Application of SMOKE-MOVES Integration Tool to Regional Air Quality Modeling

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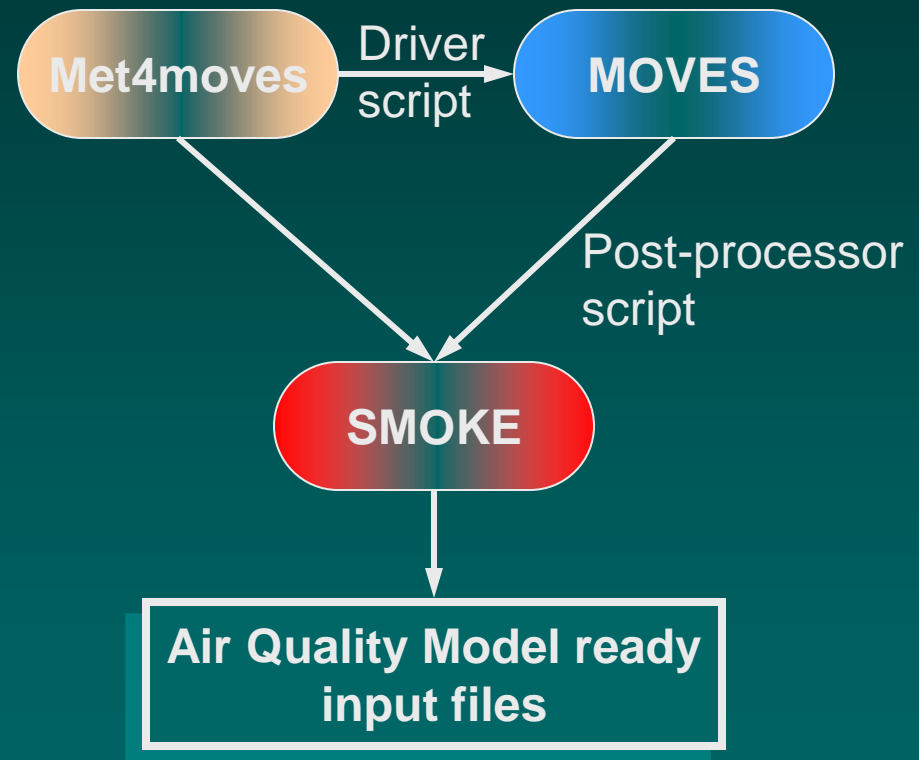*** Now at the University of Texas at El Paso**

Outline

- **Reasons to Choose the MOVES Lookup Table Approach**

- **Development of MOVES Inputs**

- **Set up MOVES Lookup Table Runs**

- **Post Processing of MOVES Lookup Tables and SMOKE Processing**
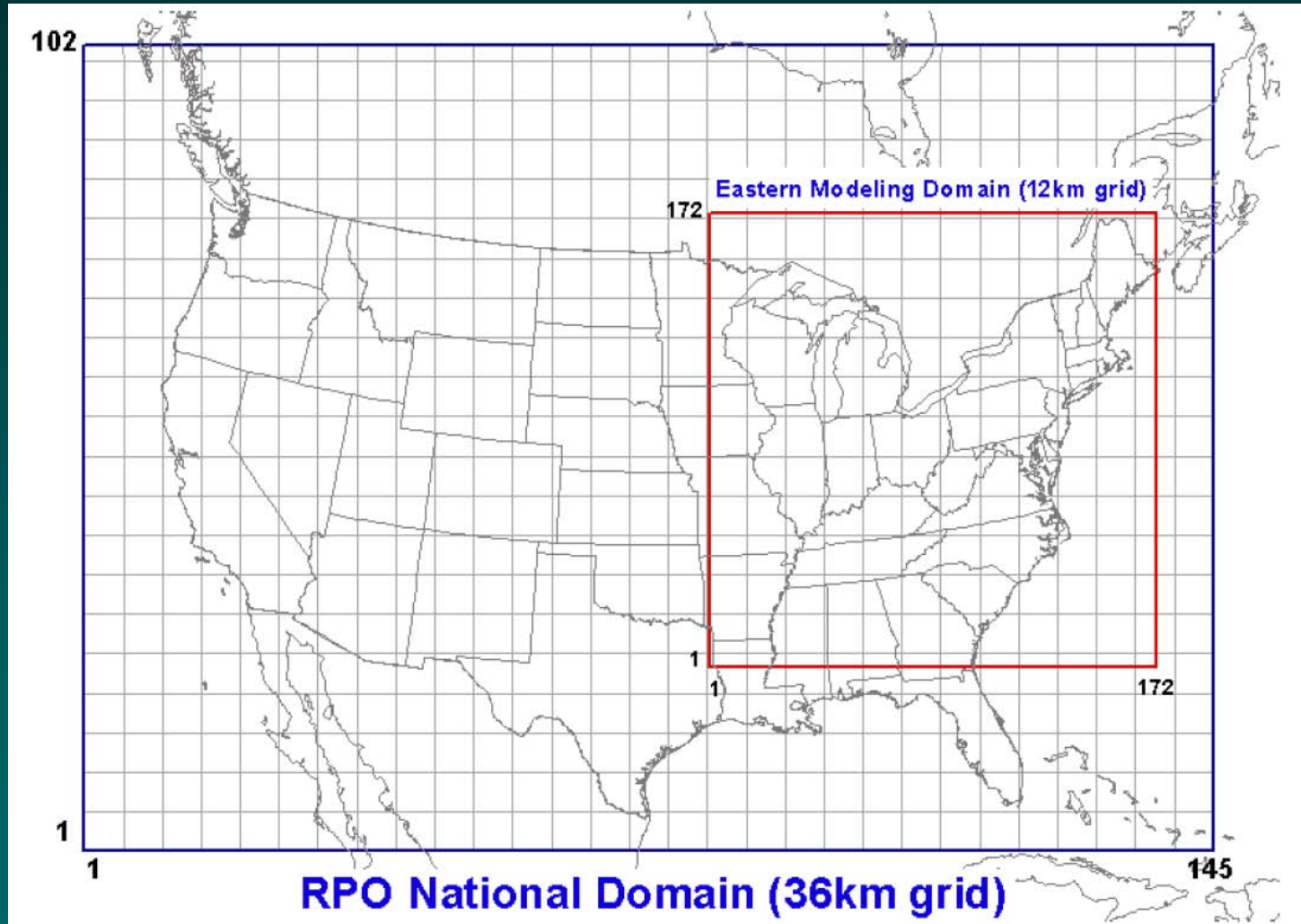
- **Acknowledgements**

Reasons to Choose the MOVES Lookup Table Approach

SMOKE-MOVES Integration Tool

◆ Met4MOVES is the meteorological data preprocessor

◆ MOVES is run to create emissions factors

◆ SMOKE processing applies the emission factors to the activity data to compute grid-cell emissions

Met4moves → **Driver script** → MOVES

Post-processor script

SMOKE

Air Quality Model ready input files

Cited from Mark Houyoux, Summary of SMOKE-MOVES Integration Tool, 2010 v3

CMAQ Modeling Domain for MANE-VU States

Cited from MANE-VU Modeling for Reasonable Progress Goals, NESCAUM, 2008
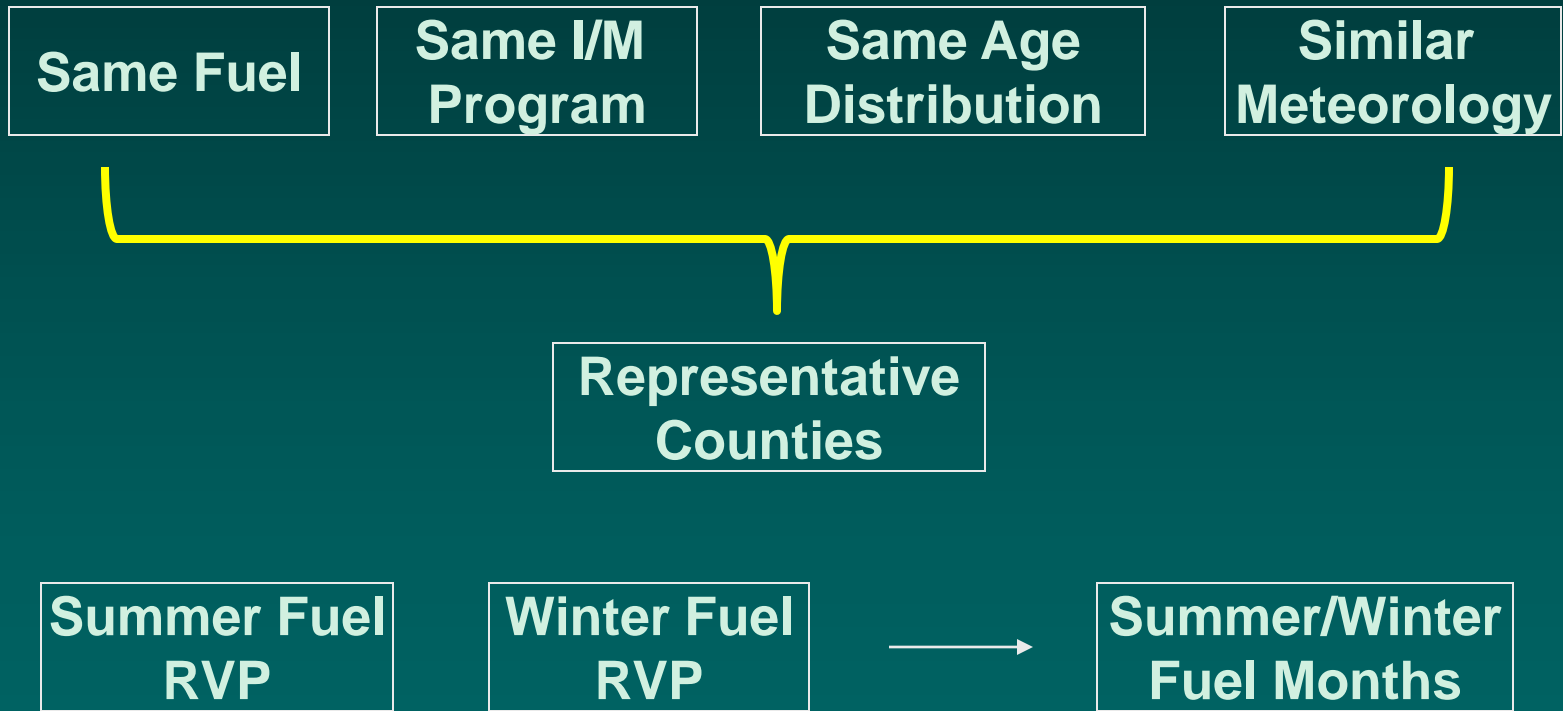
Development of MOVES Inputs

Collect MOVES Inputs from States

Vehicle Population (VPOP), Vehicle Age Distribution
Vehicle Miles Traveled (VMT), Road Type Distribution
Average Speed Distribution
Fuel Supply, Fuel Formulation
I/M Coverage
Month VMT Fraction, Day VMT Fraction, Hour VMT Fraction
Ramp Fraction
Meteorology

State Supplements

Input Summary (required)
early NLEV and/or Cal LEV
Stage II control efficiencies

Select Representative Counties and Fuel Months

Same Fuel	Same I/M Program	Same Age Distribution	Similar Meteorology

Representative Counties

Summer Fuel RVP	Winter Fuel RVP	→	Summer/Winter Fuel Months

State Experiences in MOVES Inputs Development

Development of MOVES Vehicle Population (VPOP): Maryland

- ◆ **Data Source: Maryland Motor Vehicle Administration (MVA)**

- ◆ **Extract from MVA databases 5 vehicle types**
  - MOVES vehicle types 11 (Motor Cycle), 21 (Passenger Car), and 43 (School Bus)
  - MOVES Bus types 41 (Inter-City) and 42 (Transit) were extracted together as a sum and later split into 41 and 42 according to MOVES default splits

- ◆ **Split from the total of the rest vehicle populations into 8 MOVES vehicle types**
  - MOVES default splits are used
  - MOVES truck types 31 (Passenger), 32 (Light Commercial), 51 (Refuse), 52 (Single Unit Short-haul), 53 (Single Unit Long-haul), 54 (Motor Home), 61 (Combo Unit Short-haul), and 62 (Combo Unit Long-haul)

Development of MOVES Vehicle Population (VPOP): Georgia

◆ **Data Source: Polk's Vehicle registration databases**
  – Used to develop age distribution
  – Derived from VIN
  – Vehicles counts by 16 Mobile6 vehicle classes, county and age

◆ **Convert from 16 Mobile6 vehicle classes to 13 MOVES vehicles classes (MOVES runs)**
  – Adapt from registrationdistributionconverter_veh16.xls
  – M6VType16 → M6Vtype32→ VClass28 →SourceType13

◆ **Convert from 16 Mobile6 vehicle classes to 12 SCC (for SMOKE processing)**
  – M6VType16 → M6Vtype32→ VClass28 → VType12

Development of MOVES
Vehicle Miles Traveled (VMT): Georgia

◆ **Data source**
  – VMT by 12 HPMS road types and county from Georgia DOT
  – VMT mix by 28 vehicle classes from Mobile6 runs with local age distribution

◆ **Convert to MOVES format**
  – VMT converter (vmt-converter-road-veh28-20100209)
  – Automate the process for 159 counties in Georgia using Macro written in VBA
    ◆ Inputs: VMT by 12 HPMS road types in 159 counties, VMT mix
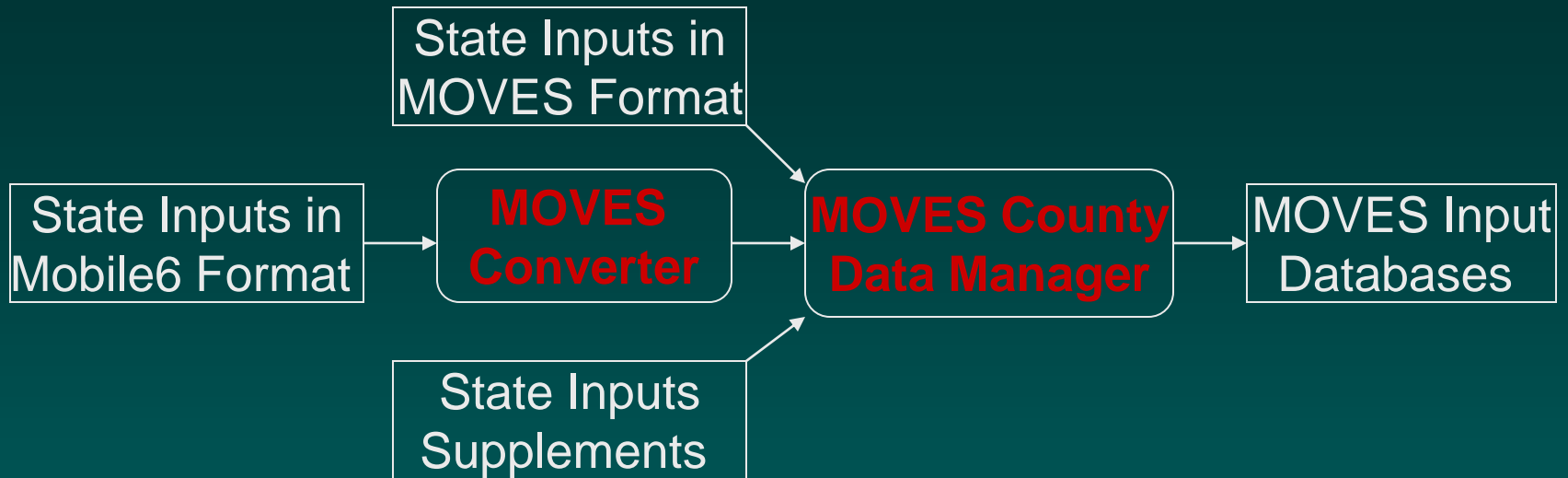   ◆ Outputs: VMT in MOVES format, one file per county in csv format

Development of MOVES Inputs for SMOKE Processing

# Develop Meteorology for Representative Counties
(simplified)

```
Representative
County File ─────┐
                  \
                   ▶   ┌──────────┐   ──▶  Representative
Fuel Month ──────────▶ │ SMOKE2.7 │        County Met
File              ▶    │ met4moves│   
                  /    └──────────┘   ──▶  Inventory
WRF/MCIP ────────┘                          County Met
Meteorology
```

Input Data	WRF/MCIP meteorology
	Representative county file
	Fuel month file
Input Scripts	SMOKE ancillary files
	SMOKE assign file
	SMOKE run script
Tools	SMOKE2.7 met4moves
Outputs	Met files for MOVES and SMOKE Processing

Build up MOVES Input Databases

State Inputs in MOVES Format → MOVES Converter / MOVES County Data Manager

State Inputs in Mobile6 Format → MOVES Converter → MOVES County Data Manager → MOVES Input Databases

State Inputs Supplements → MOVES County Data Manager

Input Data	State inputs in MOVES format
	State inputs in Mobile6 format (fuel and IM are in MOVES format)
	State input supplements (exported from MOVES2010a default database)
Input Scripts	MOVES xml importing files for MOVES County Data Manager
	MOVES Run Scripts for MOVES County Data Manager
Tools	MOVES Converter
	MOVES County Data Manager invoked in batch mode
Outputs	MOVES input databases

Develop MOVES Inputs for Representative Counties

Age, Fuel, I/M

MOVES Input Databases → VMT and VPOP → Summed VMT and VPOP

Representative County List
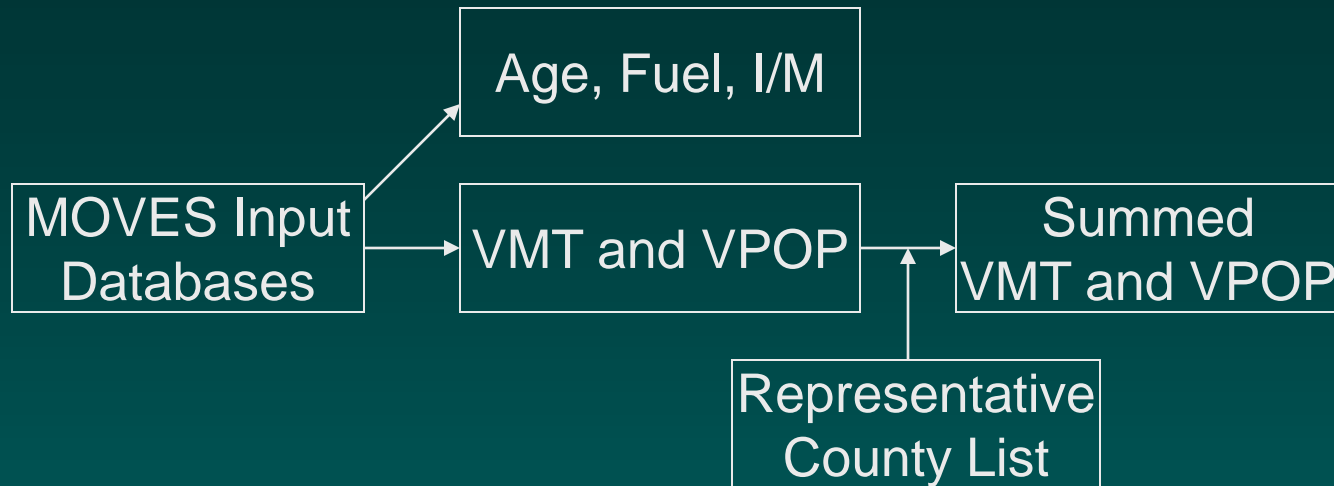
Input Data	MOVES input databases
	Representative County list
Tools	MySQL scripts
Outputs	Vehicle Age Distribution, Fuel, and I/M csv files for representative counties
	VMT and VPOP for all counties
	Summed VMT and VPOP for representative counties

# Run MOVES Inventory Mode to Convert VMT and VPOP to SCC Format for SMOKE Processing

MOVES Input Databases	→	**MOVES2010a**	→	MOVES Output Databases	→	SCC VMT VPOP

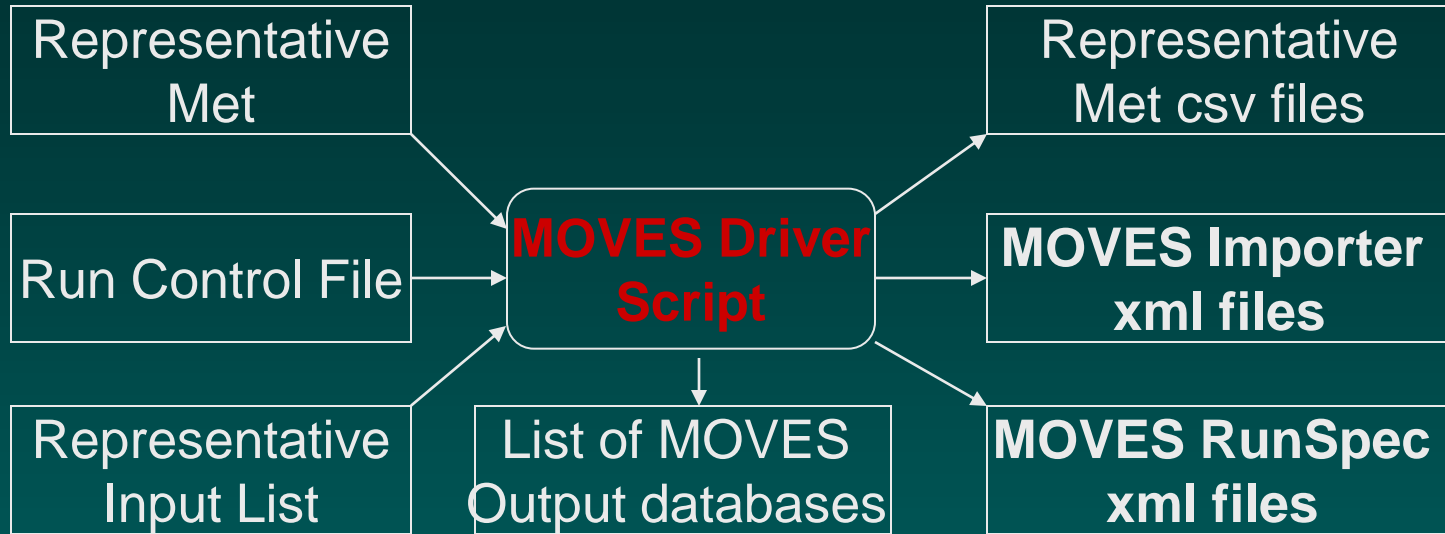|	
Input Data	MOVES input databases
Input Scripts	MOVES RunSpec files
	MOVES run scripts
Tools	MOVES2010a invoked in batch mode
Outputs	MOVES output databases
	SMOKE SCC VMT and VPOP

Some Thoughts on Quality Assurance of MOVES Inputs

◆ Follow the county-based input organization scheme and naming convention

◆ Build up MOVES input databases to ensure format correctness

◆ Cross check input tables to ensure data integrity

◆ Compare with other states to discover potential inconsistencies

◆ Compare with other years to ensure compatible trend
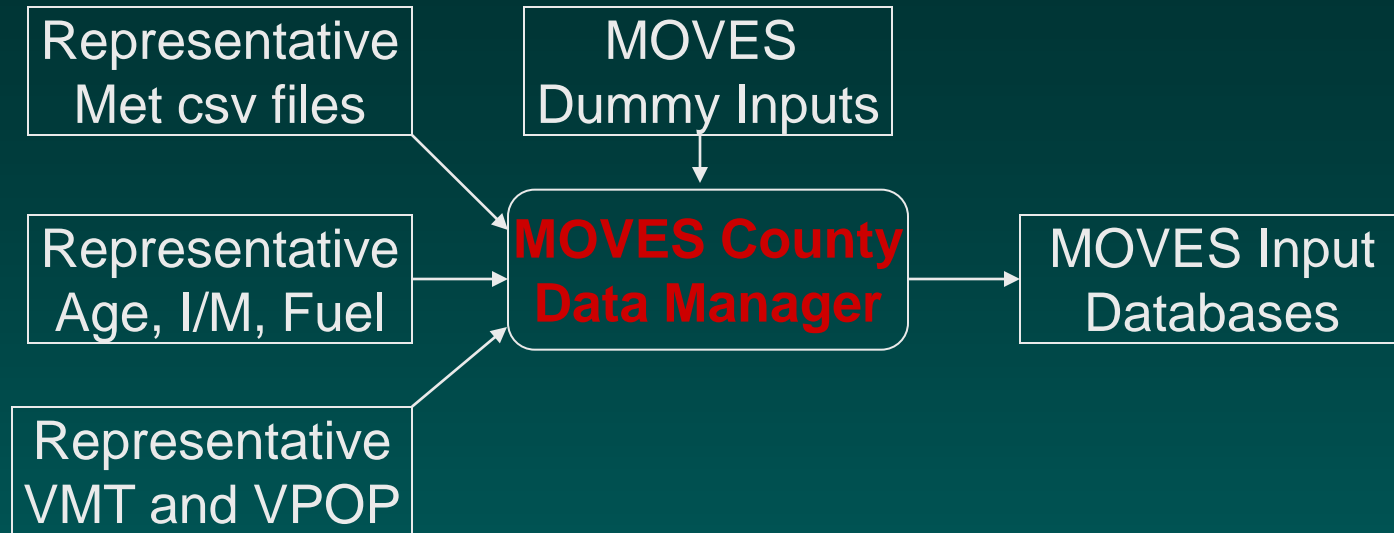
Quality Assurance of MOVES Inputs: VMT/VPOP Ratios

Quality Assurance of MOVES Inputs: VMT Percentages

Quality Assurance of MOVES Inputs: VPOP Percentages
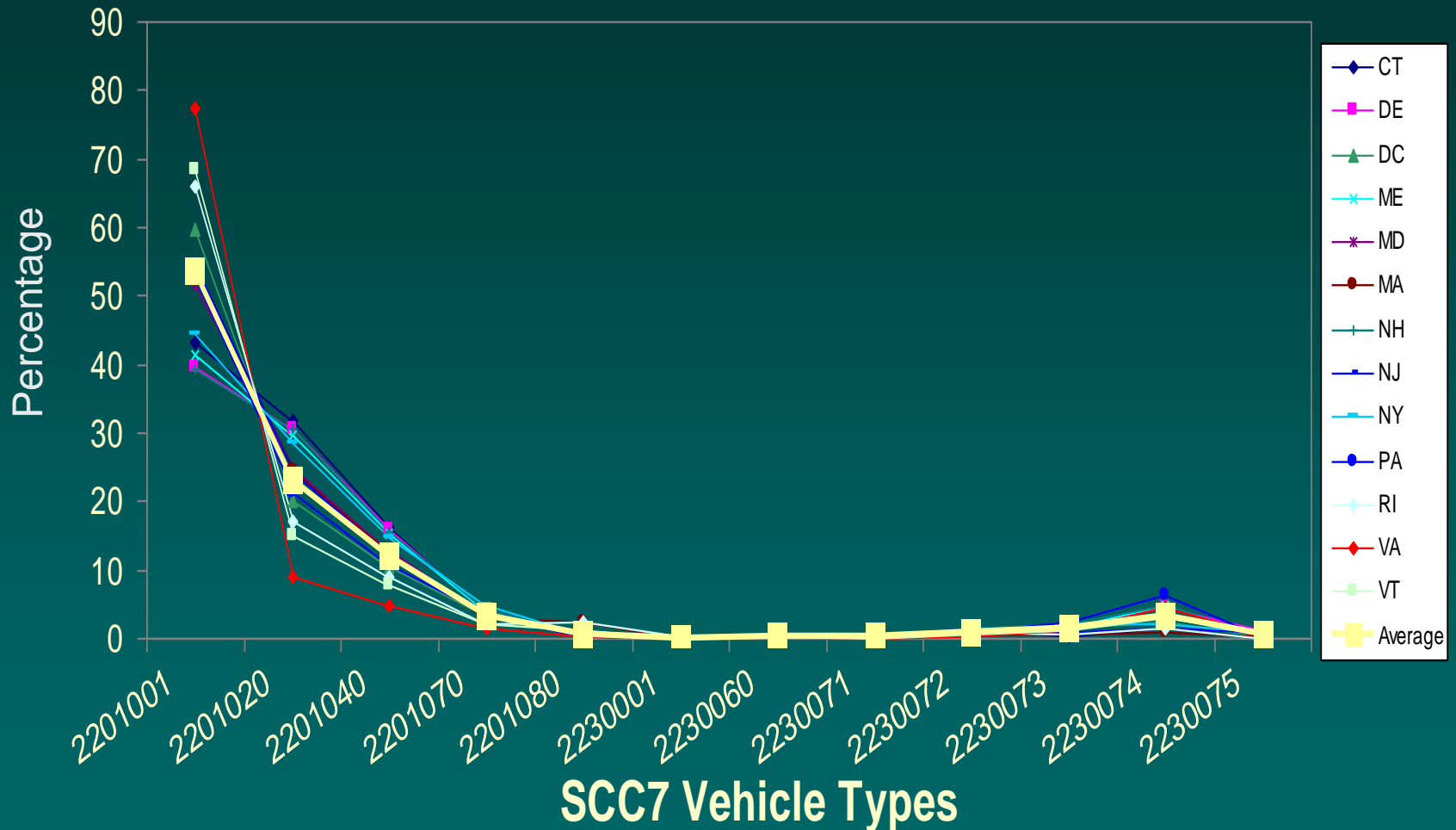
Set Up MOVES Lookup Table Runs

Run MOVES Driver Script

```
Representative                                    Representative
Met                                               Met csv files
                         ┌──────────────┐
                         │ MOVES Driver │
Run Control File ───────▶│    Script    │────▶  MOVES Importer
                         └──────────────┘        xml files
                                │
Representative           List of MOVES          MOVES RunSpec
Input List               Output databases        xml files
```
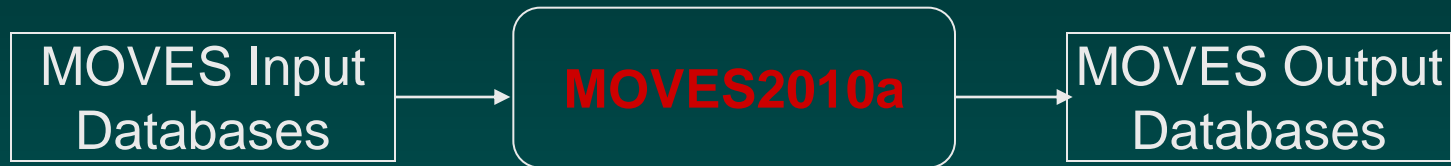
Input Data	Representative County Met generated by met4moves
Input Scripts	Run Control File
	Reference County input list file
Tools	MOVES Driver Script
Outputs	MOVES representative met csv files
	MOVES Importer xml files and batch run script
	MOVES RunSpec xml files and batch run script
	List of MOVES output databases

Run MOVES Importer

Representative
Met csv files

MOVES
Dummy Inputs

Representative
Age, I/M, Fuel

**MOVES County
Data Manager**

MOVES Input
Databases

Representative
VMT and VPOP

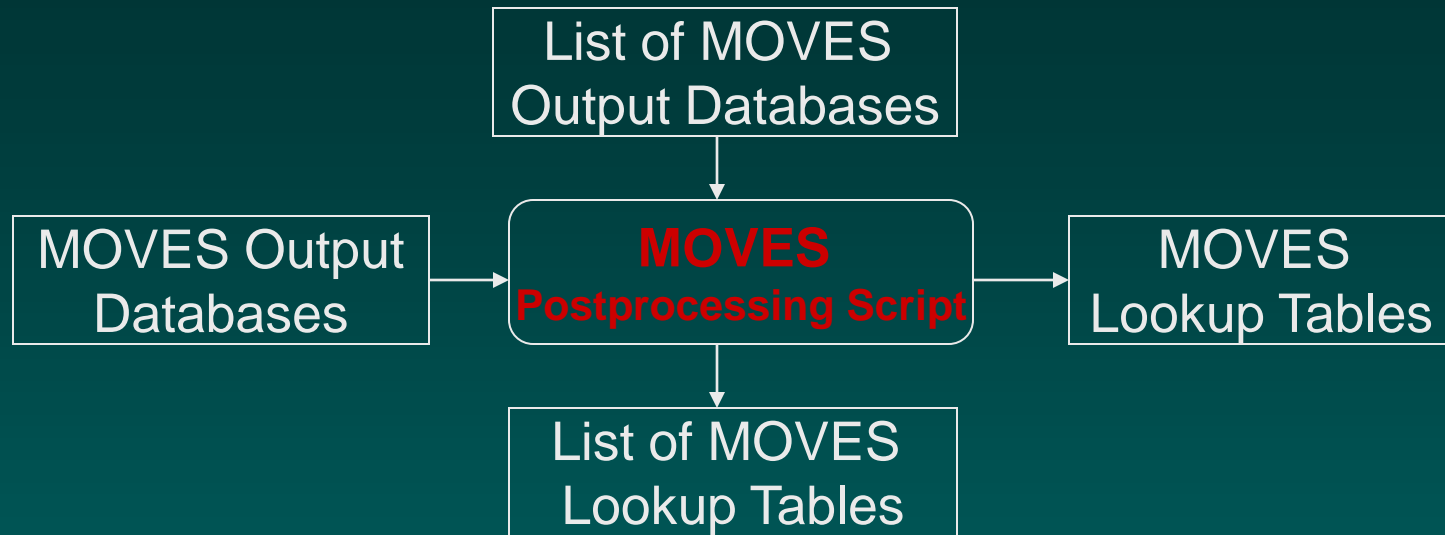| Input Data	Representative County Met generated by met4moves
	Representative County Age, I/M, and Fuel
	Representative County summed VMT and VPOP
	MOVES dummy inputs
Input Scripts	MOVES Importer xml files and batch run script generated by MOVES driver script
Tools	MOVES County Data Manager
Outputs	MOVES input databases

Run MOVES Lookup Tables

```
┌──────────────────┐      ╭──────────────────╮      ┌──────────────────┐
│ MOVES Input      │  →   │   MOVES2010a     │  →   │ MOVES Output     │
│ Databases        │      │                  │      │ Databases        │
└──────────────────┘      ╰──────────────────╯      └──────────────────┘
```

| Input Data	MOVES Input Databases for Representative Counties
Input Scripts	MOVES RunSpec xml files and batch run script generated by MOVES driver script
Tools	MOVES2010a
Outputs	MOVES output databases

Post Processing of MOVES Lookup Tables and SMOKE Processing

Postprocessing of MOVES Lookup Tables

```
                    ┌─────────────────────┐
                    │   List of MOVES     │
                    │  Output Databases   │
                    └──────────┬──────────┘
                               │
                               ▼
┌──────────────────┐   ╭─────────────────────╮   ┌──────────────────┐
│  MOVES Output    │──▶│      MOVES          │──▶│     MOVES        │
│   Databases      │   │ Postprocessing Script│   │  Lookup Tables   │
└──────────────────┘   ╰──────────┬──────────╯   └──────────────────┘
                               │
                               ▼
                    ┌─────────────────────┐
                    │   List of MOVES     │
                    │   Lookup Tables     │
                    └─────────────────────┘
```

Input Data	MOVES output databases
Input Scripts	List of MOVES output databases generated by MOVES driver script
Tools	MOVES Postprocessing Script
Outputs	MOVES lookup table csv files ready for SMOKE
	List of MOVES lookup table csv files for SMOKE

SMOKE Processing of MOVES Lookup Tables
(simplified)
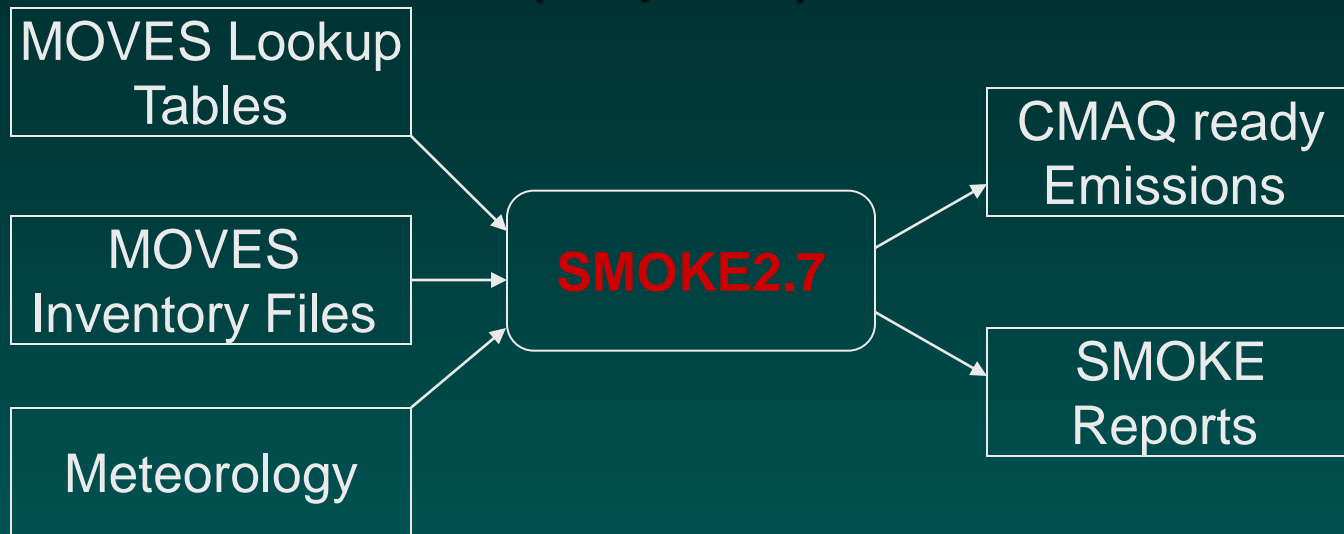
Input Data	MOVES lookup tables (emission factors)
	MOVES inventory files (activity data)
	WRF/MCIP and SMOKE met4moves meteorology
Input Scripts	SMOKE ancillary files
	SMOKE assign files
	SMOKE run scripts
Tools	SMOKE2.7
Outputs	CMAQ ready emissions and SMOKE reports

# State Experiences in SMOKE-MOVES Processing

SMOKE-MOVES Processing: New York

◆ **Regional modeling centers at VA, PA, NY, and NESCAUM provided MOVES lookup tables and SMOKE inventories and other state specific ancillary files**

◆ **New York merged regional files and set up the SMOKE modeling platform**

◆ **New York ran 7 ozone months; VA and NESCAUM ran 5 winter months**
  – The latest SMOKE2.7.5b improved processing speed dramatically. New York processed the whole year in about two days on a cluster with 8 CPUs.
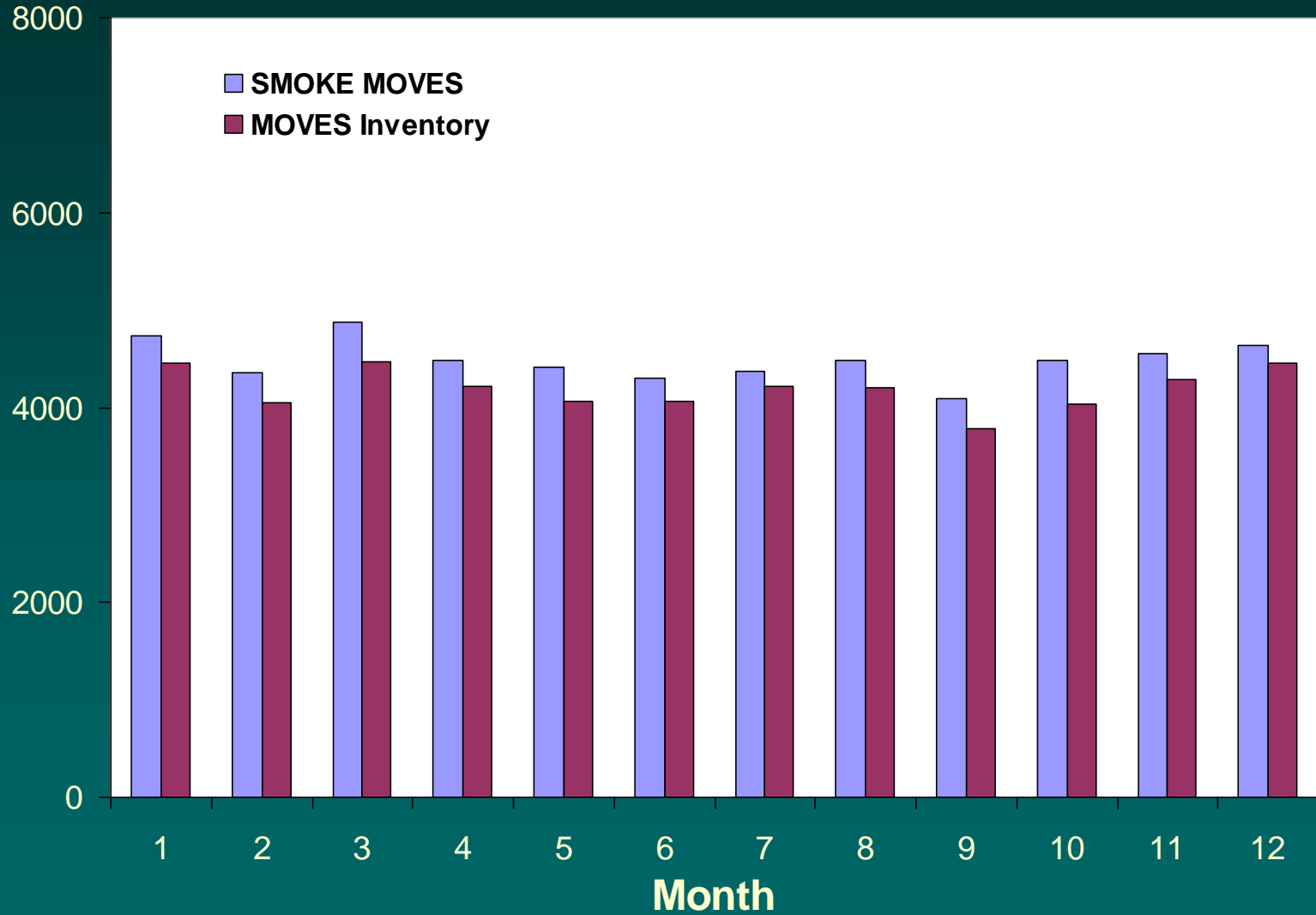
SMOKE Postprocessing: Virginia

◆ **Perl script was developed to postprocess SMOKE daily reports to csv summaries**

◆ **Criteria emissions were summarized at the state and county levels for each month**

◆ **County SCC emissions for criteria pollutants were summarized for each month**

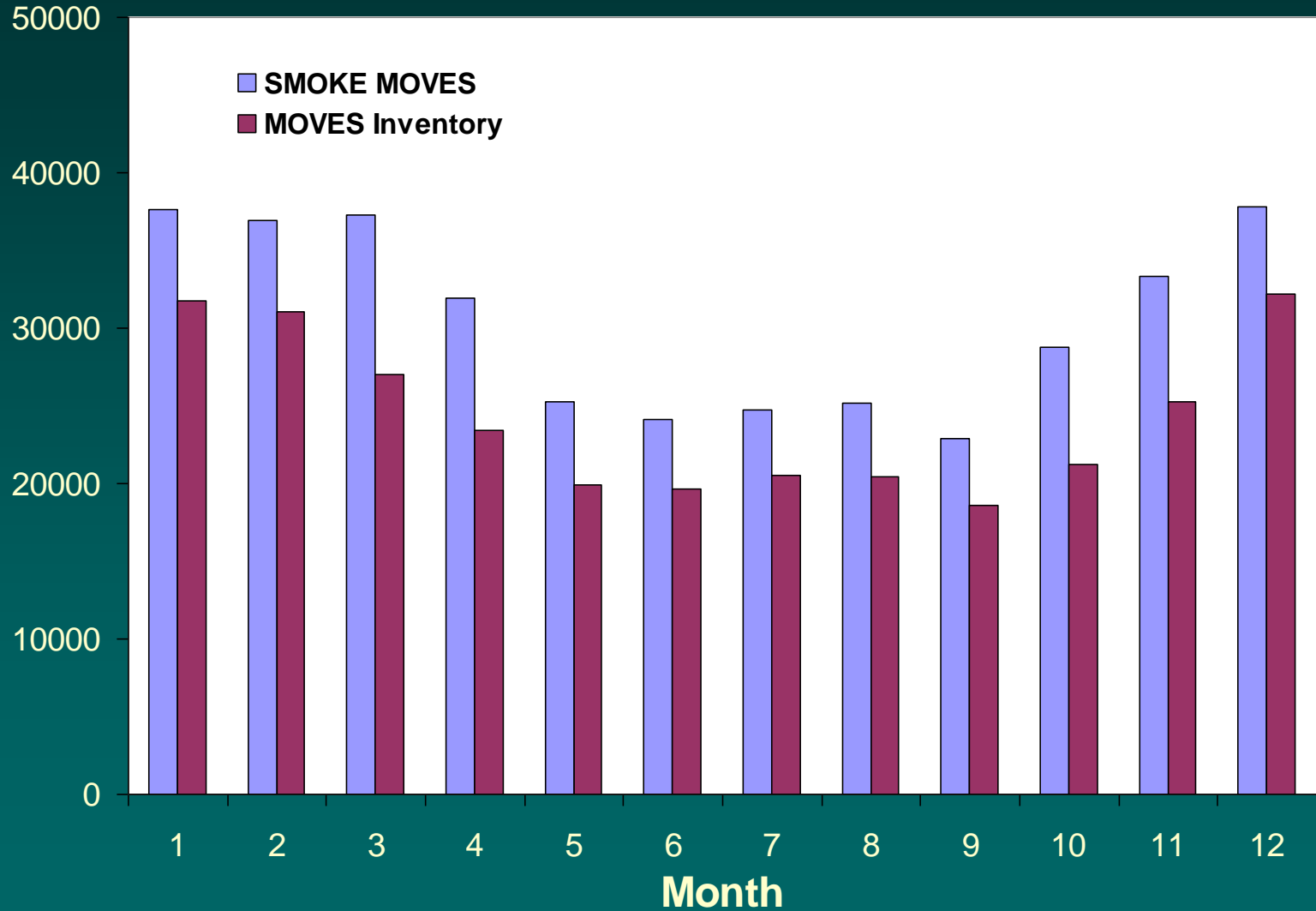# Preliminary Analysis of Onroad Emissions Generated by SMOKE MOVES
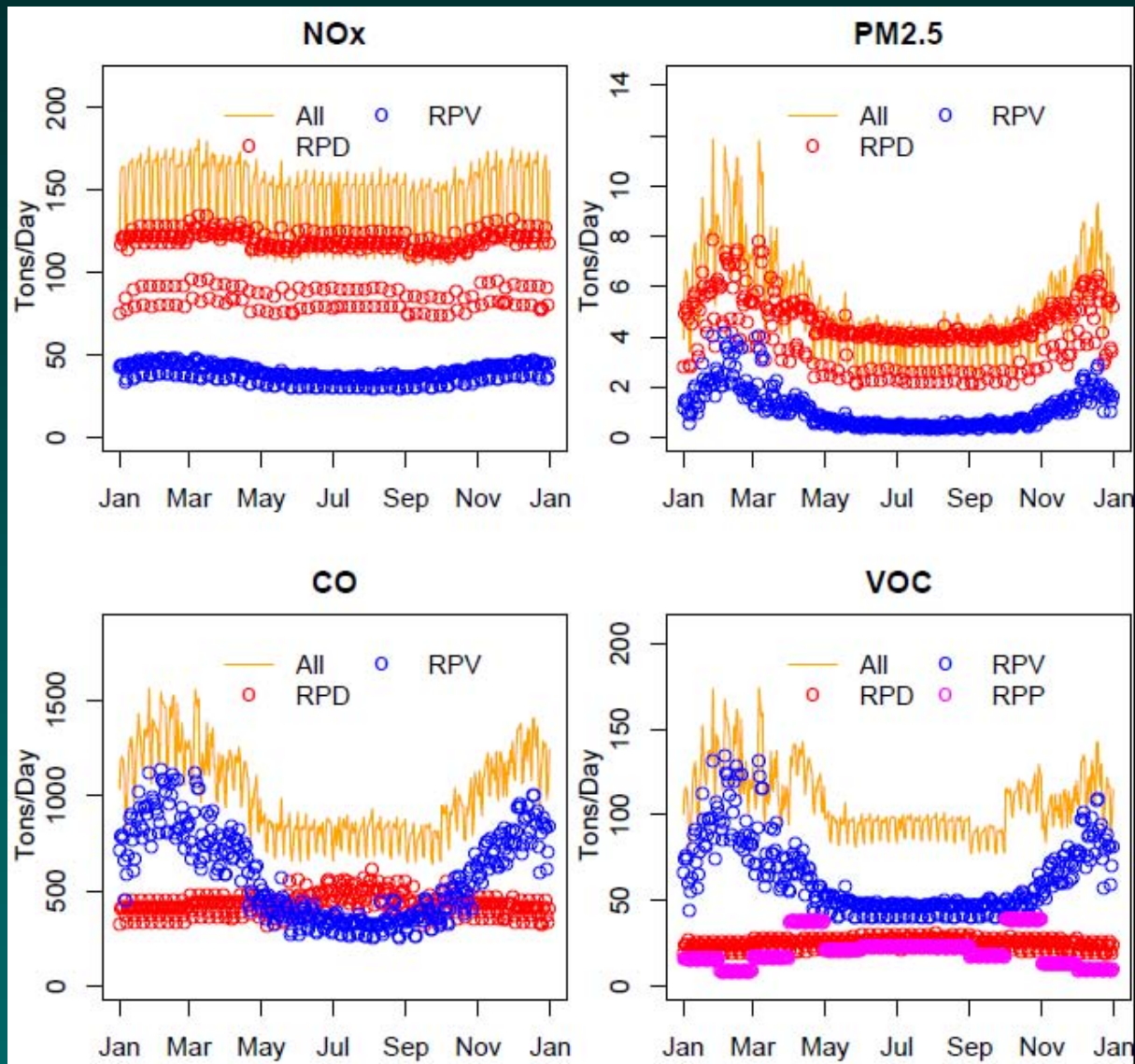
CT 2007 Onroad VOC Emissions (Tons)
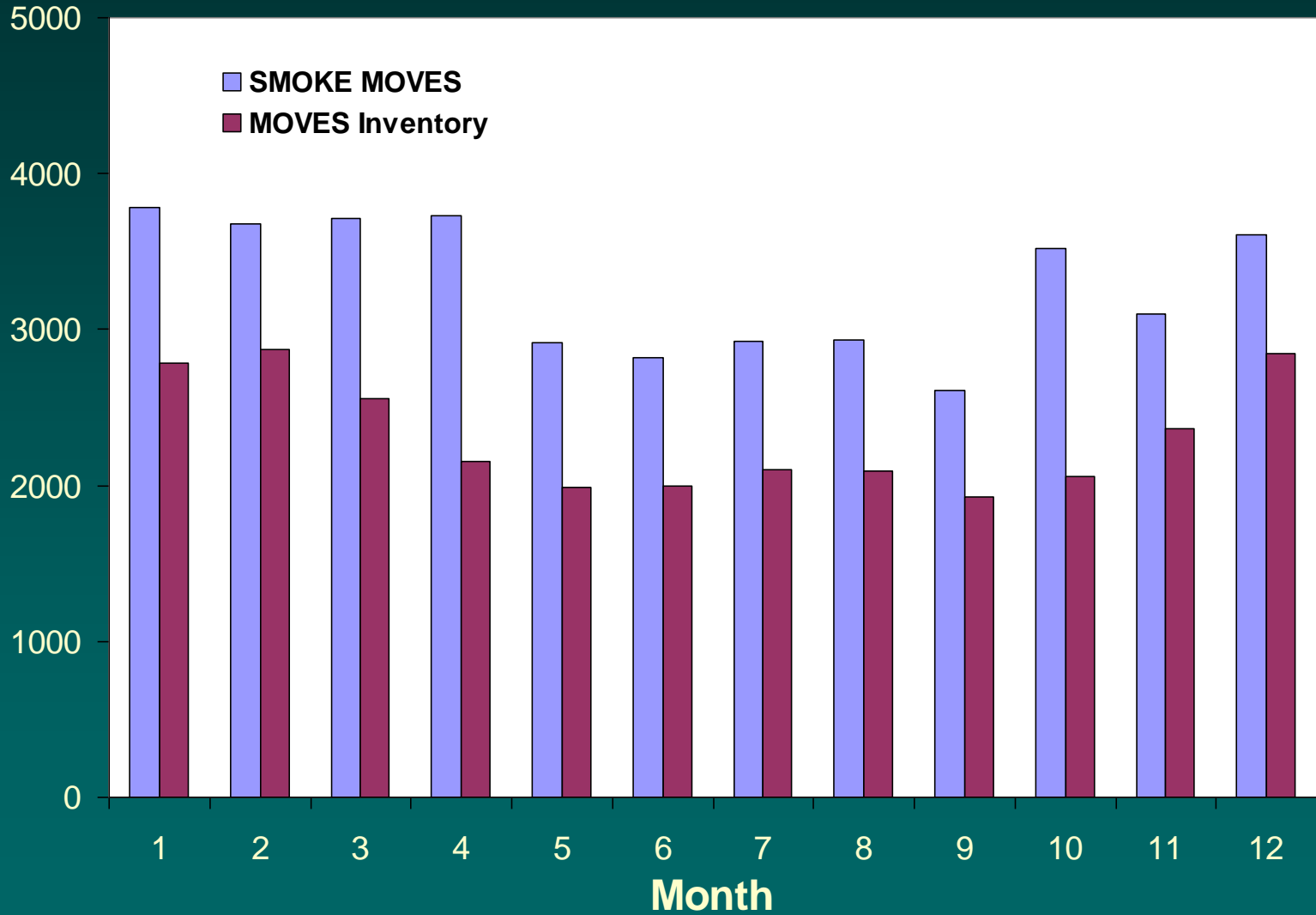
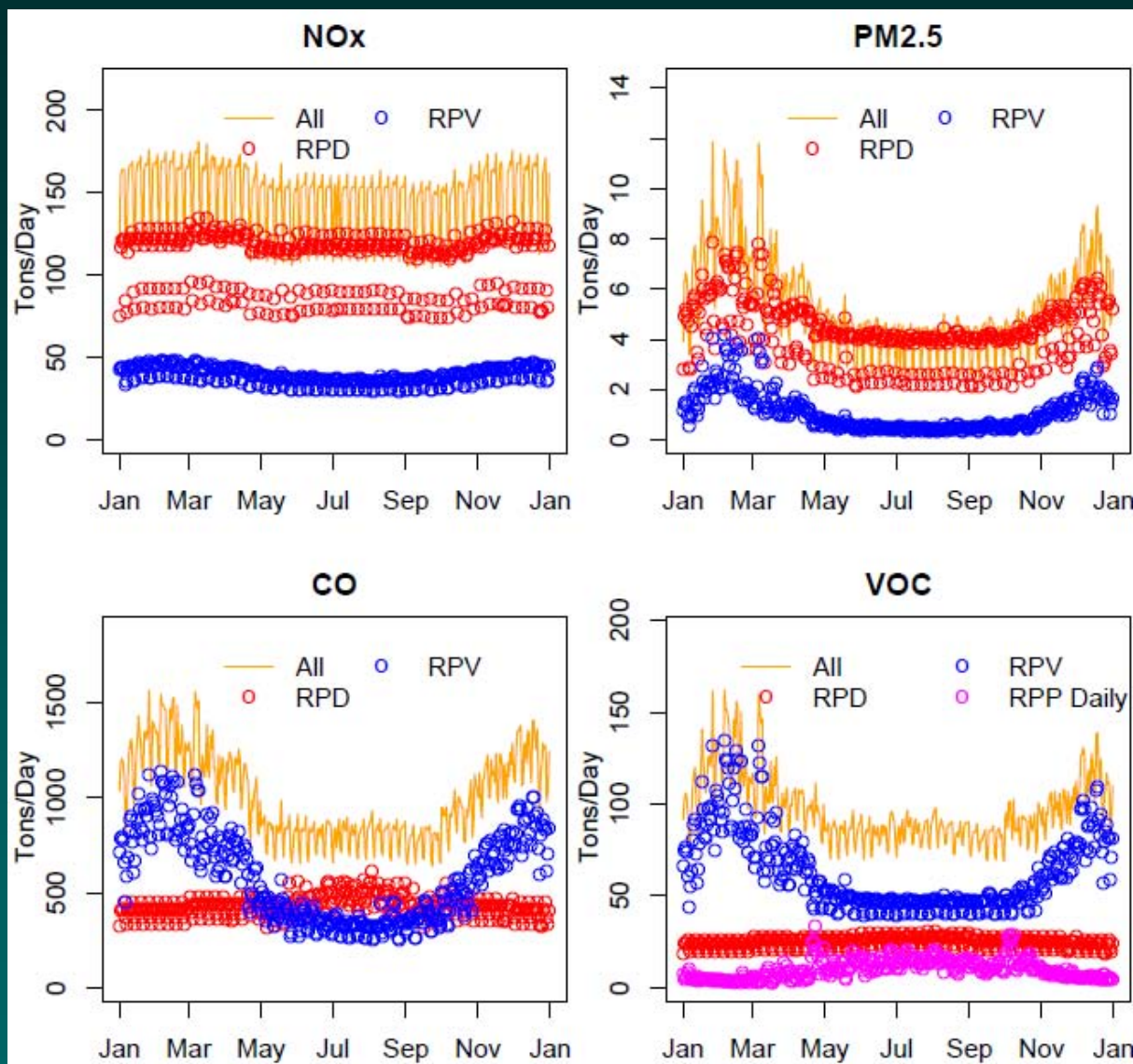# CT 2007 Onroad NOx Emissions (Tons)

CT 2007 Onroad CO Emissions (Tons)

CT 2007 Daily Emissions from SMOKE (Tons)

Cited from Christian Hogrefe, New York State Department of Environmental Conservation, 2011

CT 2007 Daily Emissions from SMOKE (Tons)

Cited from Christian Hogrefe, New York State Department of Environmental Conservation, 2011

Acknowledgements