



Using the Motor Vehicle Emission Simulator (MOVES) Model in Inventory Mode to Develop Regional On-Road Emission Inputs for Air Quality Modeling Applications

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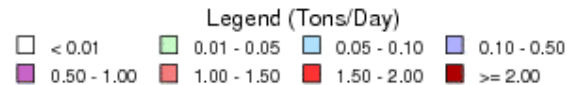
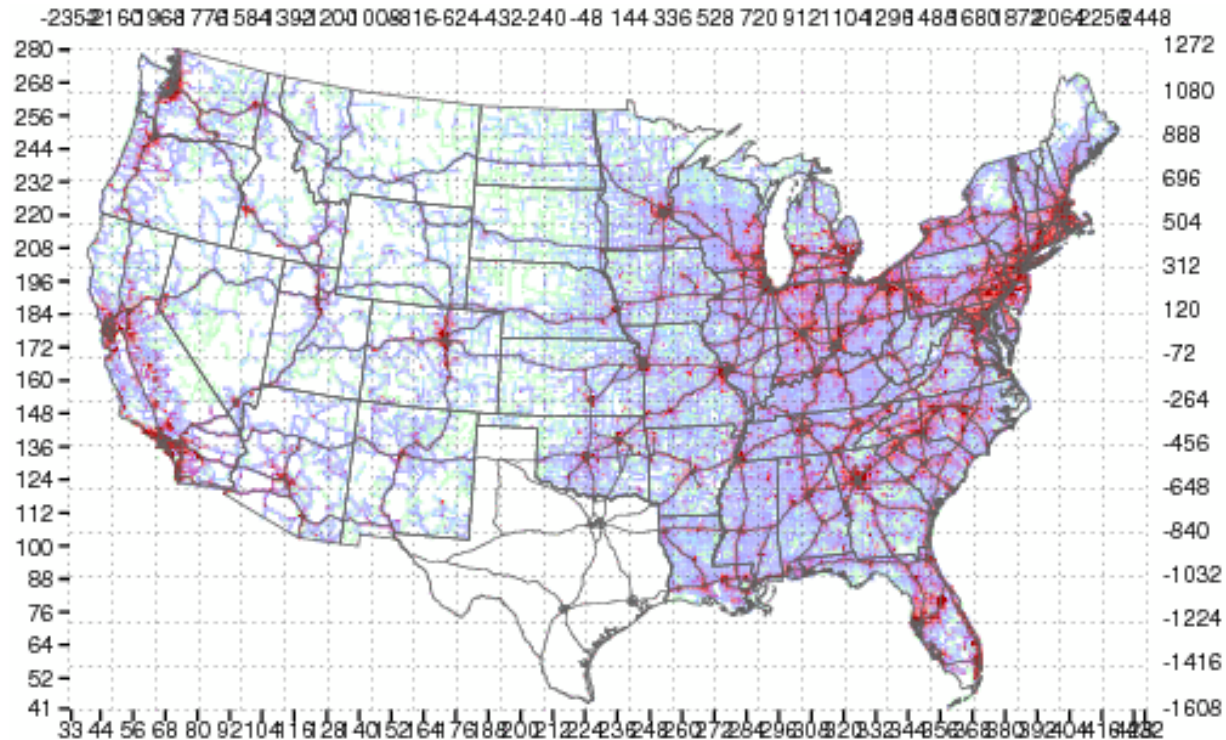


Presentation Overview

- Plots of non-Texas 2006 July weekday on-road emissions based on MOVES2010a default runs for nitrogen oxides (NO_x), volatile organic compounds (VOC), carbon monoxide (CO), and sulfur dioxide (SO₂)
- Specifying MOVES default state and local allocation factors for inventory calculation type
- Developing initial and subsequent sets of MOVES run specification files
- Running MOVES in batch mode and personal computer (PC) MOVES run times for 2,891 non-Texas U.S. counties
- MOVES run time performance issues and average run times per county
- Converting MOVES output to comma-separated values (CSV) format
- Emission processing steps with MOVES on-road inventories
- Spatial surrogate cross-referencing for MOVES categories
- Plots of non-Texas 2006 July Weekday on-road NO_x emissions by time zone
- MOVES custom classification codes for fuel types, source use types, roadway types, and emission processes
- Availability of MOVES data sets and current TCEQ on-road inventory development plans with MOVES
- Questions?

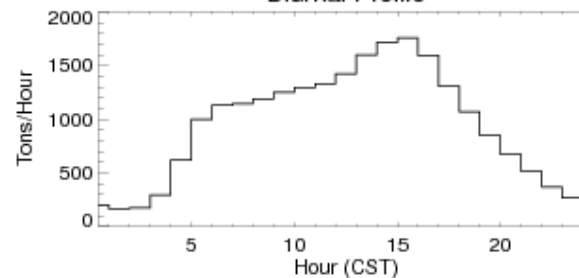


Non-Texas 2006 July Weekday On-Road NO_x Emissions Based on MOVES2010a Default Runs



Max: 73.104 t/d (1914, 318); Min: 0.000 t/d (-2346, -1602)

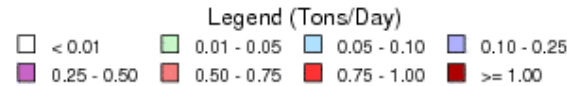
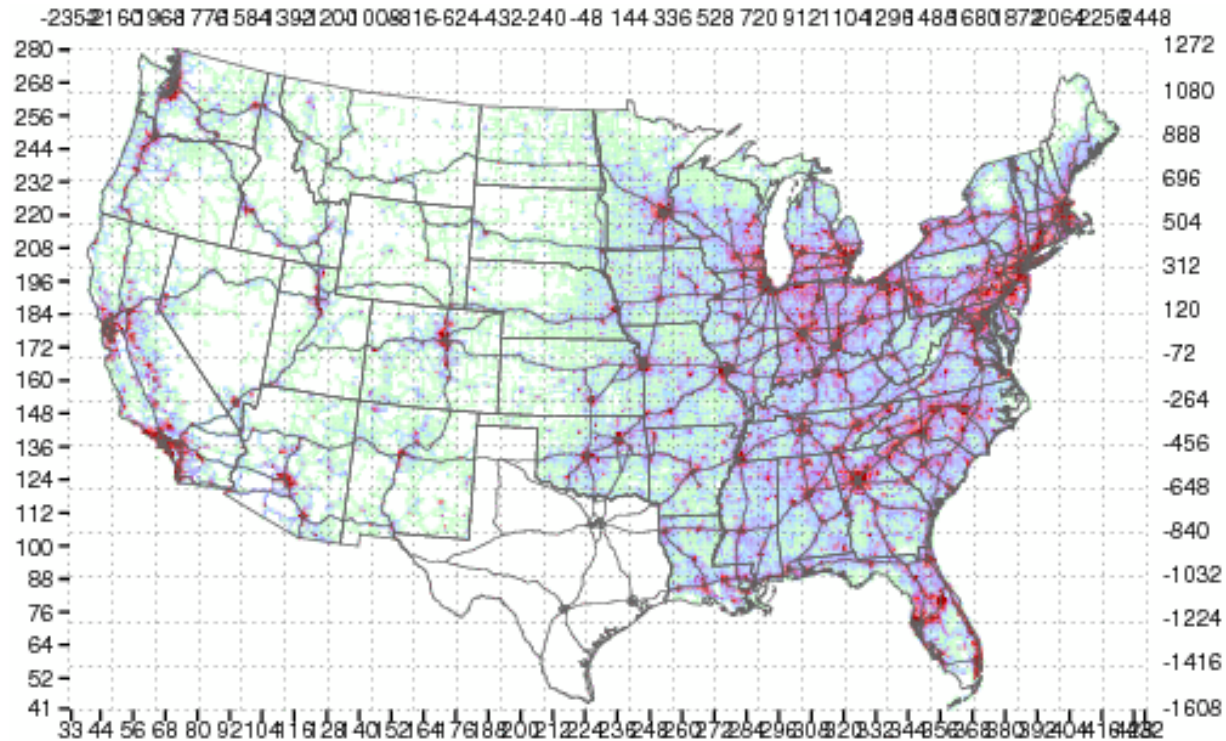
Diurnal Profile



Total Emissions:
22920.8 T/D

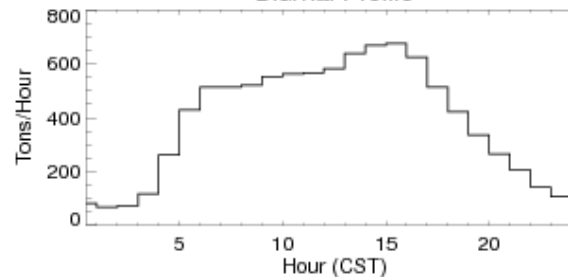


Non-Texas 2006 July Weekday On-Road VOC Emissions Based on MOVES2010a Default Runs



Max: 29.548 t/d (1914, 318); Min: 0.000 t/d (-2346, -1602)

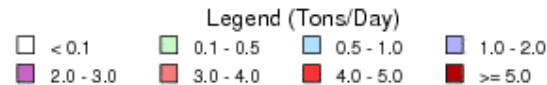
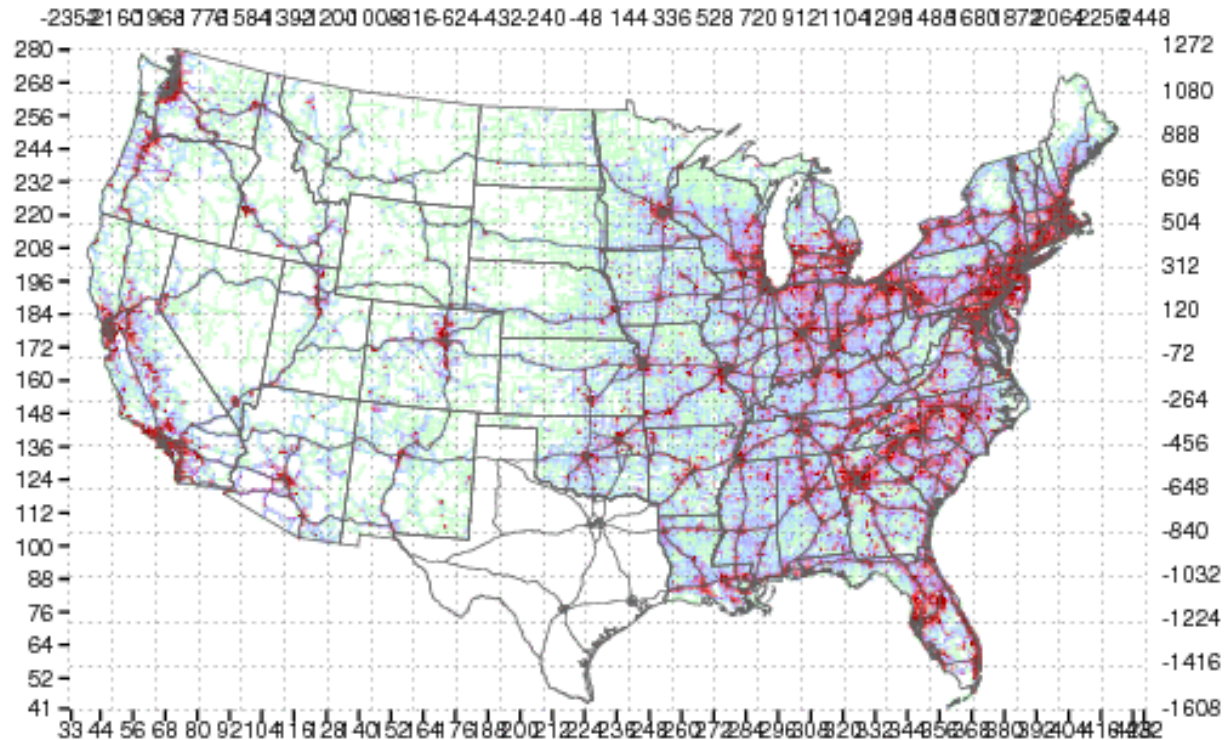
Diurnal Profile



Total Emissions:
9448.40 T/D

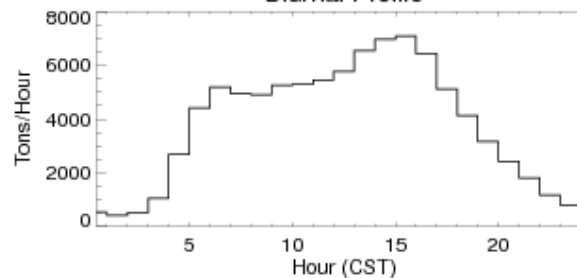


Non-Texas 2006 July Weekday On-Road CO Emissions Based on MOVES2010a Default Runs



Max: 293.208 t/d (1914, 318); Min: 0.000 t/d (-2346, -1602)

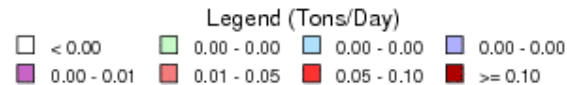
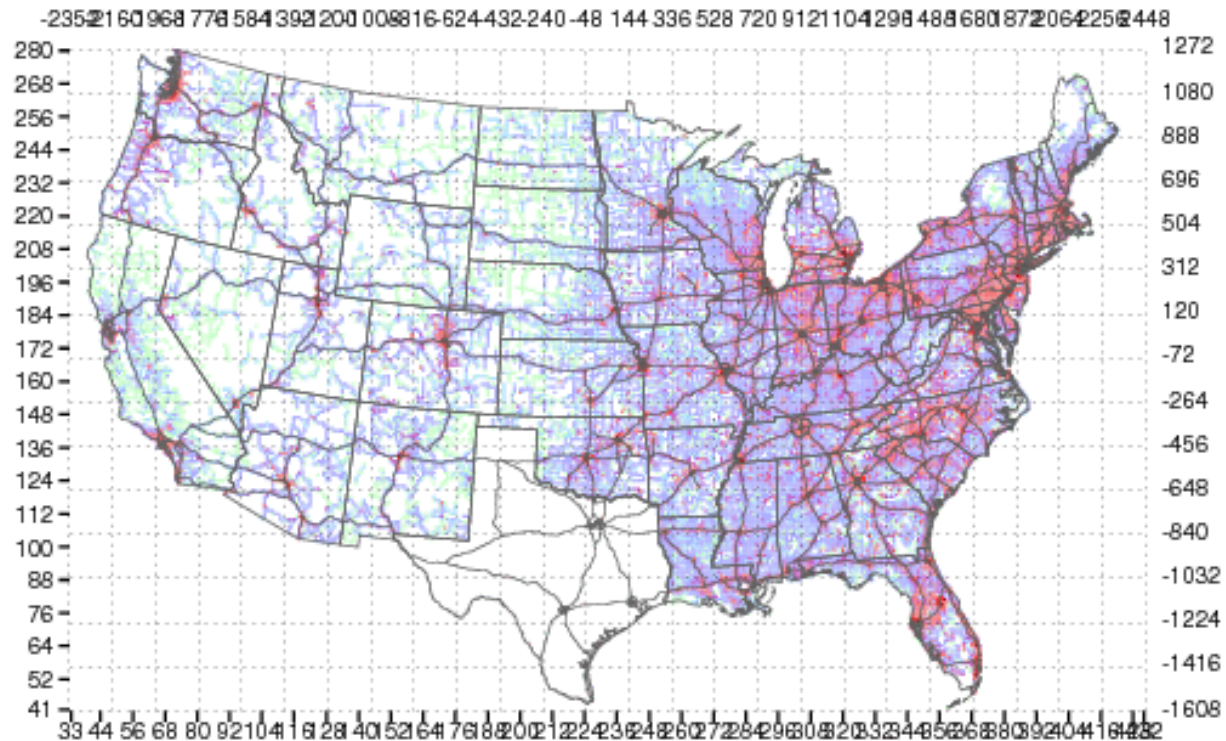
Diurnal Profile



Total Emissions:
92188.7 T/D

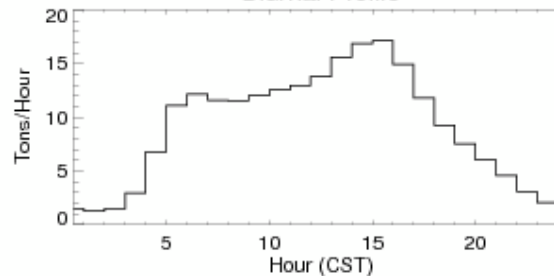


Non-Texas 2006 July Weekday On-Road SO₂ Emissions Based on MOVES2010a Default Runs



Max: 0.742 t/d (1122, 354); Min: 0.000 t/d (-2346, -1602)

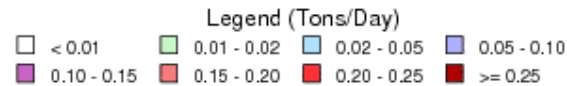
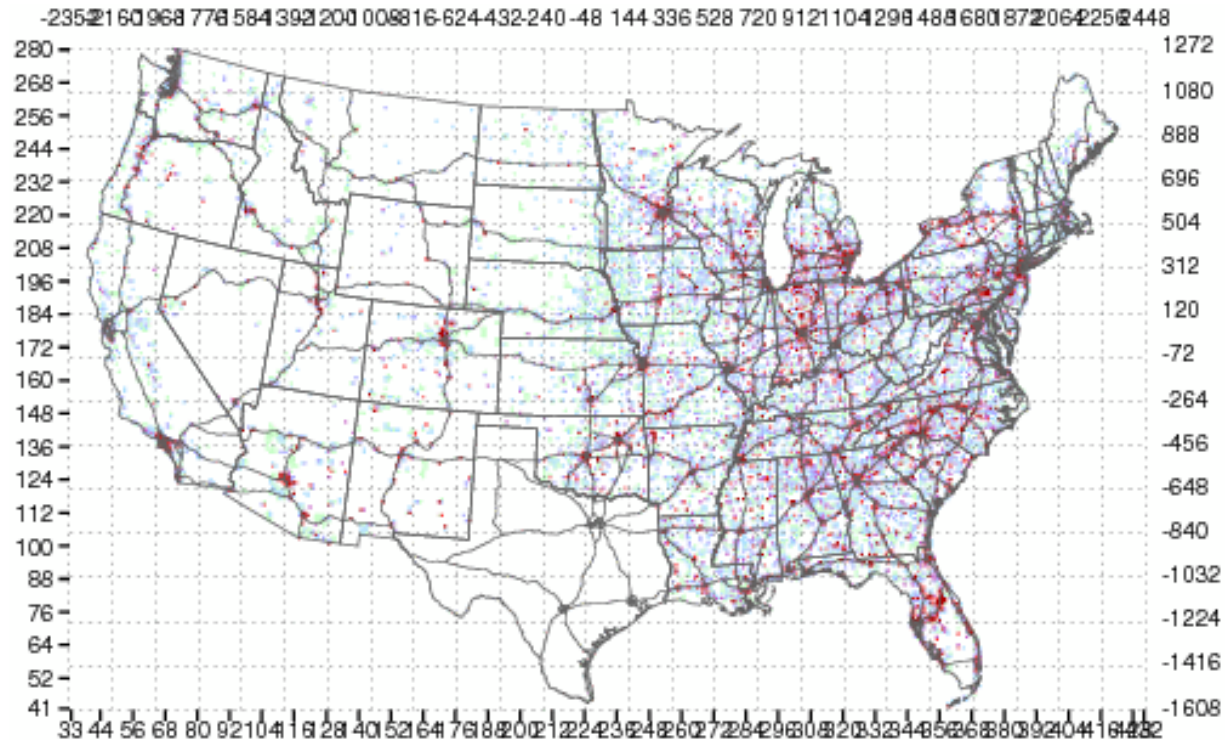
Diurnal Profile



Total Emissions:
220.398 T/D

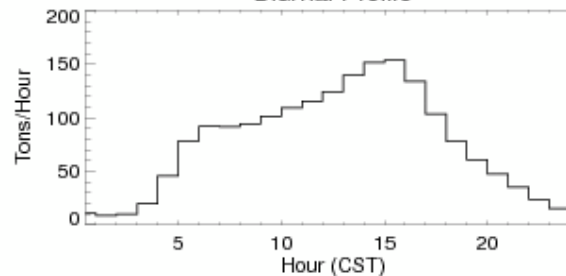


Non-Texas 2006 July Weekday Refueling VOC Emissions Based on MOVES2010a Default Runs



Max: 4.086 t/d (1134, 354); Min: 0.000 t/d (-2346, -1602)

Diurnal Profile



Total Emissions:
1842.54 T/D



Specifying MOVES Default State and Local Allocation Factors for Inventory Calculation Type

The screenshot shows the MOVES software interface. The title bar reads "MOVES - ID 8497563211372025598". The menu bar includes "File", "Edit", "Pre Processing", "Action", "Post Processing", "Tools", "Settings", and "Help".

Left Panel (Navigation):

- Description ✓
- Scale ✓
- Time Spans !
- Geographic Bounds !
- Vehicles/Equipment + !
- Road Type !
- Pollutants And Processes !
- Manage Input Data Sets ✓
- Strategies - ✓
 - Alternative Vehicle Fuels & Technologies ✓
 - On-Road Retrofit ✓
 - Rate Of Progress ✓
- Output - !
 - General Output !
 - Output Emissions Detail ✓
 - Advanced Performance Features ✓

Main Panel (Configuration):

Domain/Scale

- National** Use the default national database with default state and local allocation factors.
Caution: Do not use this scale setting for SIP or conformity analyses. The allocation factors and other defaults applied at the state or county level have not been verified against specific state or county data and do not meet regulatory requirements for SIPs and conformity determinations.
- County** Select or define a single county that is the entire domain.
Note: Use this scale setting for SIP and regional conformity analysis. Use of this scale setting requires user-supplied local data for most activity and fleet inputs.
- Project** Use project domain inputs.
Note: Use this scale setting for project-level analysis for conformity, NEPA, or any other regulatory purpose. Use of this scale setting requires user-supplied data at the link level for activity and fleet inputs that describe a particular transportation project.

Calculation Type

- Inventory** Mass and/or Energy within a region and time span.
- Emission Rates** Mass and/or Energy per unit of activity.
MOVES ScenarioID:

Caution: Changing these selections changes the contents of other input panels. These changes may include losing previous data contents.

Ready...

Windows taskbar: start, MOVES Master, MOVES Worker, MOVES Worker - ID 6..., MOVES - ID 8497563..., 6:12 PM



Developing Initial Set of MOVES Run Specification Files

- MOVES “County” scale is necessary for State Implementation Plan (SIP) work within the area of interest, but allows designation of only one county per run specification.
- “SIP quality” level of effort is not necessary for out-of-state on-road emission inputs at a coarser resolution for air quality modeling included with Texas SIP submissions.
- MOVES “National” scale allows designation of multiple counties per run specification.
- MOVES graphical user interface (GUI) was used to develop 2006 July Weekday run specifications for every non-Texas state:
 - one run specification per state, but two for those with a high number of counties (e.g., Georgia, Kentucky, Missouri, and Virginia) to speed up MOVES run time;
 - applicable source use types for gasoline and diesel fuel specified;
 - all gaseous pollutants and energy consumption parameters specified (no particulate or toxic pollutants needed for ozone modeling); and
 - all emission processes specified, including refueling.



Developing Subsequent Sets of MOVES Run Specification Files

- July 2006 Weekday set of text-based run specification files became a template for other scenarios.
- Recommend use of a text editor (such as TextPad or UltraEdit) that can perform quick search/replaces on multiple individual text files:
 - Replace `<day id="5"/>` with `<day id="2"/>` to change from Weekday to Weekend scenario.
 - Replace `<year key="2006"/>` with `<year key="2008"/>` to change calendar years.
 - Change the output database name parameters as needed.
- LINUX `rename` command used to change codes for day type and year in the run specification file name. If multiple run specification text files are contained within one directory, can type:

```
rename weekday weekend *mrs (changes weekday to weekend in files ending in "...mrs"); or
```

```
rename 2006 2018 *mrs (changes 2006 to 2008 in files ending in "...mrs").
```

- The MOVES output database contains 37 files ending with "...frm", "...MYD", "...MYI", and "...opt". Multiple output directories are made for each run script from a "blank" template directory with LINUX code that designates the calendar year, month, day type, and state:

```
for state in ak al ar az ca co ct dc de fl ga_1 ga_2 hi ia id il 'in' ks ky_1 ky_2 la ma md
do
  cp -R /ei/onroad/moves/mysql_db/blank/mvs_default_20XX_july_weekXXX_XX \
  /ei/onroad/moves/mysql_db/blank/$yyyy/$day_type/mvs_default_${yyyy}_${month}_${day_type}_${state}
done
```



Running MOVES in Batch Mode

- Batch mode is far superior to use of the GUI where only one run specification file can be activated.
- Develop a text file that lists just the file names and directory paths of the MOVES run specifications in order of sequence:

`C:\MOVES\RunSpecs\2006\Weekday\mvs_default_2006_july_weekday_dc.mrs`

`C:\MOVES\RunSpecs\2006\Weekday\mvs_default_2006_july_weekday_de.mrs`

`C:\MOVES\RunSpecs\2006\Weekday\mvs_default_2006_july_weekday_ri.mrs`

- Create a one-line text file in `C:\Program Files\MOVES20100826\` named `runmoves.bat` with:
`java -Xmx512m gov.epa.otaq.moves.master.commandline.MOVESCommandLine`
`-rl C:\MOVES\RunSpecs\Year\Day_Type\Name_of_File_With_List_of_Run_Specs`
- Populate the `C:\MySQL\data\` directory with “blank” output database folders for each run specification.
- Open a DOS Command Prompt window and the MOVES Worker (don't open the Master).
- Navigate in the DOS Command Prompt window to `C:\Program Files\MOVES20100826>`.
- Type `setenv.bat` and hit return (this file is included with the MOVES installation).
- Type `runmoves.bat` and hit return.
- Follow the progress of the batch run in the `C:\MySQL\data\` directory with Windows Explorer.



PC MOVES Run Times for 2,891 Non-Texas U.S. Counties

Calendar Year	Month and Day Type	Run Time for 2,891 Counties		
		Days	Hours	Average Minutes per County
2006	July Weekday	68	1,634	34
	July Weekend	80	1,927	40
2008	July Weekday	81	1,938	40
	July Weekend	89	2,138	44
2012	July Weekday	86	2,060	43
	July Weekend	88	2,113	44
2018	July Weekday	98	2,343	49
	July Weekend	104	2,489	52

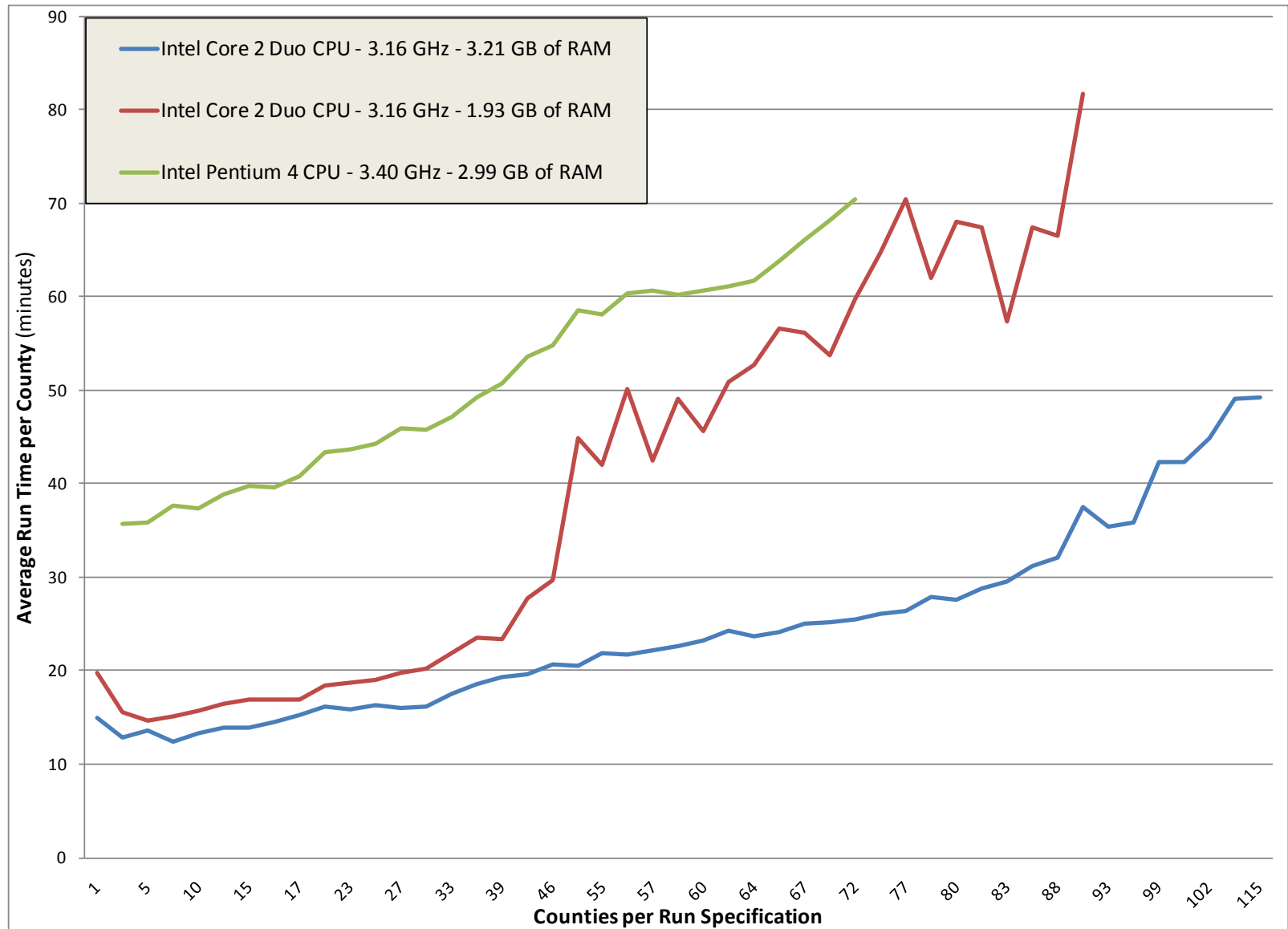


MOVES Run Time Performance Issues

- MOVES runs performed on seven individual PCs containing three different combinations of central processing units (CPUs) and random-access memory (RAM) sizes:
 - three contained an Intel Core 2 Duo CPU with 3.16 GHz and 3.21 GB of RAM;
 - three contained an Intel Core 2 Duo CPU with 3.16 GHz and 1.99 GB of RAM; and
 - one contained an Intel Pentium 4 CPU with 3.40 GHz and 2.99 GB of RAM.
- Overall performance conclusions:
 - dual-core CPU superior to a single-core CPU, and the more RAM the better; and
 - if the combination of counties, pollutants, source use types, and emission processes per run specification is too large, overall run times can be extremely long.
- MOVES ran in stand-alone mode on each of these PCs instead of multiple-computer processing:
 - This “many slow tortoises” approach minimizes the chances of network interruption during multi-week batch runs.
 - A single “fast hare” approach with multiple networked PCs would be appropriate for runs that would take a few days or perhaps one to two weeks.
 - Roughly two or three times per month, each PC on our network receives a system update during overnight or weekend times that automatically reboots each PC, which would cancel a multiple-computer Master/Worker batch run.



MOVES Average Run Times per County





Converting MOVES Output to CSV Format

- MOVES database output converted to CSV text files with My Structured Query Language (MySQL) scripts.
- If you wish to run these scripts from the MOVES GUI Post Processing tab, create two text files to be placed under `C:\Program Files\MOVES20100826\database\OutputProcessingScripts`.

- File called `movesoutput.sql`:

```
select yearID, monthID, dayID, hourID, stateID, countyID, pollutantID, processID,
sourcetypeID, fueltypeID, roadtypeID, emissionquant
from movesoutput
into outfile 'movesoutput.csv'
fields terminated by ','
lines terminated by '\r\n';
```

- File called `movesactivityoutput.sql`:

```
select yearID, monthID, dayID, hourID, stateID, countyID, sourcetypeID, fueltypeID,
roadtypeID, activitytypeID, activity
from movesactivityoutput
into outfile 'movesactivityoutput.csv'
fields terminated by ','
lines terminated by '\r\n';
```



Preparing Emission Processor Input Files

- Use a combination of LINUX master run script and custom SAS code to develop files in Area and Mobile Source (AMS) format for input into the PREAM module of the Emissions Processor System Version 3 (EPS3).
- SAS code reads in MOVES CSV output file for each state:
 - Keeps current pollutants of interest, which are nitrogen oxide (NO), nitrogen dioxide (NO₂), VOC, CO, and SO₂.
 - Matches MOVES numeric codes for fuel type, source use type, roadway type, and emission process to custom alpha codes so emissions can be reported by ten-digit identifiers.
 - Matches the county with the appropriate time zone.
 - Performs a time zone shift using the MOVES hourID field to convert hourly emissions into Central Standard Time (CST) for photochemical model input.
 - Creates separate output files by four time zones (Eastern, Central, Mountain, and Pacific) for subsequent EPS3 processing.



Emission Processing Steps With MOVES On-Road Inventories

- Chemical speciation:
 - Separate VOC profiles using the Carbon Bond 6 (CB6) mechanism for exhaust, fuel vapor, and fuel liquid.
 - With MOBILE6 emissions, NO_x used to be split into 90% NO and 10% NO₂ components.
 - NO_x split no longer required if MOVES is directed to report NO and NO₂ in the Pollutants and Processes menu.
- Temporal allocation:
 - Not necessary if MOVES is directed to report hourly emissions instead of daily totals in the Output Emissions Detail menu.
 - Previous tools like National Mobile Inventory Model (NMIM) or National Emissions Inventory (NEI) data sets only reported daily/monthly/annual totals.
 - Weekday and Weekend scenarios within MOVES have different hourly profiles.
- Spatial allocation:
 - Based on EPA national grid surrogates, which are available at <http://www.epa.gov/ttn/chief/emch/spatial/newsurrogate.html>.



Spatial Surrogate Cross-Referencing for MOVES Categories

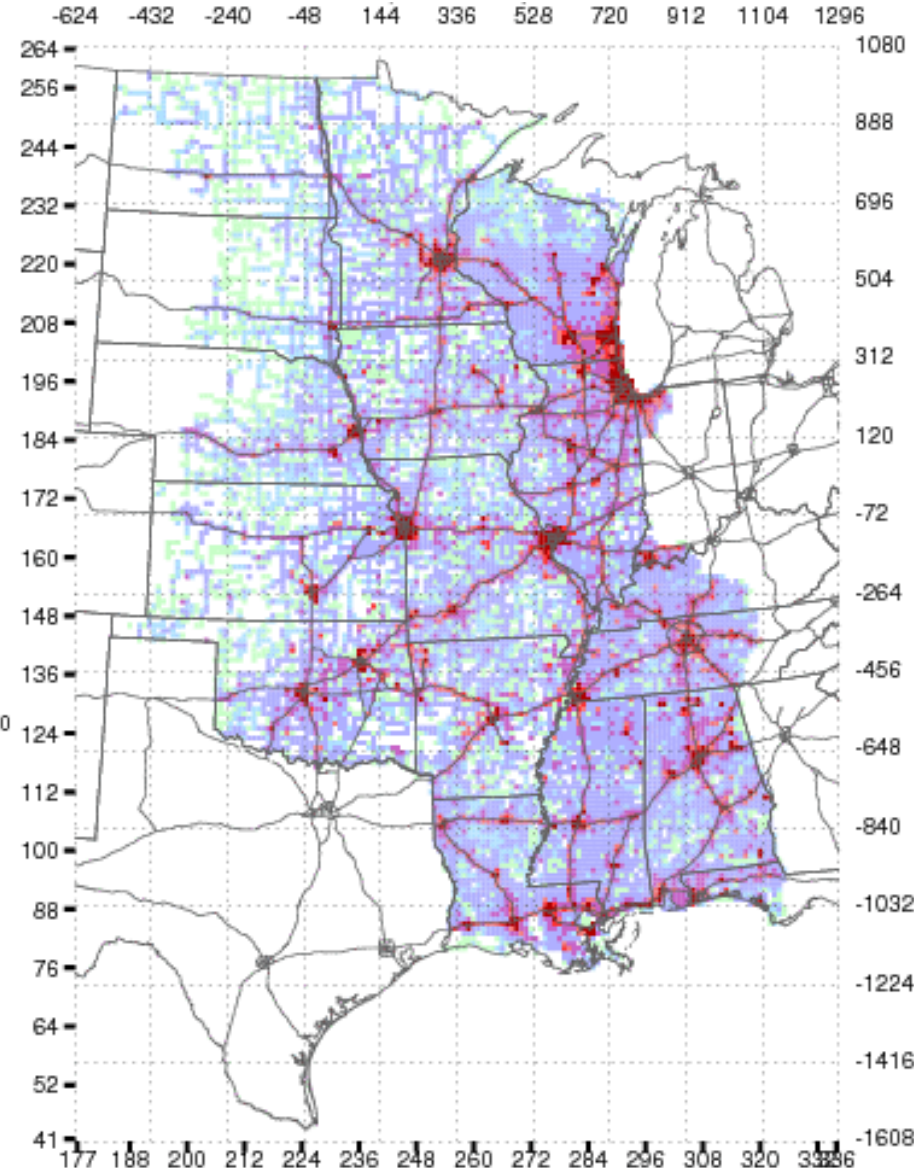
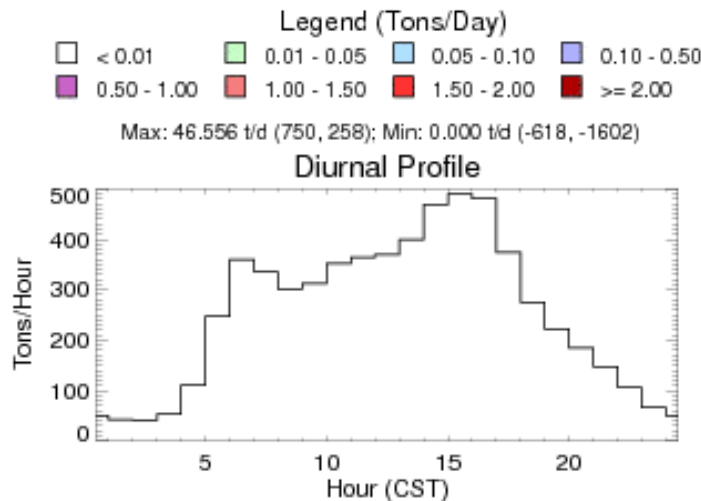
MOVES Category	MOVES Roadway Type	Surrogate Description	Surrogate Code
All Source Use Types	Rural Restricted Access	Rural Primary Road Miles	210
	Rural Unrestricted Access	Rural Secondary Road Miles	230
	Urban Restricted Access	Urban Primary Road Miles	200
	Urban Unrestricted Access	Urban Secondary Road Miles	220
Light-Duty Sources	Off Network	Population	100
Heavy-Duty Sources		Total Road Miles	240
Extended Idling		Urban and Rural Primary Road Miles	250
Refueling		Gas Stations	600



2006 July Weekday On-Road NO_x Emissions Non-Texas Central Time Zone Counties

- 1,239 non-Texas U.S. counties located within the Central Time Zone
- Morning rush hour peak at:
 - 7-8 AM Central Daylight Time; or
 - 6-7 AM Central Standard Time.

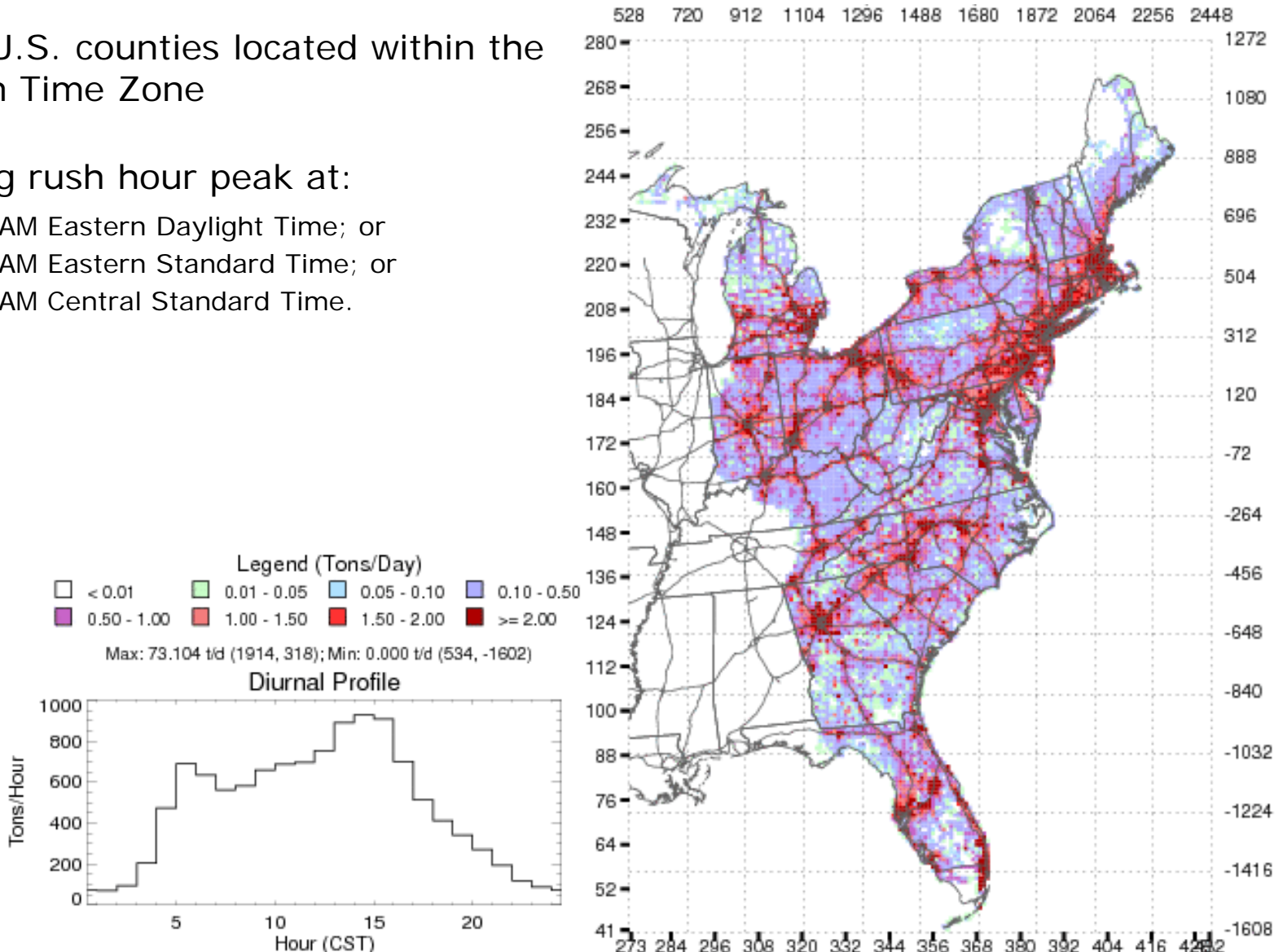
Total Emissions:
6159.96 T/D





2006 July Weekday On-Road NO_x Emissions Eastern Time Zone Counties

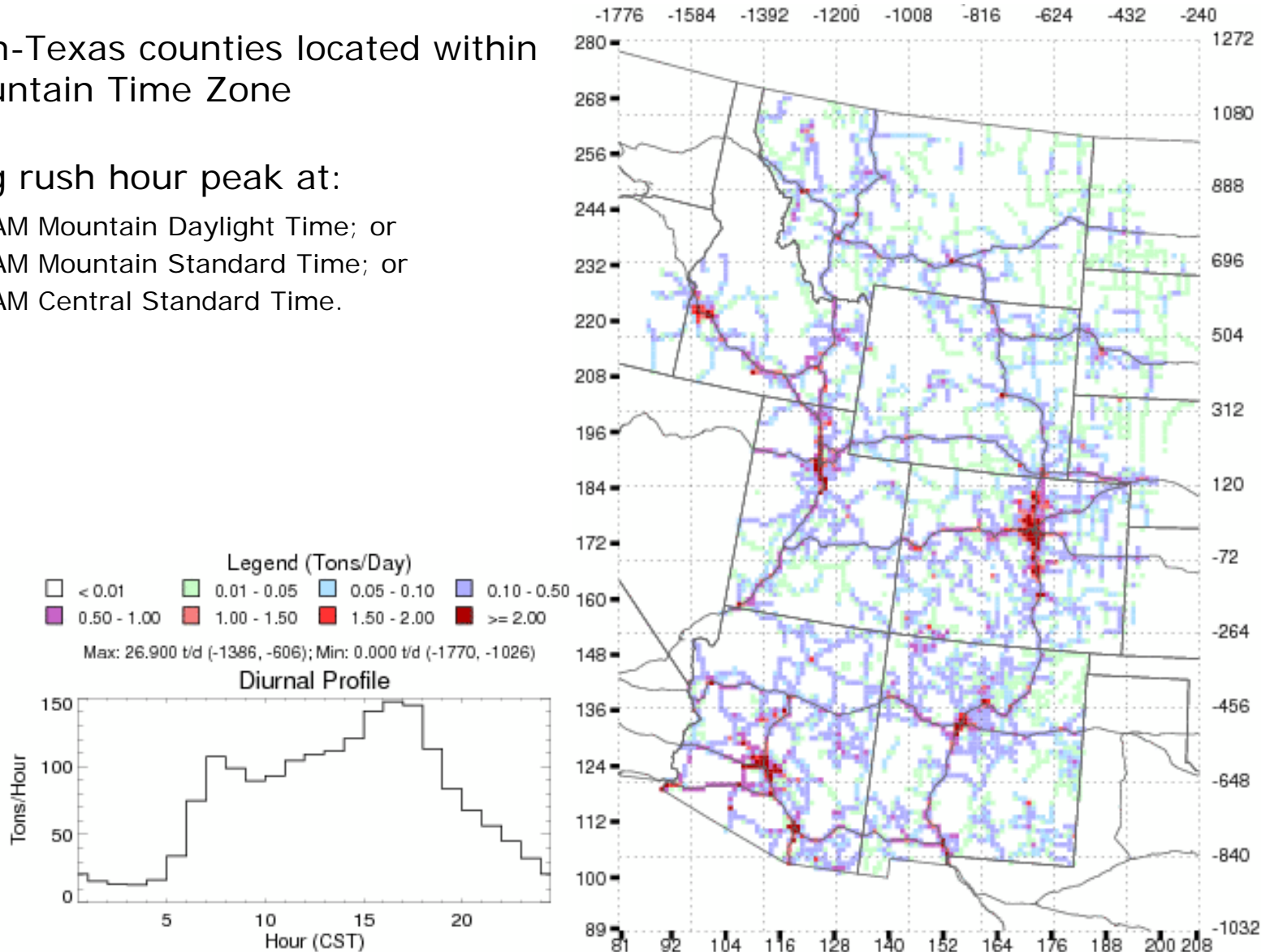
- 1,153 U.S. counties located within the Eastern Time Zone
- Morning rush hour peak at:
 - 7-8 AM Eastern Daylight Time; or
 - 6-7 AM Eastern Standard Time; or
 - 5-6 AM Central Standard Time.





2006 July Weekday On-Road NO_x Emissions Non-Texas Mountain Time Zone Counties

- 304 non-Texas counties located within the Mountain Time Zone
- Morning rush hour peak at:
 - 7-8 AM Mountain Daylight Time; or
 - 6-7 AM Mountain Standard Time; or
 - 7-8 AM Central Standard Time.

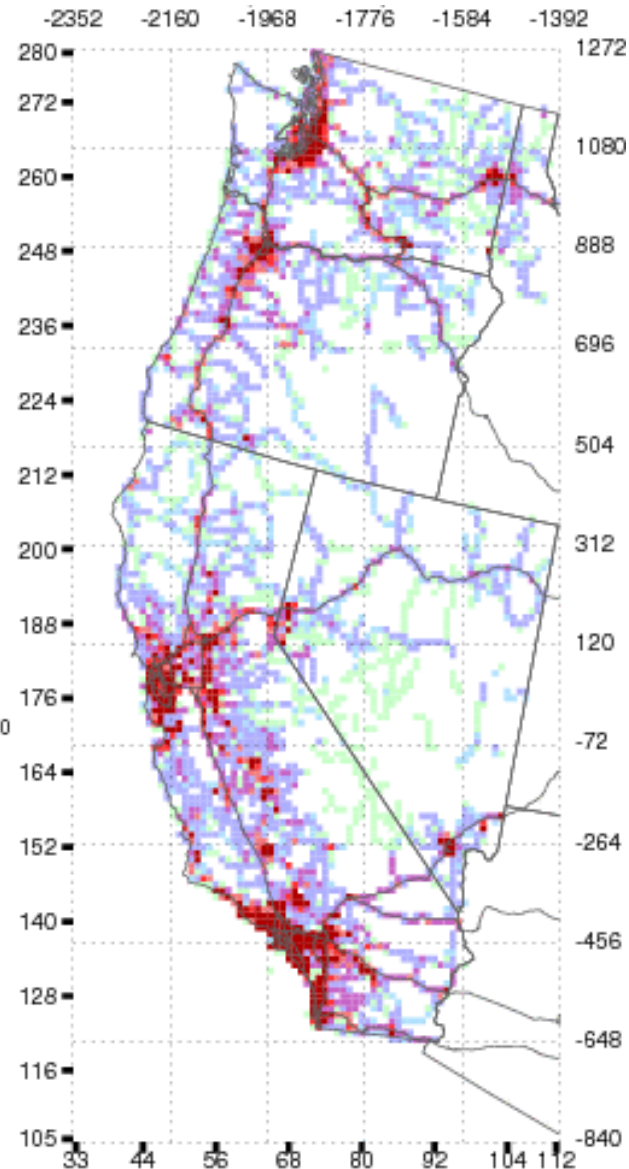
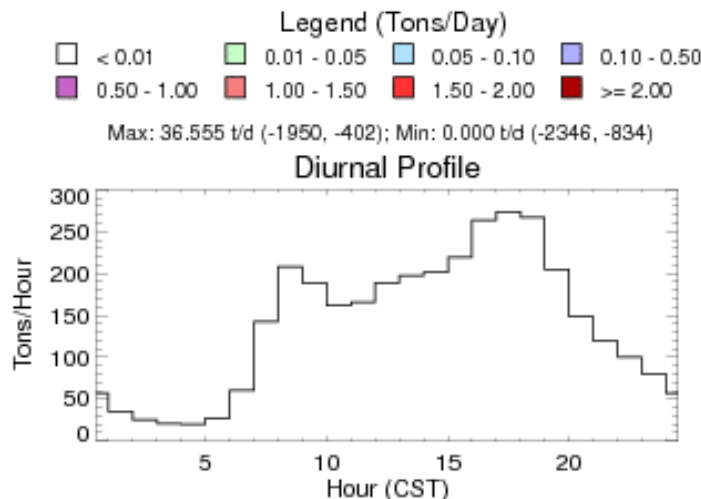




2006 July Weekday On-Road NO_x Emissions Pacific Time Zone Counties

- 159 counties located within the Pacific Time Zone
- Morning rush hour peak at:
 - 7-8 AM Pacific Daylight Time; or
 - 6-7 AM Pacific Standard Time; or
 - 7-8 AM Mountain Standard Time; or
 - 8-9 AM Central Standard Time.

Total Emissions:
3379.95 T/D





MOVES Custom Classification Codes

- Ten-digit source classification code (SCC) is the essential identifier for photochemical model emissions processing:
 - tracking and reporting by fuel type, source use type, etc.;
 - chemical speciation (e.g., gasoline versus diesel, exhaust versus evaporative); and
 - spatial/temporal allocation, post-processing, and control strategy adjustments.
- Custom numeric approach proposed by TCEQ based on the existing mobile SCC structure:
 - begins with "22...";
 - digits 3 and 4 are for fuel type;
 - digits 5 and 6 are for source use type;
 - digits 7 and 8 are for roadway type; and
 - digits 9 and 10 are for emission process.
- If the current numeric MOVES database codes are used in this sequence, no overlap would occur with the existing 1,175 on-road and non-road mobile SCCs.
- Custom alpha coding can be more convenient than numeric coding for emissions processing:
 - instant identification for fuel type, source use type, roadway type, and emission process; and
 - some categories can be aggregated to increase processing efficiency when no differences exist in speciation, temporal allocation, and/or spatial allocation (e.g., emission processes for running exhaust and crankcase running exhaust).
- Running exhaust from a gasoline-powered passenger car on an urban restricted access roadway:
 - **2201210401** under a numeric approach; or
 - **MVGSPCURRX** under an alpha approach.



MOVES Custom Classification Codes for Fuel Types

MOVES Code	MOVES Description	Alpha Code	Numeric Code
1	Gasoline	GS	01
2	Diesel Fuel	DS	02
3	Compressed Natural Gas (CNG)	CN	03
4	Liquefied Petroleum Gas (LPG)	LP	04
5	Ethanol	ET	05
9	Electricity	EL	09



MOVES Custom Classification Codes for Source Use Types

MOVES Code	MOVES Description	Alpha Code	Numeric Code
11	Motorcycle	MC	11
21	Passenger Car	PC	21
31	Passenger Truck	PT	31
32	Light Commercial Truck	LC	32
41	Intercity Bus	IB	41
42	Transit Bus	TB	42
43	School Bus	SB	43
51	Refuse Truck	RT	51
52	Single Unit Short-Haul Truck	SS	52
53	Single Unit Long-Haul Truck	SL	53
54	Motor Home	MH	54
61	Combination Short-Haul Truck	CS	61
62	Combination Long-Haul Truck	CL	62



MOVES Custom Classification Codes for Roadway Types

MOVES Code	MOVES Description	Alpha Code	Numeric Code
1	Off-Network	OF	01
2	Rural Restricted Access	RR	02
3	Rural Unrestricted Access	RU	03
4	Urban Restricted Access	UR	04
5	Urban Unrestricted Access	UU	05
6 (assumed)	Ramp	RP	06



MOVES Custom Classification Codes for Highway Performance Monitoring System (HPMS) Roadway Types

HPMS Roadway Type Description	HPMS Numeric Code	MOVES Numeric Code (no alpha)
Rural Interstate	110	11
Rural Other Principal Arterial	130	13
Rural Minor Arterial	150	15
Rural Major Collector	170	17
Rural Minor Collector	190	19
Rural Local	210	21
Urban Interstate	230	23
Urban Other Freeways and Expressways	250	25
Urban Other Principal Arterial	270	27
Urban Minor Arterial	290	29
Urban Collector	310	31
Urban Local	330	33



MOVES Custom Classification Codes for Emission Processes

MOVES Code	MOVES Description	Alpha Code	Numeric Code	Aggregation Description	Aggregation Alpha Code
1	Running Exhaust	RE	01	Running Exhaust	RX
15	Crankcase Running Exhaust	CR	15		
2	Start Exhaust	SE	02	Start Exhaust	SX
16	Crankcase Start Exhaust	CS	16		
90	Extended Idle Exhaust	IE	90	Idle Exhaust	IX
17	Crankcase Extended Idle Exhaust	CI	17		
11	Evaporative Permeation	EP	11	Vapor	VP
12	Evaporative Fuel Vapor Venting	EF	12		
13	Evaporative Fuel Leaks	EL	13	Liquid	LQ



Availability of MOVES Data Sets

- Relatively small data sets (highlighted below in red) will be posted to TCEQ's FTP site.
- Relatively large data sets will be available via hard drive if the sender provides:
 - external hard drive with USB port pre-formatted for LINUX; and
 - proper packaging and pre-paid label for return shipping.
- Data set file sizes for 2006 July Weekday scenario:

Aggregate Data Set	Specific Data Set	Uncompressed Size (MB)	Compressed Size (MB)
MOVES Files	Run Specifications (text)	2	<1
	MySQL Database Output (binary)	19,850	2,113
CSV Output	Activity (text)	618	112
	Emissions (text)	13,262	2,156
EPS3 File Sets	PREAM Input (text)	2,463	278
	GRDEM Output (gridded binary)	2,467	151
	MRGUAM Output (gridded binary)	617	143
	Message Files (text)	458	58
Total		39,736	5,011



Current TCEQ On-Road Inventory Development Plans With MOVES

- Get MOVES operating on the TCEQ LINUX system to speed up run time:
 - After 2006, 2008, 2012, and 2018 data sets are completed, emissions for additional years will be developed as identified for SIP modeling purposes.
 - If LINUX run time is significantly faster, particulate pollutants may be added to the default runs.
- Continue working with the Texas Transportation Institute (TTI) and North Central Texas Council of Governments (NCTCOG) on development of “SIP quality” on-road inventories based on using MOVES in emission rate mode:
 - Travel demand model (TDM) output for Texas metropolitan areas used to develop hourly link-based emissions by season type (School versus Summer) and day type (Monday-Thursday Weekday, Friday, Saturday, and Sunday).
 - Highway Performance Monitoring System (HPMS) data sets used to develop hourly non-link Summer season emissions for 254 Texas counties by roadway category and four day types.
- Both Texas and non-Texas data work should be completed and posted to these FTP directories by the end of this year for 2006, 2008, 2012, and 2018:
 - ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/DFW/mvs/ for the Dallas-Fort Worth area;
 - ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/HGB/mvs/ for the greater Houston area;
 - ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/Statewide/mvs/ for all Texas counties; and
 - ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/USA/mvs/ for all non-Texas counties.



Questions?

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