is associated with which hour. The overall min and max temperature of the modeling episode define the range of expected temperatures. An increment (such as the default set at 5°F) is then used to divide the temperature range into user-defined temperature bins. Each temperature bin may be assigned sequentially to hours for purposes of populating the RatePerDistance table. This approach enables a large range of temperature and speed conditions to fit into a single day's MOVES run.

The RatePerVehicle and RatePerProfile emission factors depend on hour of the day and day type. The interaction of temperature and hour necessitates a different approach for using temperature in MOVES inputs compared to the RatePerDistance approach. The same temperature range and increment used again in RatePerVehicle MOVES runs, but unlike RatePerDistance, a single temperature bin is repeated at all hours for both a weekday and weekend day. The number of RatePerVehicle runspec files is determined by the number of temperature bins.

The RatePerProfile table requires a third approach to using temperature for MOVES runs. Off-Network Evaporative Fuel Vapor Venting emissions are affected by changes in ambient temperature between hours and also activity assumptions of time spent parked per hour. A cloudy day with a relatively flat diurnal temperature profile will have significantly lower Evaporative Fuel Vapor Venting Emissions than a day where steeper temperature gradients between morning and afternoon warm the fuel tanks of parked vehicles, causing evaporation and expulsion of fuel vapor. For a long modeling episode and vast geographic area, a wide variety of diurnal profiles can occur. Rather than model each individual episode day for each grid cell or county, an unique approach was developed that relies on an average diurnal temperature profile shape, which is normalized and fit with a range of daily minimum and maximum temperatures within the same temperature range used in RatePerDistance and RatePerVehicle processing. Humidity input to all MOVES runs represents a daytime average to reflect the condition during the time where majority of emissions occur.

2.1 The MOVES Driver Script

ENVIRON created a MOVES Driver Script to automate the MOVES run setups and prepare two kinds of batch files. When launched, the batch files instruct MOVES to (1) import data into MySQL County Scale databases and (2) run MOVES for each runspec file. The resulting RatePerDistance, RatePerVehicle and RatePerProfile tables, after enhancement from the Post-Processing Script, contain all conditions needed for regional modeling in SMOKE.

The inputs to the MOVES Driver Script include the temperature and humidity conditions output from MET4MOVES and two additional inputs, the RunControl and RepCounty files. The RunControl file contains pollutant selections and the file path location to the MET4MOVES output. The RepCounty file contains file path locations to user-created MOVES-formatted inputs for age distribution, fuel supply and formulation, inspection and maintenance programs, county level population and annual VMT for each reference county. Precise formats of the RunControl and RepCounty files can be found in the User's Guide for the SMOKE-MOVES Integration Tool.

2.2 The MOVES Post-Processing Script

Once a MOVES batch run completes, MOVES will have populated the three output lookup tables with formats listed in Table 3, which are current as of the MOVES2010 release. ENVIRON developed a MOVES Post-Processing Script in Perl to interact with MySQL to modify the default formats shown in Table 3 into a format readable by SMOKE, shown in Table 4. The Post-Processing script also fully speciates the particulate matter into species needed for air quality modeling.

Table 3. MOVES2010 Emission Rate Lookup Table Format, Before MOVES Post-Processing Script

RatePerDistance (grams/mile)	**RatePerVehicle** (grams/vehicle/hour)	**RatePerProfile** (grams/vehicle/hour)
MOVESScenarioID	MOVESScenarioID	MOVESScenarioID
MOVESRunID	MOVESRunID	MOVESRunID
yearID	yearID	temperatureProfileID
monthID	monthID	yearID
dayID	dayID	dayID
hourID	hourID	hourID
linkID	zoneID	pollutantID
pollutantID	pollutantID	processID
processID	processID	sourceTypeID
sourceTypeID	sourceTypeID	fuelTypeID
fuelTypeID	fuelTypeID	modelYearID
modelYearID	modelYearID	Temperature
roadTypeID	Temperature	ratePerVehicle
avgSpeedBinID	ratePerVehicle	
Temperature		
relHumidity		
ratePerDistance		

The current release of MOVES Post-Processing Script maps from MOVES sourceTypeID (vehicle class), processID (emission process), and roadTypeID to SCC using the same methodology MOVES2010 uses in Inventory Mode Calculation to map from the MOVES types to SCC. The next release of MOVES2010 is slated to output emission rates by SCC, so this feature is currently being removed for the next release of the MOVES-SMOKE tool.

The Post-Processing Script performs some cosmetic changes to the structure of the tables, including the addition of a countyID field in each table and mapping MOVES emission process ID to a three-letter character string to indicate process to SMOKE. None of the MOVES2010 lookup tables (refer back to Table 16) contain a countyID field solely dedicated to a state-county FIPS code and SMOKE needs this information. The Post-Processing Script creates a county field by extracting it from other fields that include county codes as part of their value. The RatePerDistance table contains a linkID field that contains countyID in the leading five digits followed by additional numbers to allow for future implementation of link modeling. The RatePerVehicle table has a zoneID field which is countyID with a trailing zero. The RatePerProfile table has a TemperatureProfileID field, which also leads with countyID and is trailed by other numbers to indicate month and other identification. The post-processing script parses the state-county FIPS code from linkID, zoneID and TemperatureProfileID and stores it as a unique field, countyID. The script also removes fields that are uninformative to SMOKE, including the MOVES source type, fuel type and road type, hourID in RatePerDistance, TemperatureProfileID in RatePerProfile.

Table 4. Emission Rate Lookup Tables Formatted for SMOKE, After MOVES Post-Processing Script

RatePerDistance_smoke (grams/mile)	**RatePerVehicle_smoke** (grams/vehicle/hour)	**RatePerProfile_smoke** (grams/vehicle/hour)
MOVESScenarioID	MOVESScenarioID	MOVESScenarioID
MOVESRunID	MOVESRunID	MOVESRunID
yearID	yearID	yearID
monthID	monthID	monthID
countyID	dayID	dayID
SCC	hourID	hourID
processName	countyID	countyID
avgSpeedBinID	SCC	SCC
Temperature	processName	processName
relHumidity	Temperature	Temperature
CO	CO	THC
TOG	NOX	TOG
BENZENE	PM10OC	VOC
…	…	…

The Post-Processing Script greatly reduces the output database table size by performing a cross-tab query on the pollutant emissions, listing each pollutant in a separate field rather than in a single column with a higher number of data records. The script also sorts the lookup tables by countyID, monthID and SCC for more efficient processing in SMOKE.

The Post-Processing Script enhances the existing outputs by fully speciating the partially speciated exhaust particulate matter (PM) output. PNO3, METAL, NH4, POC, PMFINE, and PMC are all calculated by the Post-Processing Script. The speciation equations were developed by EPA OTAQ and OAQPS. The advantage of using this approach over the approach used for speciating total PM2.5 is that

this approach allows the speciated emissions from MOVES; i.e., elemental carbon and particulate sulfate to be retained and only the remainder of the PM2.5 to rely on speciation profiles.
The speciation equations are the following:

(1) PEC = PM25EC
(2) PEC_72 = PEC / PEC_Tadj
(3) PSO4 = PM25SO4
(4) PNO3 = PEC_72 × *FNO3* / *FEC*
(5) METAL = PEC_72 × *FMETAL* / *FEC*
(6) NH4 = (PNO3/62.0049 +2 × PSO4/96.0576) × 18.0383
(7) POC = 5/6 × (PM25OM – METAL – NH4 – PNO3)
(8) PMFINE = METAL + NH4 + 0.2 × POC
(9) PMC = ($R_{PM10\text{-}to\text{-}PM25}$-*1)* × (PMFINE + PEC + POC + PSO4 + PNO3)

where

Gasoline SCCs	All SCCs begin with "2201"
Diesel SCCs	All SCCs begin with "2230"
PEC	Mass of primary elemental carbon, a species needed for CMAQ
PM25EC	Mass of primary elemental carbon provided by the MOVES model
PM25SO4	Mass of primary sulfate provided by the MOVES model
PSO4	Mass of primary sulfate, a species needed for CMAQ
PNO3	Mass of primary nitrate, a species needed for CMAQ
PEC_72	Mass of primary elemental carbon when MOVES runs at 72°F or higher temperature; calculated by "backing out" the temperature adjustment factor, PEC_T_{adj}
PEC_T_{adj}	The MOVES cold-temperature adjustment factor to PM25EC from gasoline vehicles.
FNO3, FEC, FMETAL	Percentages of nitrate, elemental carbon, and metal derived from the vehicle-type-specific speciation profile; values are provided in Table 21
METAL	Mass of metal component of PM2.5, which is a component of PMFINE
NH4	Mass of ammonium component of PM2.5, which is a component of PMFINE
62.0049	Molecular weight of nitrate
96.0576	Molecular weight of sulfate
18.0383	Molecular weight of ammonium
POC	Mass of primary organic carbon, a species needed for CMAQ
PM25OM	Mass of organic material provided by the MOVES model;this actually includes more than organic matter: it includes the mass of all components of PM2.5 other than PEC and PSO4
PMFINE	Mass of other primary PM2.5 not accounted for in PEC, POC, PSO4, and PNO3; this is a species needed for CMAQ. This mass includes the ammonium, metals, water, and the mass of the noncarbon material, i.e., hydrogen, oxygen, and other atoms attached to the organic carbon
PMC	Mass of the coarse fraction of PM10; defined as PM10 – PM2.5; this is a species needed for CMAQ
$R_{PM10\text{-}to\text{-}PM25}$	Ratio of PM10-to-PM2.5, which is a constant that is dependent upon fuel type; values are provided in Table 21

The final step of the Post-Processing Script is to write to ASCII file the three processed tables RatePerDistance_smoke, RatePerVehicle_smoke and RatePerProfile_smoke.

3 SMOKE Model Processing

Once the MET4MOVES meteorology preprocessor and the MOVES model processing that results in the SMOKE-formatted emissions factor lookup tables are completed, we address the remaining major component of the SMOKE-MOVES tool: the SMOKE model processing step. The goals of this step are (1) to estimate emissions from on-road mobile sources based on MOVES-based emissions lookup tables and meteorology data from MET4MOVES, (2) to create hourly gridded speciated air quality model-ready input files, and (3) to produce various types of reports for the user.

As some readers are aware, MOBILE6 and MOVES are both vehicle emissions modeling systems used with SMOKE. However, they differ in their approaches to calculating off-network evaporative emissions. In MOBILE6, off-network emissions processes are calculated as emission factors in grams/mile, which is related to VMT. MOVES, on the other hand, uses the source (vehicle) type population (VPOP) to calculate start and off-network evaporative emissions, which are assigned to off-network emissions processes; these processes are hour-dependent due to VPOP (activity) assumptions built into the MOVES model. Thus, compared to the SMOKE-MOBILE6 approach, the SMOKE-MOVES approach requires additional vehicle population inventory data as input for estimating mobile-source emissions from off-network emissions processes. This requirement is reflected in the discussion below.

When processing mobile-source emissions, SMOKE performs the following basic steps. (For more information on these SMOKE programs, please see the SMOKE user's manual.)

1. SMKINVEN imports county-total VMT and average speed data by SCC and county-total vehicle population (VPOP) by vehicle type.

2. SPCMAT computes the chemical speciation factors for each county, source (=vehicle) type, road type, emission process, and pollutant, and stores the necessary factors for the VMT-to-species and VPOP-to-species transformations.

3. GRDMAT allocates the county sources to grid cells and uses spatial surrogates to allocate county-total VMT and VPOP to grid cells, storing the factors needed for these allocations.

The way the MOVES-generated emissions factor lookup tables are used varies according to whether SMOKE is modeling on-roadway emission processes or off-network emissions processes.

On-roadway emission processes: When estimates of on-roadway emission processes (e.g., exhaust running, on-road evaporative, tire and brake wear) are needed, SMOKE requires county-total VMT and average hourly speed (SPEED) inventory data as inputs to a new SMOKE postprocessor called "MOVESMRG," which is part of the SMOKE-MOVES tool. MOVESMRG uses the MOVES-based RatePerDistance (RPD) table (Table 4) to estimate on-road sources emission. The key lookup fields for the factors are gridded hourly temperature and average hourly speed from the avgSpeedBinID field. SMOKE interpolates in the RPD table (in unit of grams/mile) based on gridded hourly temperature and

average speed. Figure 2a shows processing steps for on-roadway emissions processes in the SMOKE system using VMT and SPEED inventory input data.

Off-network emission processes: When estimates are needed for off-network emissions processes, including the off-network vapor venting emissions process, SMOKE uses county-total VPOP by vehicle type as input to MOVESMRG together with the RatePerVehicle (RPV) and RatePerProfile (RPP) lookup tables (Figure 2b). A significant difference in the processing steps between the on-roadway emissions processes (RPD table) and the off-network emissions processes (RPV and RPP tables) is that off-network emissions processing does not require the TEMPORAL program step because vehicle population (VPOP) does not need to be temporally allocated. In the RPV table, gridded hourly temperature and hour of the day are the key lookup fields SMOKE uses to estimate hourly off-network emissions in unit of grams/vehicle/hour. For the evaporative fuel off-network vapor venting emissions process only, MOVESMRG uses the RPP lookup table to estimate the emission rates based on the minimum and maximum temperatures computed by MET4MOVES.

For all three emission rate lookup tables (RPD, RPV, RPP), SMOKE performs linear interpolation when using them.

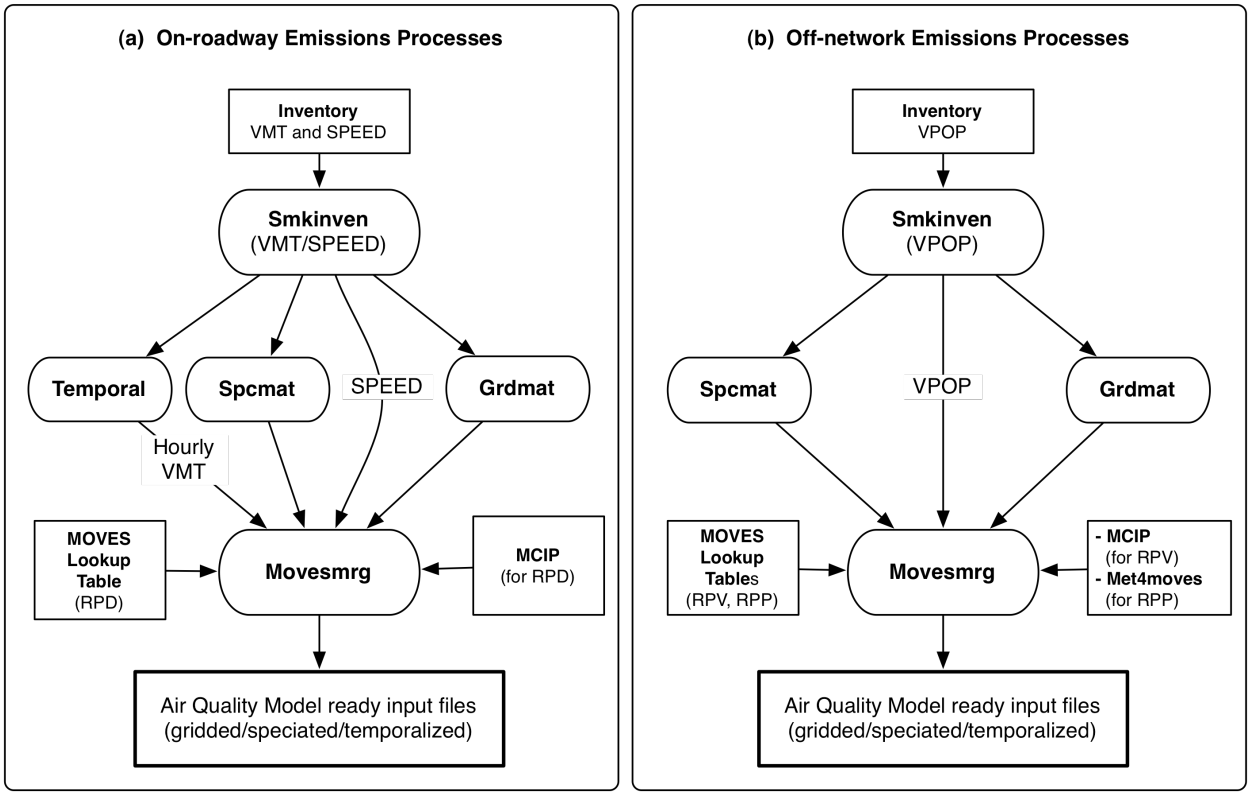

Figure 2. Flow diagrams of SMOKE-MOVES processing by emission processes.

3.1 Processing MOVES-based Lookup Tables

3.1.1 On-roadway Emissions Processes Emissions Factors (RPD)

The Rate Per Distance (RPD) lookup table (see Table 4) is used to provide estimates of on-roadway emissions processes from mobile sources, using a separate file for each reference county. The on-road running processes that appear in this table include running exhaust (EXR), crankcase running exhaust

(CXR), brake wear (BRK), tire wear (TIR), on-road evaporative permeation (EVP), on-road evaporative fuel leaks (EFL), and on-road evaporative vapor venting (EFV) (Table 1). The units of the emission rates in this table are grams/mile. The lookup fields for the factors are temperature and average speed. There are 16 set speed bins defined in Table 2 (i.e., avgSpeedBinID 1=2.5mph, 2=5mph, 3=10mph, …16=75mph). The avgBinSpeed is used for interpolation in the RPD table.

3.1.2 Off-network Emissions Processes Emissions Factors (RPV)

The Rate Per Vehicle (RPV) lookup table (see Table 4) is used to provide estimates of off-network emission processes (parked engine-off, engine starts, and idling), except for the evaporative off-network vapor venting emissions process. A separate file is provided for each reference county. The off-network emission processes include start exhaust (EXS), crankcase start exhaust (CXS), off-network evaporative permeation (EVP), off-network evaporative fuel leaks (EFL), extended idle exhaust (EXT), and crankcase extended idle exhaust (CEI) (Table 1). Fuel month, temperature, and local hourID are the lookup fields in this table, and hours are in the local time of the countyID. The units of the emission rates are grams/vehicle/hour.

Note: Although the units are grams/vehicle/hour, the number of vehicles (i.e., population) should not be temporally allocated to hours in SMOKE. Instead, a county total of vehicle population should be multiplied by emission rates at any given hour. The number of starts per vehicle by hour is already accounted for in the MOVES lookup table.

3.1.3 Off-network Vapor Venting Emissions Processes Emissions Factors (RPP)

The Rate Per Profile (RPP) table (see Table 4) is used only to estimate emissions for off-network fuel vapor venting (EFV) when the vehicle is parked. This process type includes diurnal (when the vehicle is parked during the day) and hot soak (immediately after a trip when the vehicle parks) emissions types. The process depends on the rate of rise in temperature and the maximum temperature achieved during the day for the diurnal emissions type, and on the hourly temperatures for the hot soak emission type. The lookup fields for this table are reference (=fuel) month and hour of day. As with the RPV table, the units of the emission rates are grams/vehicle/hour. The estimated emissions rates need to be multiplied by the county vehicle population.

The reference county lookup tables contain 24-hour emission rates per hour per vehicle using a reference-county temperature profile with different minimum and maximum temperatures. The average day county emissions are determined by interpolating between the minimum and maximum temperatures for the county listed in the MET4MOVES output file for SMOKE.

3.2 Final Merging (MOVESMRG)

MOVESMRG is a new, mobile-sources-only program, loosely based on the SMOKE program Smkmerge, that combines the intermediate files produced by the other SMOKE programs (i.e., GRDMAT, SPCMAT, TEMPORAL). Similar to SMKMERGE, the main goal of MOVESMRG is to create (1) gridded, speciated, hourly air quality model-ready input files and (2) county-level SCC summaries. The primary difference between MOVESMRG and SMKMERGE is that MOVESMRG uses the MOVES emission rate lookup tables to compute emissions on the fly, by multiplying the emissions factors by hourly VMT (for RPD) or by monthly or annual vehicle populations (for RPV or RPP).

MOVESMRG must be run three times to compute on-roadway and off-network (including vapor venting) emissions processes individually, since the emission rate calculation methods in SMOKE for these categories are quite different. Once all three emissions processes have been computed, the

emission output files can be merged (optionally along with other 2-D sectors separate from onroad) using MRGGRID, which combines any number of 2-D or 3-D hourly, gridded, and speciated emission data files. See the SMOKE user's manual for more details on the above programs.

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