MOVES-Matrix Running Module
Quick Start Guide

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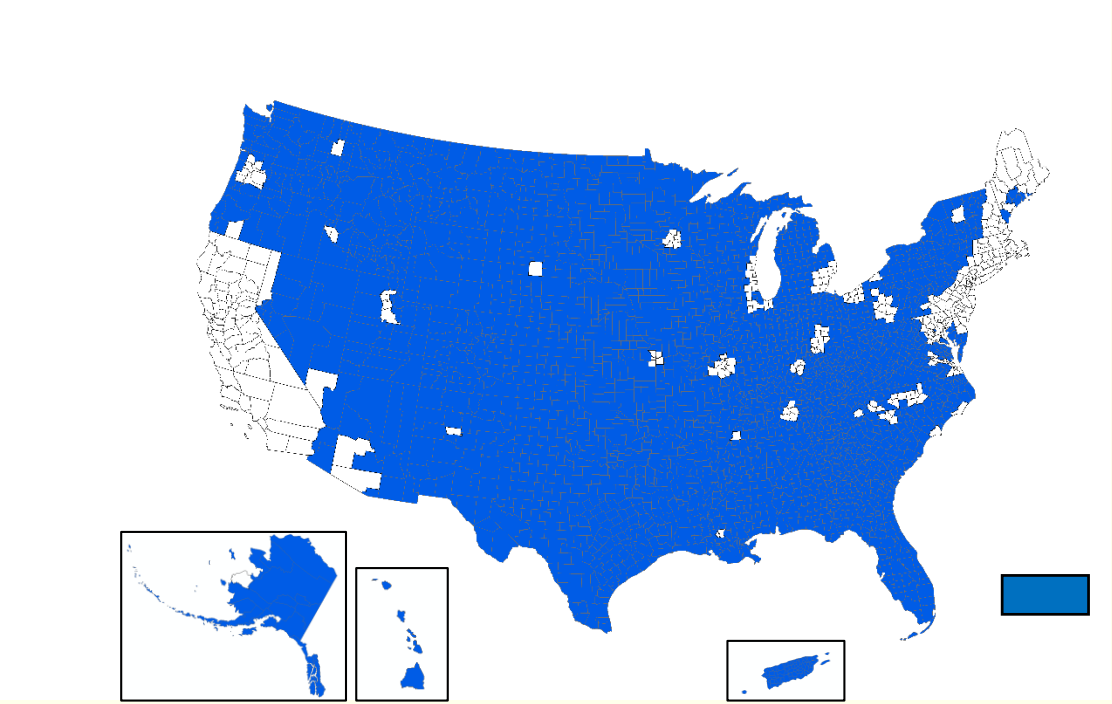
Quick Start Guide

- Slides provide a quick start guide for using the MOVES-Matrix running module to analyze project-level emissions
  - For experienced MOVES modelers
- Emission rates are derived from MOVES2014b project-level runs iterated across input variables
- The accompanying data files specifically reflect:
  - The five regions' MOVES default fuel supply
  - The five regions' MOVES default I/M program

MOVES-Matrix Background

- MOVES-Matrix provides fuel consumption and running exhaust emissions for project-level analyses and county-level runs
- The MOVES-Matrix database is populated with the results from more than 100,000 iterative MOVES runs
- MOVES-Matrix yields the exact same values obtained by running MOVES, but runs in a fraction of the time
- Users apply specific emission rates to each link in the transportation network via a scripting process

MOVES-Matrix Current Coverage
(Updated Sep 2021)



Python is Required for MOVES-Matrix

- Install Python 2.7 or higher on your computer
- Option 1 (recommended)
  - Install Anaconda2 (for python2.7) or Anaconda3 (for python3) (which includes needed modules)
  - https://www.continuum.io/downloads
- Option 2
  - Install Python
  - Add required modules (csv, os, math, time, sys, and pandas)

Six File Sets are Provided in the "MOVES-Matrix" Folder

- MOVES-matrix Python program
  - moves_matrix_py27_113018.py
- Batch mode allocation spreadsheet
  - batchmode.csv
- MOVES-Matrix emission rate database
  - MatrixData
- Input CSV files in the 'input' folder
  - Standard set of MOVES input files
- Output CSV files in the 'output' folder
  - Emission inventory and emission rates
- OpMode Distribution from MOVES default cycles
  - default_opmode_project.csv

Change the Python Directory Paths

- **Edit the Python code**
  - **Use Spyder if you installed Anaconda, or**
  - **Use any standard text editor (e.g., notepad)**
- **In the first lines, set the path for your MOVES-Matrix working directory and your database directory:**

```
## this path may need to be changed to locate matrix working directory
path = "E:\\MMatrix_Running Module"
## this path may need to be changed to locate matrix database directory
matrixdatapath = "E:\\MMatrix_Running Module\\MatrixData"
```

Running MOVES-Matrix

Step 1: Prepare input files (can be scripted)

Step 2: Set up batch mode tasks

Step 3: Start the Python program

Step 1: Input File Preparation

- **Prepare input files in ‘input’ folder as if running MOVES at the project level**
  - **csv files for link information**
    Same as the MOVES link input module
  - **csv files for link source type distribution**
    Same as MOVES linksourcetypehour input module
  - **csv files for age distribution**
    Same as the MOVES sourcetypeagedistribution input module

Step 1: Input File Preparation

- **Prepare input files in the ‘input’ folder as if running MOVES at project level**
  - **csv files for meteorology information**
    Same as the MOVES meteorology input module
    - **Set temperature between 10-110°F in 5°F bins (10,15,20…)**
    - **Set humidity between 0-100% in 5% bins (0,5,10…)**

Step 1: Input File Preparation

- Prepare input files in the ‘input’ folder as if running MOVES at the project level
  - csv files for operating information
    If you use customized operating input data
    - OpMode distributions, similar to the opmodedistribution module in MOVES (see slide 16 for details)
    - Or, drive schedules, same as driveschedulesecondlink input module in MOVES
- You don’t need to prepare operating input, if you want to obtain emissions based on MOVES default driving cycles (default_opmode_project.csv is applied here)

Step 1: Input File Preparation

- Modeled transportation links (link module)
- Source type distributions (linksourcetypehour module)
- Fleet age (sourcetypeagedistribution module)
- Meteorology (meteorology module)
- Operating mode distributions
  If you use customized operating inputs
  - opmodedistribution module
  - driveschedulesecondlink module

Prepare the Link File

- **Modeled transportation links**
  - **linkID: link ID**
  - **countyID: county ID (not used in MOVES-Matrix)**
  - **zoneID: zone ID (not used in MOVES-Matrix)**
  - **roadTypeID: road type ID (needed for MOVES default cycle)**
  - **linkLength: link length in mile**
  - **linkVolume: link volume in # of vehicles**
  - **linkAvgSpeed: link average speed in mph**
    Not needed if driving schedule is provided)
  - **linkDescrption: link description (not used)**
  - **linkAvgGrade: link road grade (not used)**

linkID	countyID	zoneID	roadTypeID	linkLength	linkVolume	linkAvgSpeed	linkDescription	linkAvgGrade
1	13121	131210	4	10	1200	55	Urban restricted	0
2	13121	131210	5	5	600	20	Urban unrestricted	0

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Prepare Source Type and Age Distributions

- **Source type distributions**
  - **linkID: link ID**
  - **sourceTypeID: source use type ID**
  - **sourceTypeHourFraction: operating time fraction (usually sum to 1 within each link)**

linkID	sourceTypeID	sourceTypeHourFraction
1	11	0.028857869
1	21	0.453908367
1	31	0.311555405

- **Age distributions**
  - **sourceTypeID: source use type ID**
  - **yearID: calendar year**
  - **ageID: vehicle age in years**
  - **ageFraction: fleet age fraction (usually sum to 1 within each source type)**

sourceTypeID	yearID	ageID	ageFraction
11	2014	0	0.071822023
11	2014	1	0.068843178
11	2014	2	0.06477528
11	2014	3	0.051962457
11	2014	4	0.046925796
11	2014	5	0.048601487
11	2014	6	0.086120656
11	2014	7	0.076624358
11	2014	8	0.072596604

Prepare Meteorology Inputs

- **Meteorology**
  - **monthID: month (1-12)**
  - **zoneID: zone ID (not used)**
  - **hourID: hour (0-23, not used)**
  - **temperature: in F**
    - **Set temperature between 0-110°F in 5°F bins (0,5,10…)**
  - **relHumudity: in %**
    - **Set humidity between 0-100% in 5% bins (0,5,10…)**

monthID	zoneID	hourID	temperature	relHumidity
1	131210	9	45	60

Prepare Operating Mode Inputs
OpMode Distribution or Drive Schedule

- **opmodedistribution**
  - sourceTypeID: source use type ID
  - linkID: link ID
  - opModeID: operating mode bin
  - opModeFraction: fraction of operating mode bin (usually sum to 1 within each source type and link)

sourceTypeID	linkID	opModeID	opModeFraction
11	1	0	0.04932
11	1	1	0.013572
11	1	11	0.019541
11	1	12	0.01788
11	1	13	0.007915

- **driveschedulesecondlink**
  - linkID: link ID
  - secondID: time series (seconds from start)
  - speed: second-by-second speed (mph)
  - grade: second-by-second road grade (%)

linkID	secondID	speed	grade
1	0	46.7	0
1	1	46.9	0
1	2	47.2	0
1	3	47.8	0
1	4	48.2	0
1	5	49	0

Step 2: Set Up Batch Mode Tasks

- Open batchmode.csv in the ‘MOVES-Matrix’ directory
- Fill in corresponding input file names within each row
  - Each row represents one task
- Users may enter input file name with or without the ‘.csv’ extension

Preparing Batch Mode Tasks File

taskID	region	calendarYear	meteorologyFileName	sourceTypeDistributionFileName	ageDistributionFileName	linkFileName	driveSchedule/OpModeDistribution	opmode(o)/cycle(d)/speed(v)
0	atlanta	2014	meteorology_ATL_13121_07.csv	sourceTypeDistribution_2014.csv	ageDistribution_2014.csv	link_ATL_13121.csv		v
1	atlanta	2014	meteorology_ATL_13121_07.csv	sourceTypeDistribution_2014.csv	ageDistribution_2014.csv	link_ATL_13121.csv	drivingCycle.csv	d
2	atlanta	2014	meteorology_ATL_13121_07.csv	sourceTypeDistribution_2014.csv	ageDistribution_2014.csv	link_ATL_13121.csv	opModeDistribution_MOVESMatrix	o
3	atlanta	2018	meteorology_ATL_13121_07.csv	sourceTypeDistribution_2018.csv	ageDistribution_2018.csv	link_ATL_13121.csv		v
4	atlanta	2018	meteorology_ATL_13121_07.csv	sourceTypeDistribution_2018.csv	ageDistribution_2018.csv	link_ATL_13121.csv	drivingCycle.csv	d
5	atlanta	2018	meteorology_ATL_13121_07.csv	sourceTypeDistribution_2018.csv	ageDistribution_2018.csv	link_ATL_13121.csv	opModeDistribution_MOVESMatrix	o

- **taskID: task ID, similar to MOVESRunID in MOVES**
- **region: enter one of the five regions:**
  - **denver, atlanta, buffalo, dc, seattle**
- **calendarYear: calendar year**
- **meteorologyFileName: meteorology csv input file**
- **sourceTypeDistributionFileName: source type distribution input file**

Preparing the Batch Mode Tasks File

taskID	region	calendarYear	meteorologyFileName	sourceTypeDistributionFileName	ageDistributionFileName	linkFileName	driveSchedule/OpModeDistribution	opmode(o)/cycle(d)/speed(v)
0	atlanta	2014	meteorology_ATL_13121_07.csv	sourceTypeDistribution_2014.csv	ageDistribution_2014.csv	link_ATL_13121.csv		v
1	atlanta	2014	meteorology_ATL_13121_07.csv	sourceTypeDistribution_2014.csv	ageDistribution_2014.csv	link_ATL_13121.csv	drivingCycle.csv	d
2	atlanta	2014	meteorology_ATL_13121_07.csv	sourceTypeDistribution_2014.csv	ageDistribution_2014.csv	link_ATL_13121.csv	opModeDistribution_MOVESMatrix	o
3	atlanta	2018	meteorology_ATL_13121_07.csv	sourceTypeDistribution_2018.csv	ageDistribution_2018.csv	link_ATL_13121.csv		v
4	atlanta	2018	meteorology_ATL_13121_07.csv	sourceTypeDistribution_2018.csv	ageDistribution_2018.csv	link_ATL_13121.csv	drivingCycle.csv	d
5	atlanta	2018	meteorology_ATL_13121_07.csv	sourceTypeDistribution_2018.csv	ageDistribution_2018.csv	link_ATL_13121.csv	opModeDistribution_MOVESMatrix	o

- **ageDistributionFileName: age distribution input file**
- **linkFileName: link input file**
- **driveSchedule/opModeDistributionFileName: drive schedule file or opMode distribution file**
- **opmode(o)/cycle(d)/speed(v):**
  - **'d' if drive schedule is used**
  - **'o' if opmode distribution is used**
  - **'v' to apply MOVES default cycles**

opmode(o)/cycle(d)/speed(v) Method

- If ‘d’ is chosen: drive schedule input is needed
- If ‘o’ is chosen: opmode distribution input is needed. Average speed in link input file is needed
- If ‘v’ is chosen: average speed and road type ID is needed in link input file (no operating inputs needed)
  - Average speed: choose from 1-80 mph in 0.1 mph interval
  - Road type ID: 2-Rural restricted access, 3-Rual unrestricted access, 4-Urban restricted access, 5-Urban unrestricted access

Step 3: Start the Python Program

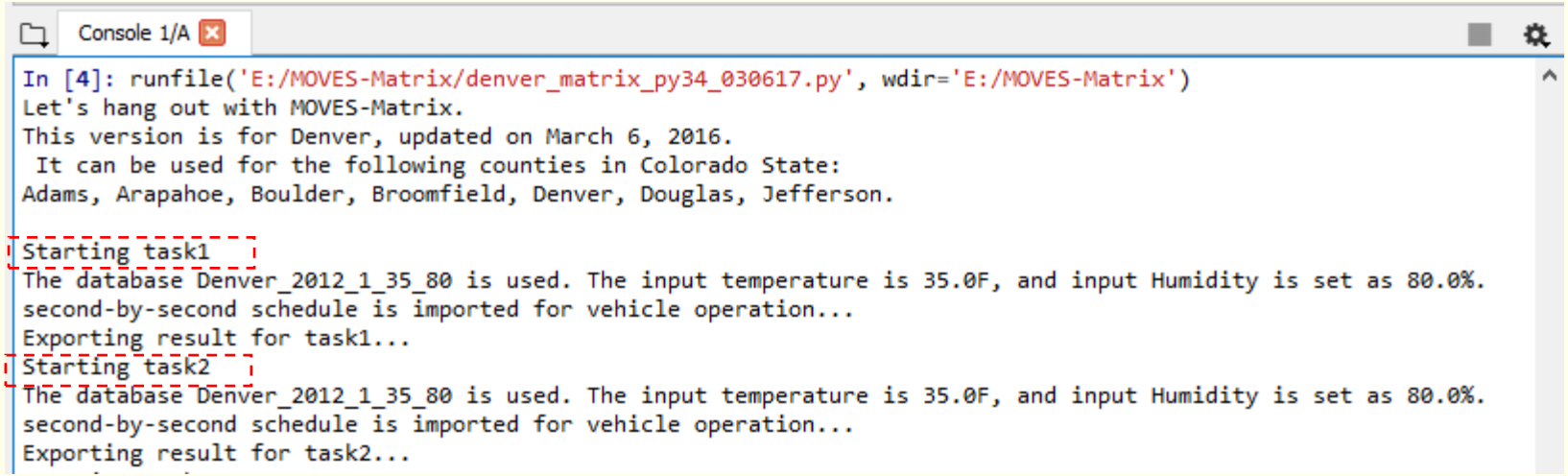
- Run the program moves_matrix_py27_113018.py
- Option 1: Use Anaconda (recommended):

  Use Spyder to open python code, click  to run
- Option 2: Run python code through command line

  Change directory to MOVES-Matrix folder path,
  type 'python moves_matrix_py27_113018.py'
  and press ENTER

Calculation Process

- **Program takes several seconds to finish calculations**
- **Status of each task is shown on the program screen**



Visually Verify Input File Information

- For each task, MOVES-Matrix grabs a specific emission rate table from the matrix database, based upon region, calendar year (in batchmode.csv), month, and meteorology (in meteorology input file)
- The database table that will be used in the each task analysis is displayed on the program screen.

```
Starting task1
The database Denver_2012_1_35_80 is used. The input temperature is 35.0F, and input Humidity is set as 80.0%.
second-by-second schedule is imported for vehicle operation...
Exporting result for task1...
Starting task2
The database Denver_2012_1_35_80 is used. The input temperature is 35.0F, and input Humidity is set as 80.0%.
second-by-second schedule is imported for vehicle operation...
Exporting result for task2...
```

Files Generated

- The output file in the working directory will contain four csv files generated by the Python script
  - taskX_emissionbylink.csv
  - taskX_emissionbylinksource.csv
  - X is the task number defined in batchmode.csv

Output Tables

- taskX_emissionbylink.csv
  - Column[emquant]: Emissions and energy consumption (g or KJ) for each link in each task (similar to MOVES results in the ‘movesoutput’ table)
  - Column[emrate]: Emission and energy consumption rates (g/mile or KJ/mile) for each link in each task (similar to MOVES results in the ‘rateperdistance’ table)

Output Tables

- taskX_emissionbylinksource.csv
  - Column[emquant]: Emissions and energy consumption (g or KJ) for each source type within each link in each task (similar to MOVES results in the ‘movesoutput’ table when disaggregated by source type)
  - Column[emrate]: Emission and energy consumption rates (g/mile/vehicle or KJ/mile/vehicle) for each source type within each link in each task

Scripting Input Files to Handle Network Runs

- Users can create input files using Python or Perl for simulation model runs or complex corridor analysis
  - Example: Atlanta Travel Demand Model: 74,000+ links
    Obtain volume and speed for each link and assign corresponding operation and fleet composition
- When drive schedule mode is used, all vehicles on the link are assigned the drive schedule provided
- When opmode distribution mode is used, each source type can be assigned a different opmode distribution on each link
- When MOVES default cycle mode is used, all vehicles on a link are assigned the same average speed

MOVES-Matrix Quick Start Summary

- The Georgia Tech research team has provided:
  - MOVES-Matrix database for five regions
  - MOVES-Matrix Python scripts
- MOVES users can easily implement MOVES-Matrix
  - Very fast, high-resolution modeling runs
  - Users can develop scripts to create input files
  - Users can script multiple runs

References

- Guensler, R., H. Liu, X. Xu, Y. Xu, and M.O. Rodgers (2016). MOVES-Matrix: Setup, Implementation, and Application. 95th Annual Meeting of the Transportation Research Board. Washington, DC. January 2016
- Xu, X., H. Liu, Y. Xu, M. Hunter, M.O. Rodgers and R. Guensler (2016). Estimating Project-Level Vehicle Emissions with VISSIM and MOVES-Matrix. Transportation Research Record, No. 2570, pp. 107-117.
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Questions:

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