MOVES
Motor Vehicle Emission Simulator

MOVES and Inventory Research Needs

Presentation for
Air Quality Modeling Needs Workshop (CRC A-98)
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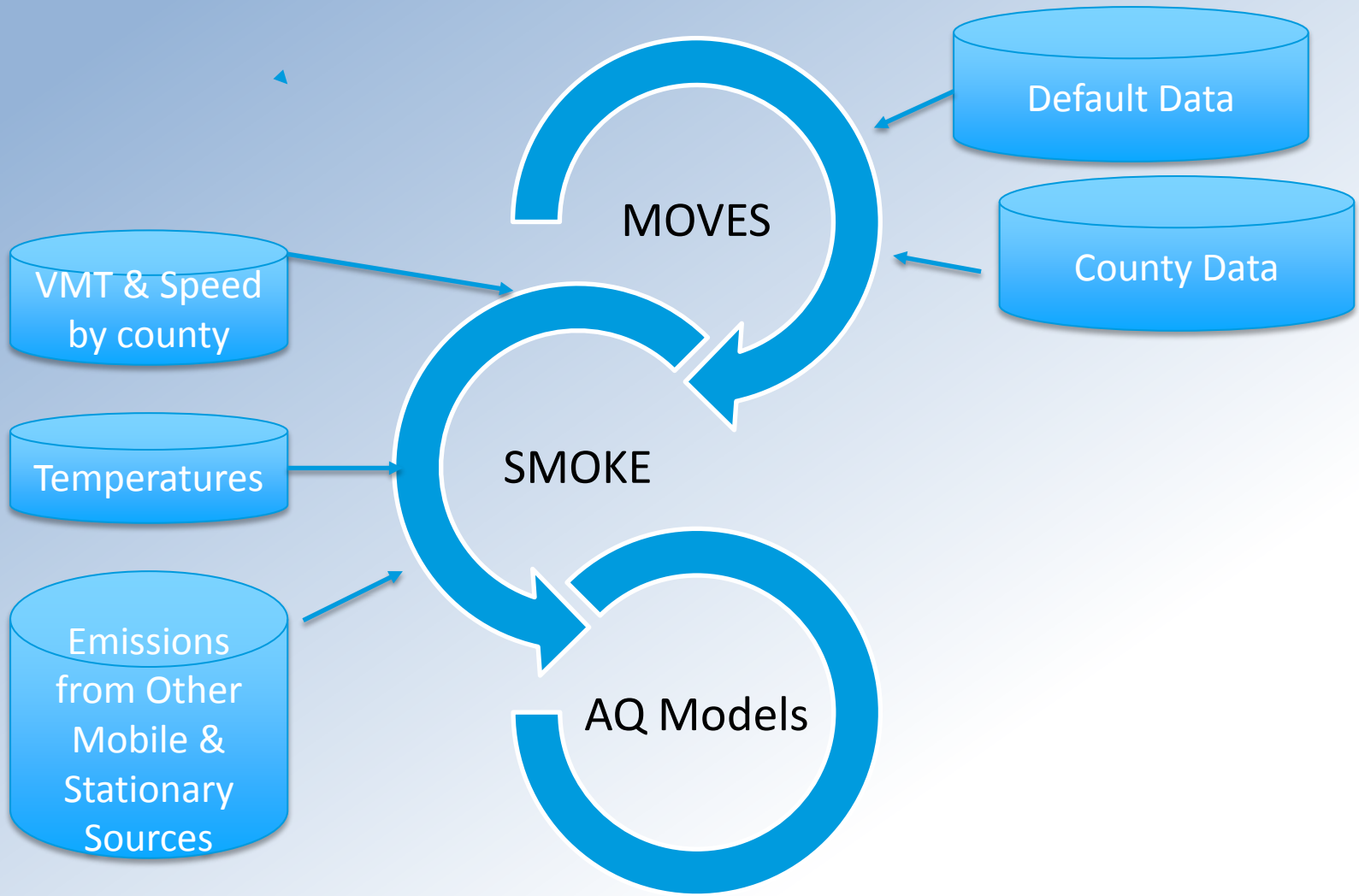
Building Regional Air Quality Estimates



MOVES: EPA's Official Emissions Inventory Model For Mobile Sources

- MOVES: Motor Vehicle Emission Simulator
- Estimates emissions & energy use from all kinds of moving equipment:
  - On-road: passenger cars, light-trucks, heavy-duty trucks, buses, motorcycles
  - Non-road equipment: construction, industrial, agricultural, lawn& garden, commercial, logging, airport, oil & gas, mining, railroad service, recreational vehicles
- Estimates many different type of emissions:
  - Engine running/working, engine starting, idling, evaporative, etc.
- Estimates fuel consumption & emissions of many different pollutants
  - Criteria pollutants and precursors: hydrocarbons (HC), nitrogen oxides (NOx), particulate matter (PM), sulfur dioxide (SO_2), and carbon monoxide
  - GHG pollutants: carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4)
  - >180 air toxics

Other uses of MOVES

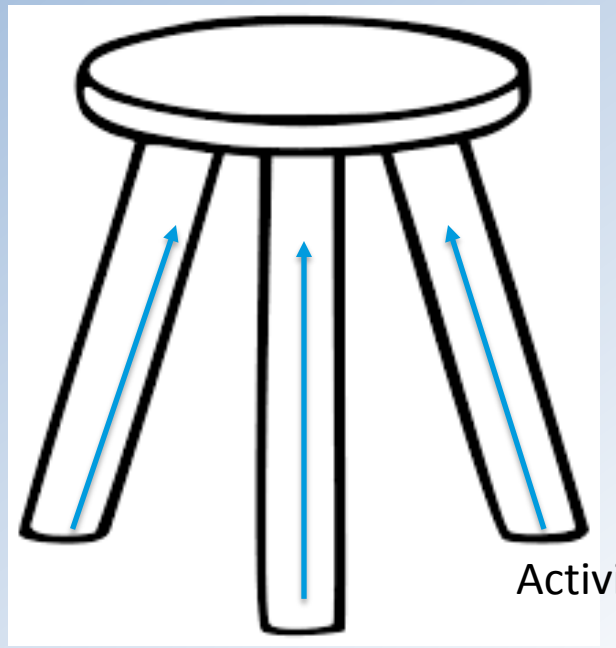
In addition to regional AQ estimates, MOVES and inventories are used in:

- Project-level analysis
  - Detailed vehicle population and activity information
- Conformity determinations
  - Inventory forecasts & comparisons for transportation plans
- Broad policy assessment
  - Simplified assessments without county-level detail

*All these uses have overlapping, but not identical research needs. Today's workshop focuses on the needs for **regional air-quality modeling**.*

How Are Emissions Inventories Constructed?

Inventories



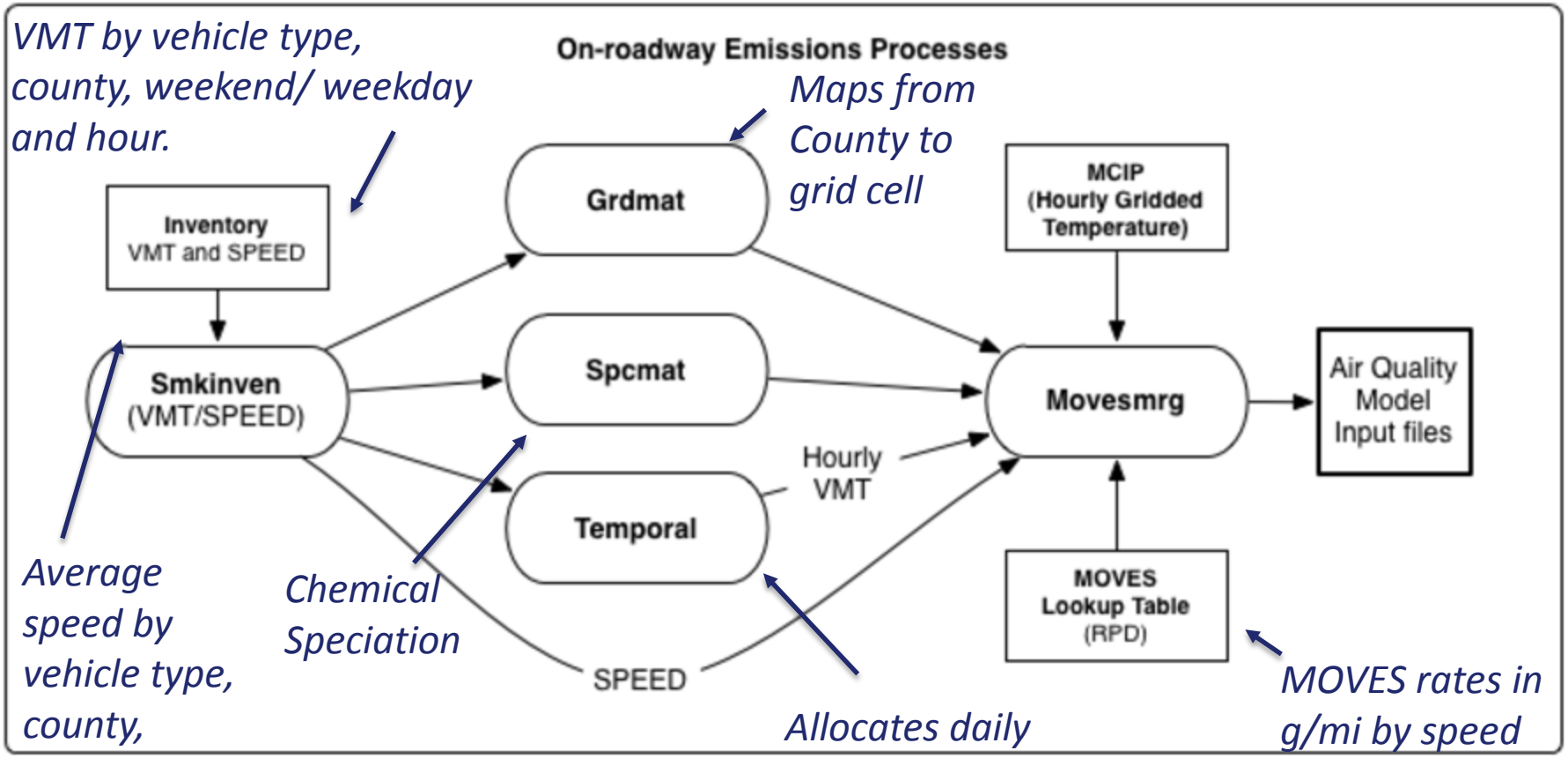
Emission Rates

Activity

Vehicle/Equipment Populations

SMOKE transforms MOVES rates to gridded, hourly AQ inputs

Example: Car & truck running emissions



Scope of "MOVES & Inventories"

- Sources: Onroad, nonroad, aircraft, locomotive, marine, upstream
- Emission factors
- Adjustment factors
- Temperature and humidity
- Fuel supply details
- Vehicle (and equipment) populations & activity
  - Including speed and operating modes
  - And their variation in space & time

Important Research Questions: Nonroad Mobile Sources

For construction equipment, agriculture equipment, lawn & garden, etc. And aircraft, locomotive, marine:

- What are the populations and activity of nonroad equipment today?
- Where are they? When and how do they operate?
- How are activity and populations changing over time?
- What are the real world emissions of modern equipment and vehicles?

Important Research Questions: Onroad Vehicle Emissions

Topic	Vehicle Types	Details
Extended Idle	Long-haul combination trucks	Emission rates, locations, alternatives?
Real world SCR	LD and HD Diesels	Selective Catalytic Reduction controls NOx less during moderate driving. When and where do these conditions occur? What's the impact?
Start emissions	All	Changes with vehicle age?
Real world exhaust rates	Light-duty	How do emissions trend with age for MY 2001+?
Real world activity	Light-duty	Idling, start frequencies, time on ramps, speeds– How much? When? Where?
Real-world evap	Light-duty	Prevalence of degraded canisters? Frequency of "long" parking periods (beyond canister capacity)?
Brake & tire wear	All	Have emission rates changed with new technologies?

What is EPA doing? (Nonroad)

Topic	EPA Research
Nonroad Population & Activity	• Collecting data to update population, activity, growth, sales, usage, expected life.
Nonroad Emissions	• Compiling modal emissions data
Aircraft	• Updated inventory for 2014 NEI based on new activity and the latest emission rates • Updated global aircraft activity and fleets data • Migrating to new flight performance model
Marine	• Updated inventory for 2014 NEI based on new activity data. • OTAQ investigating use of Automatic Identification Systems (AIS) data. • Contractor is updating bunker fuel growth rates

What is EPA doing? (Onroad)

Topic	EPA Research
Real world SCR	• Analyzing 2010+ MY data from manufacturer heavy-duty in-use testing (HDIUT). • Looking for additional SCR equipped HDV data.
Start emissions	• CE-CERT (UCR) is collecting relevant HD data. We plan to analyze it this year.
Extended Idle	• We are updating 2007+ emission rates.
Real world light-duty exhaust rates	• Exploring IM240 tests for Tier 2 and earlier vehicles. Investigating trends with mileage, age
Real world light-duty activity	• Evaluating ramp activity, and assessing starts, soak times, and idling through a large telematics dataset.
Real-world evap	• Testing hybrid vehicles with long parking times.
Validation	• Comparing MOVES emission rates to other studies. • NOx "Deep Dive" -- Better understand emissions at selected locations where modelled AQ doesn't match monitors.

More Research Needed (Nonroad)

Topic	Research needs
Nonroad Population & Activity	• Distribution of activity in space & time. • Age distributions and scrappage of nonroad equipment • Updates every few years
Nonroad Emissions	• Basis for modal emission rates (e.g., MAP as power surrogate?) • Distinguish start, running, idle emission processes? • Develop application specific duty cycles?
Aircraft	• Update emission rates, activity, and fleet data
Locomotive	• Updated activity, including short-haul railroads. Grade effects.
Marine	• Updated emission rates. Fleet turnover and updated age distributions for US ports

More Research Needed (Onroad)

Topic	Research Needs
Start emissions	Do start emissions change as vehicles age?
Extended Idle	Better information on where idling happens. Information on non-hotelling idling.
Real world SCR	Need data for additional vehicles types and duty cycles, especially start and extended idle emissions. How to model history effects?
Real world LD emissions	What are the emissions from Tier 3-compliant Gas Direct Injection (GDI) vehicles?
Real world LD activity	Locations of vehicles starts, evap, idling. National defaults and guidance for county-specific inputs. Age distributions and vehicle migration.
Real-world evap	Understand canister degradation. Understand multi-day parking patterns.
Brake & tire wear	Update rates with information on modern brakes and tires.
Speciation	Better data on PM and VOC speciation, especially for newer technologies.

Additional Needs

There are other research needs on our list, including:

- Emissions at extreme temperatures, including base emission rates, fuel effects, and the impact of block heaters/cold-weather idling
- Improved data on crankcase emissions (especially pre-2007 PM)
- Better rates for HONO, N2O, NH3

Acknowledgments

- Helpful comments from many EPA colleagues.

- CRC Project No. E-101: Review of EPA's MOVES2014 Review, draft report, January 8, 2016