EPA
United States
Environmental Protection
Agency

SMOKE-MOVES

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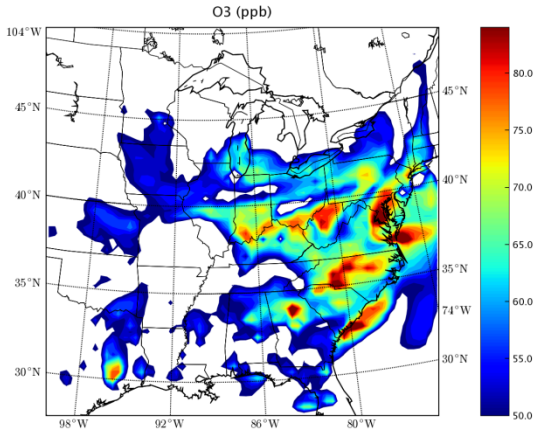
SMOKE and Modeling Emissions for AQ

inventory emissions:
ascii
county
inventory pollutants (e.g. NOx, VOC)
annual/monthly

SMOKE

AQ model-ready emissions:
binary
gridded
AQ species (e.g. NO2,NO, HONO, Acetaldehyde, Ethene, ...)
hourly

AQ model



Why SMOKE-MOVES?

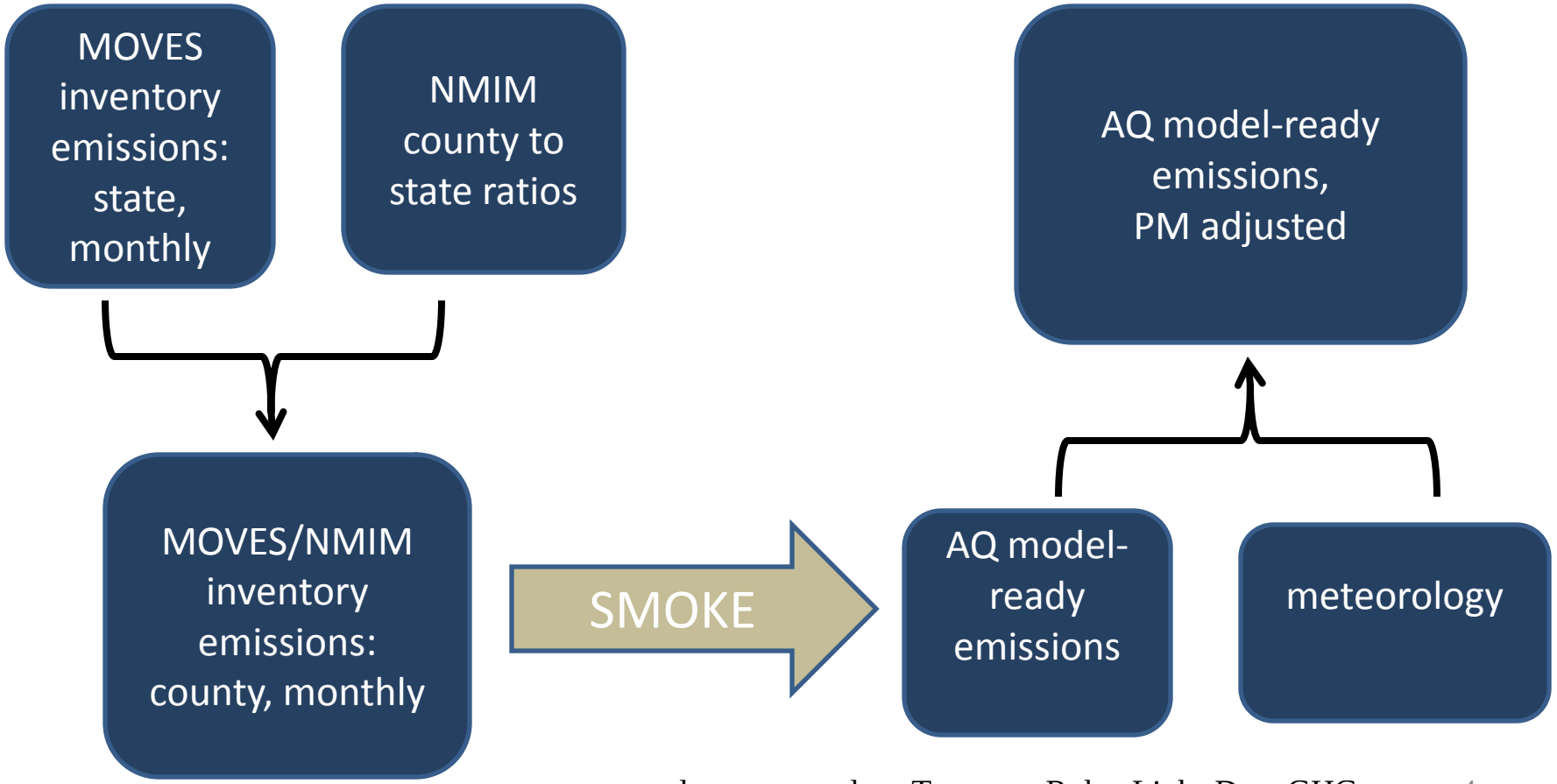
Historically:

- Run MOVES (previously MOBILE6) in inventory mode
- Produce state estimates to create monthly inventories, allocate to counties via NMIM estimates
- Process inventories through SMOKE as month-specific area/nonpoint sources

Motivation for SMOKE-MOVES:

- More closely integrate MOVES into the emissions modeling process
- Emission factors for multiple pollutants are sensitive to temperature
  - PM, VOC, NOx, etc.
  - Want to include more temporally/spatially resolved temperatures
- Computational considerations
  - Keep computation demands “reasonable”
  - Representative counties reduce the number of runs needed
  - Use lookup tables for emission factors

SMOKE and MOVES Previous Approach



recent regulatory examples: Transport Rule, Light-Duty GHG

Temperature and Emission Factors (EF)

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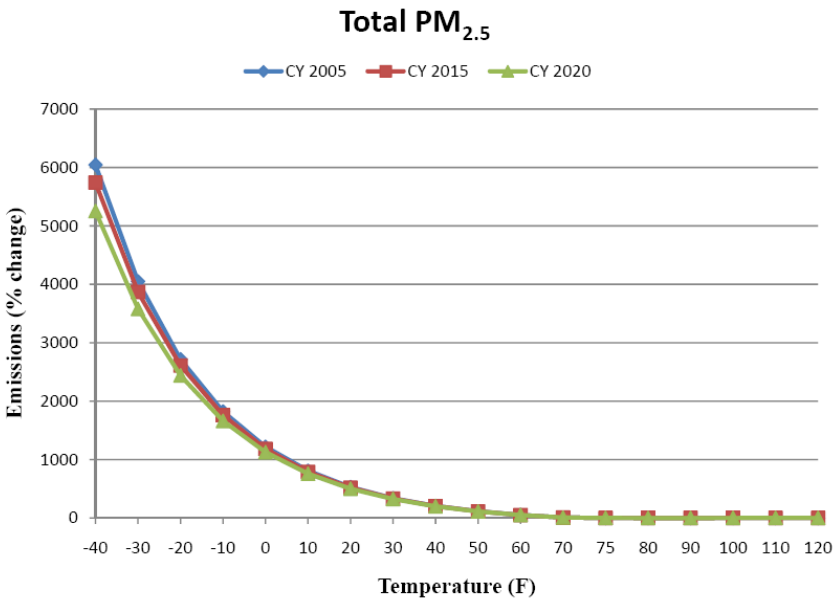
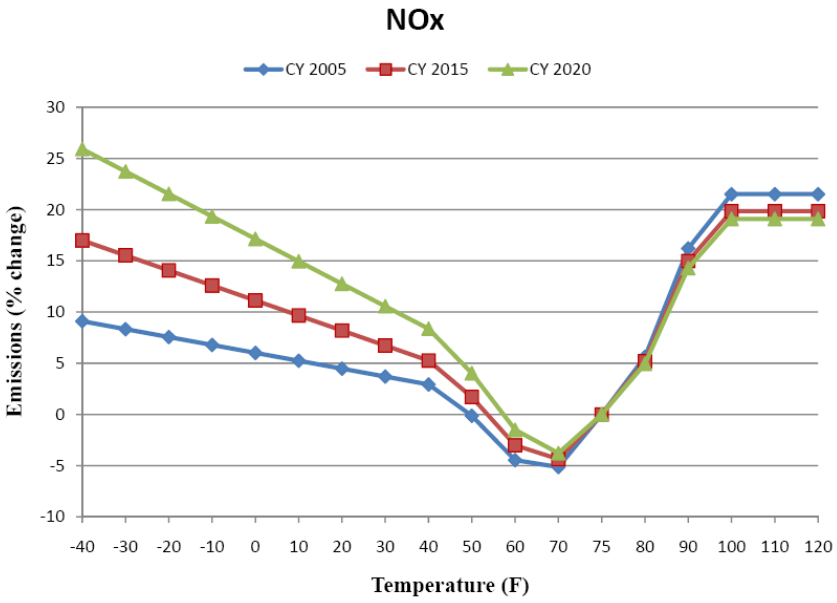
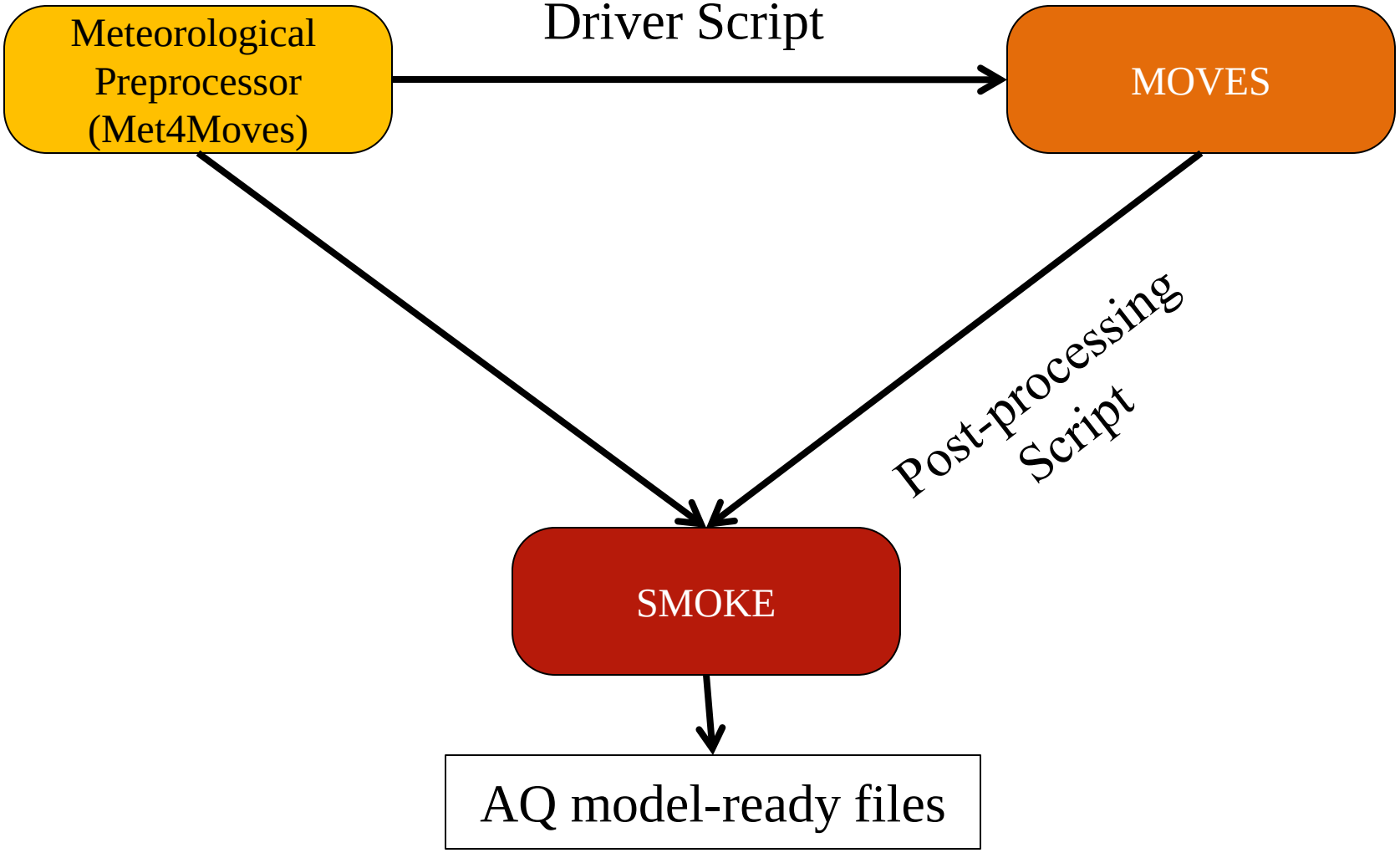
Gasoline vehicles





from OTAQ

SMOKE-MOVES Integration Tool



SMOKE-MOVES Overview

- Met4Moves
  - Produces temperature ranges, diurnal temperature profiles, and relative humidity (RH) values for specific counties
- MOVES
  - Runs series of scenarios for each of the temperature profiles and temperature bins
  - Produces emission factors (EF)
- SMOKE
  - Takes EF, activity data (VMT, SPEED, VPOP) and temperature data
  - Produces AQ model-ready emissions

Overview: Reference County

- Reduces the computational burden of running MOVES on every county in your modeling domain
- Represent a set of similar counties (i.e., inventory counties) called a county group.
- Key emission rates for the single reference county in MOVES can be utilized to estimate emissions for all counties in the county group through SMOKE.

- *Criteria* : Similar fuel parameters, fleet age distribution and I/M programs.

Overview: Fuel Month

- Similar to the reference county, the fuel month reduces the computational time of MOVES by using a single month to represent a set of months.
- Represent a particular set of fuel properties over the months used in MOVES
- Example: Run MOVES for January, use that run to represent a series of months with similar fuel types (e.g. Oct, Nov, Dec, Jan, Feb, Mar)

- *Criteria* : Fuel supply data in the MOVES database for each reference county

Overview: Emission Processes

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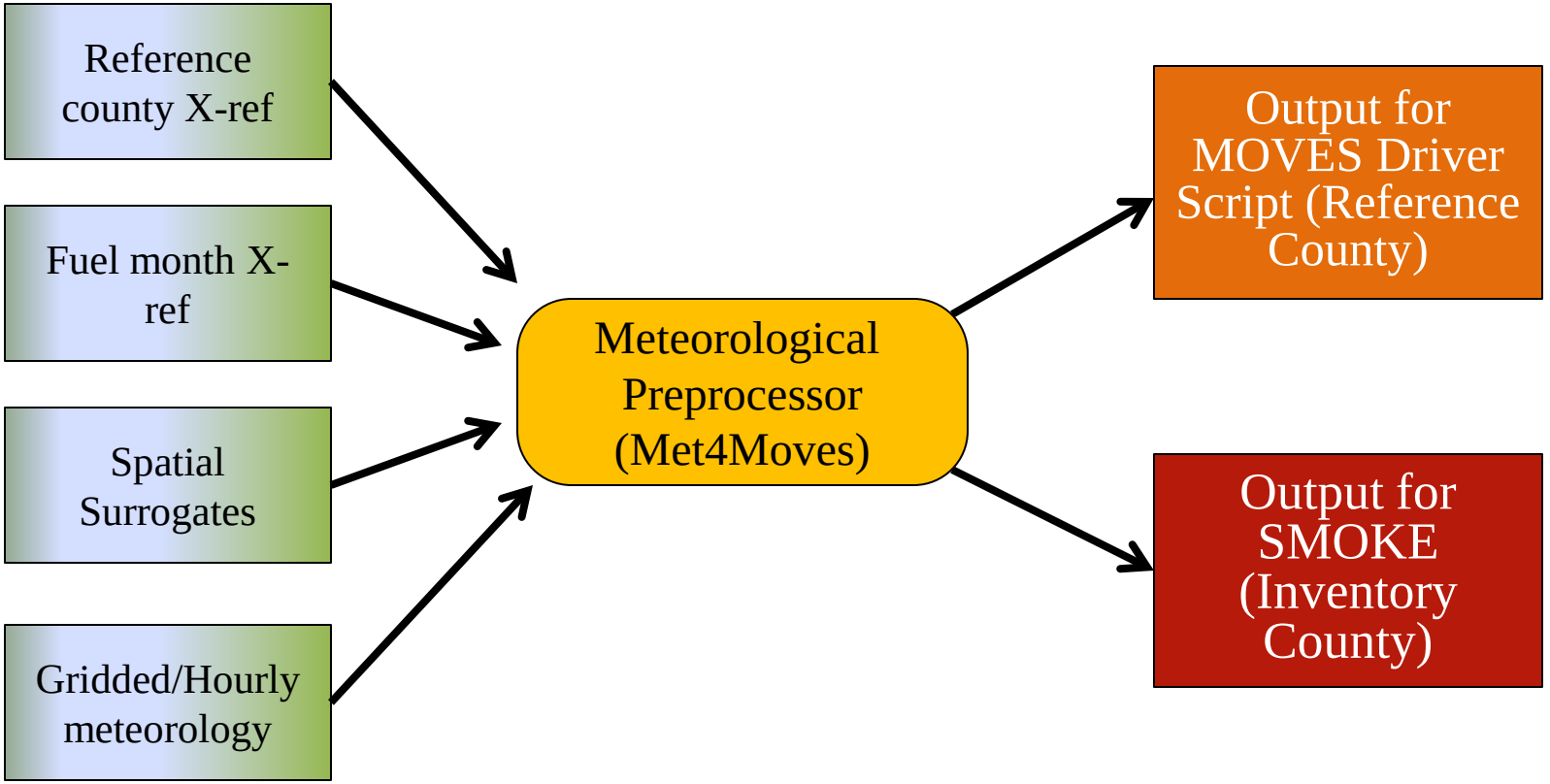
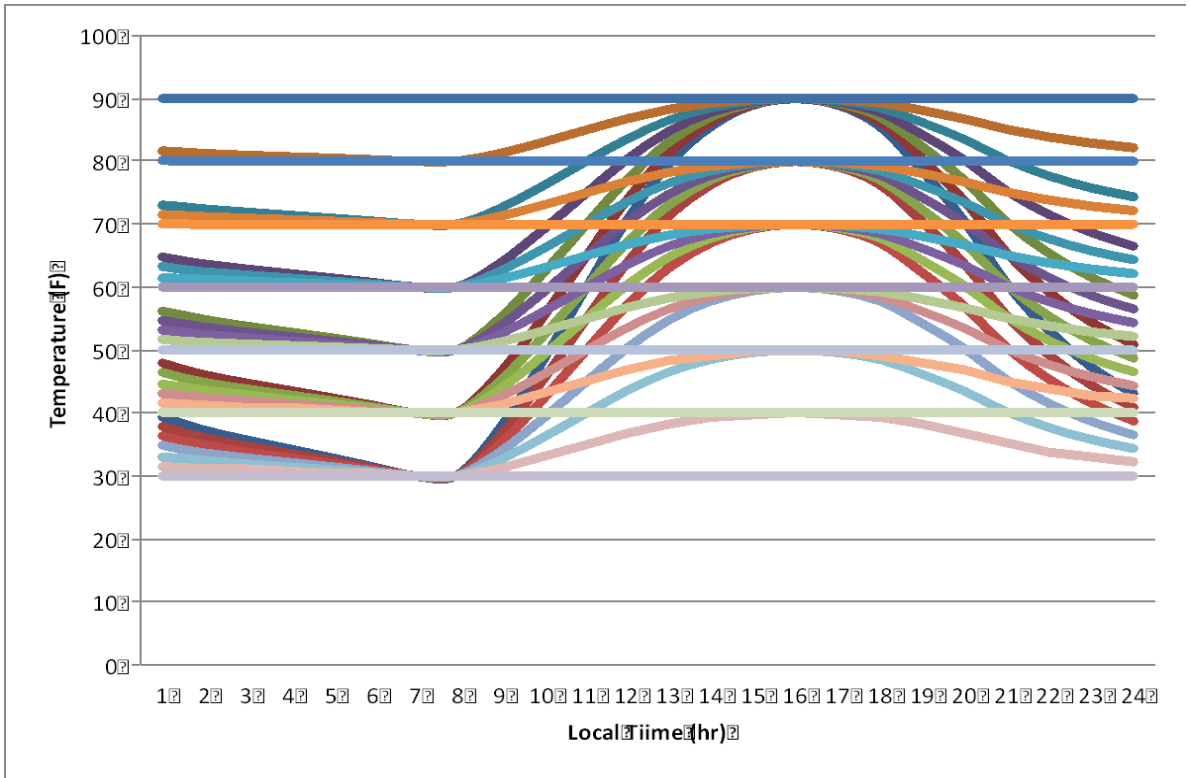
- Rate-per-distance (RPD)
  - On-roadway emissions
  - Exhaust, evaporative, brake and tire wear
  - SMOKE uses: VMT, SPEED, speed profiles, and T (gridded, hourly)
- Rate-per-vehicle (RPV)
  - Off-network emissions
  - Exhaust, evaporative
  - SMOKE uses: VPOP and T (gridded, hourly)
- Rate-per-profile (RPP)
  - Off-network emissions
  - Parked vehicles, including diurnal (when the vehicle is parked during the day) and hot soak (immediately after a trip)
  - Evaporative fuel vapor venting
  - SMOKE uses: VPOP and T (county based, daily diurnal profiles)

Met4Moves


Reference county X-ref
Fuel month X-ref
Spatial Surrogates
Gridded/Hourly meteorology
Meteorological Preprocessor (Met4Moves)
Output for MOVES Driver Script (Reference County)
Output for SMOKE (Inventory County)

Met4Moves: Output for MOVES

- RPD/RPV
  - average RH and min/max T across the county group and fuel month
- RPP
  - Diurnal T profiles
  - Normalized 24 hr T profiles based on min/max T of county group



Met4Moves: Output for SMOKE

- Daily (or monthly) average RH and min/max T for RPP
- County and date specific
- All counties in domain

Inventory County	fuelMonth	Month	julianDate	RH	Temp (Minimum)	Temp (Maximum)
13001	1	3	2009060	51.1	25.2	65.1
13002	1	3	2009060	55.2	29.1	58.9
13003	1	3	2009060	52.6	21.4	59.3
13005	1	3	2009060	51.7	25.8	62.1
…	…	…	…	…	…	…
13001	4	4	2009090	61.1	44.2	75.1
13002	4	4	2009090	66.6	39.9	63.7
13003	4	4	2009090	61.1	45.1	80.5
13005	4	4	2009090	56.2	46.2	79.5
…	…	…	…	…	…	…

MOVES Driver Script

- Creates the input data tables for import
- Creates run specification (runspec) XML files to run MOVES for large number of conditions
  - Separate runs for each T bin or T profile and for each reference county and fuel month
- Generates specific T and RH csv files based on Met4Moves output
- Creates scripts to run all the importers and all the MOVES scenarios

Run MOVES

Need to run MOVES for every
reference county/fuel month/process/Tbin

This may take awhile .....

MOVES Post-processing Scripts

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- Convert MOVES MySQL tables to SMOKE-ready EF tables
  - Produces 3 types of EF tables RPD, RPV, RPP EF tables
  - Produces separate set of tables for each reference county and fuel month
- Maps MOVES PM species to SMOKE PM species
  - Appropriate for CB05 with SOA
  - AE5 species: PMC, POC, PEC, PNO3, PSO4, PMFINE
- Maps MOVES emission processes to SMOKE emission processes
  - Optionally consolidate down to “typical” SMOKE modes: EVP, EPM, EXH, BRK, TIR

MOVES Post-processing Scripts: Emission Processes

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EXH

EVP

Emission Rate Lookup Table	Units	SMOKE ProcessID	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)

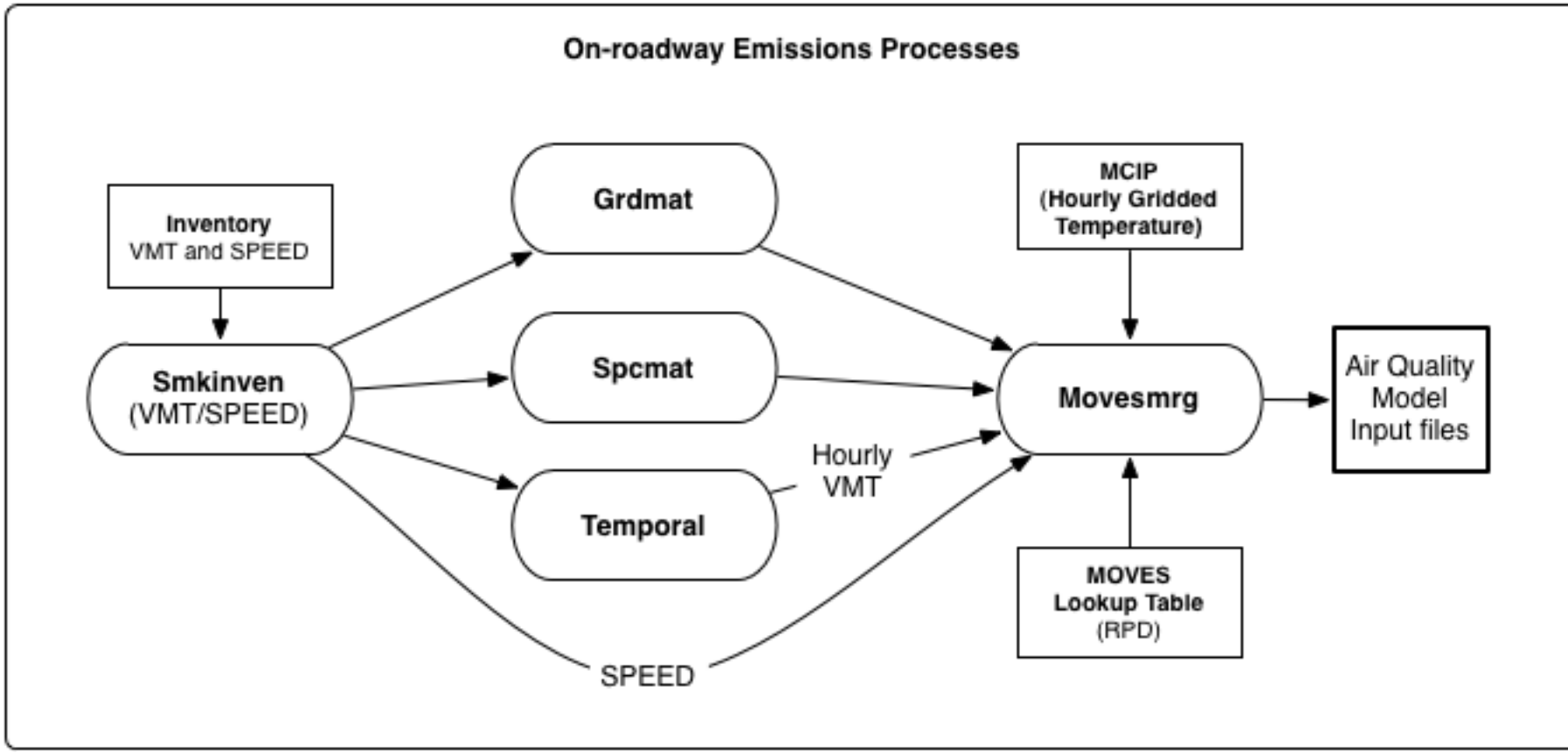
SMOKE Modeling System

- RPD (grams/miles) : On-roadway Emission Process EFs
  - Lookup Fields: SCC, speed (optional 24-hr speed profiles), representative county, fuel month, and temperature.

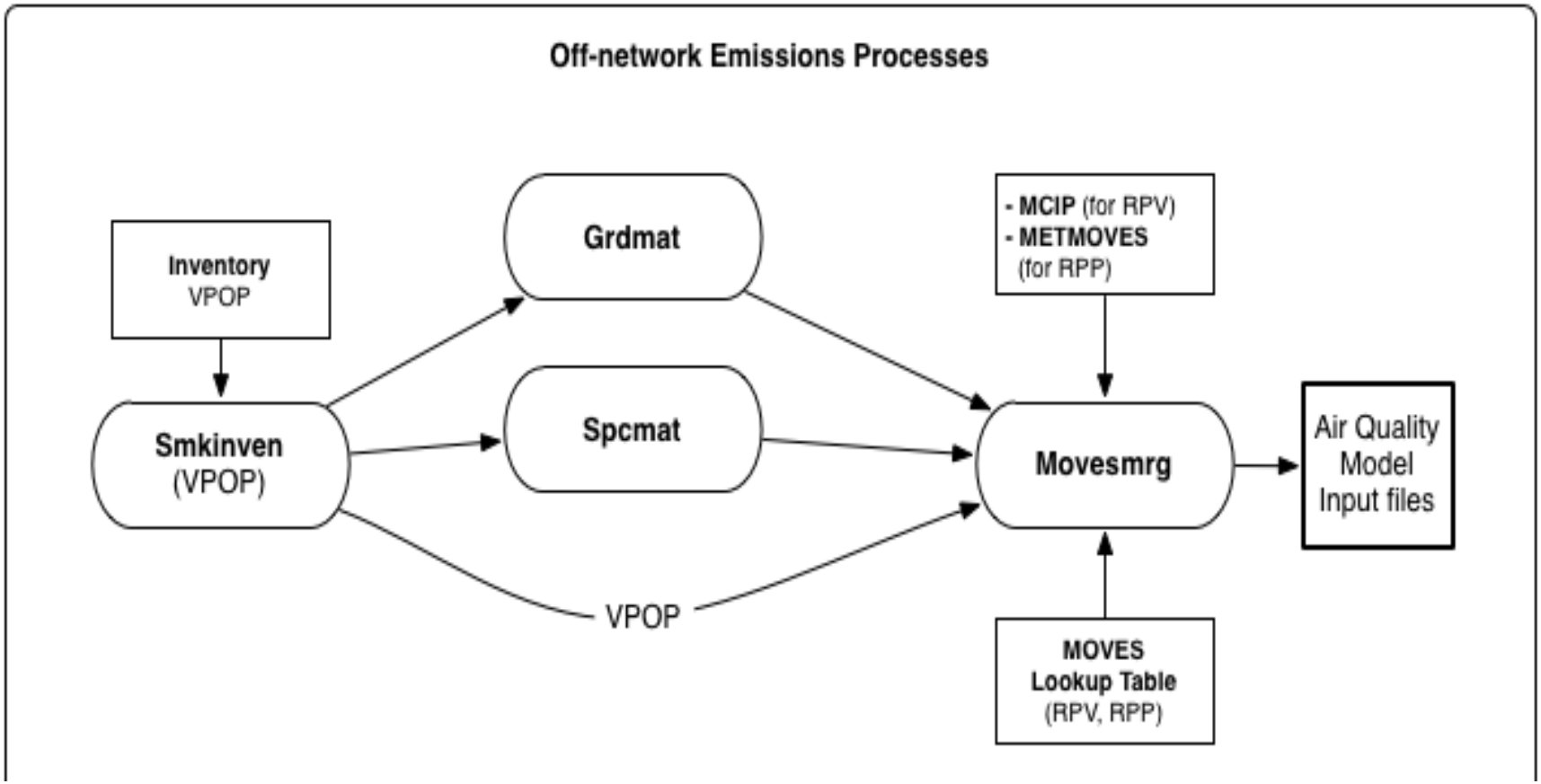
- RPV (grams/vehicle-hr) : Off-network Emission Process EFs
  - Lookup Fields: SCC, representative county, fuel month, temperature, local time (hourID).

- RPP (grams/vehicle-hr) : Off-network Vapor Venting Evap. EFs
  - Lookup Fields: SCC, representative county, fuel month, temperature profiles, local time (hourID).

SMOKE: On-roadway Processing (RPD)



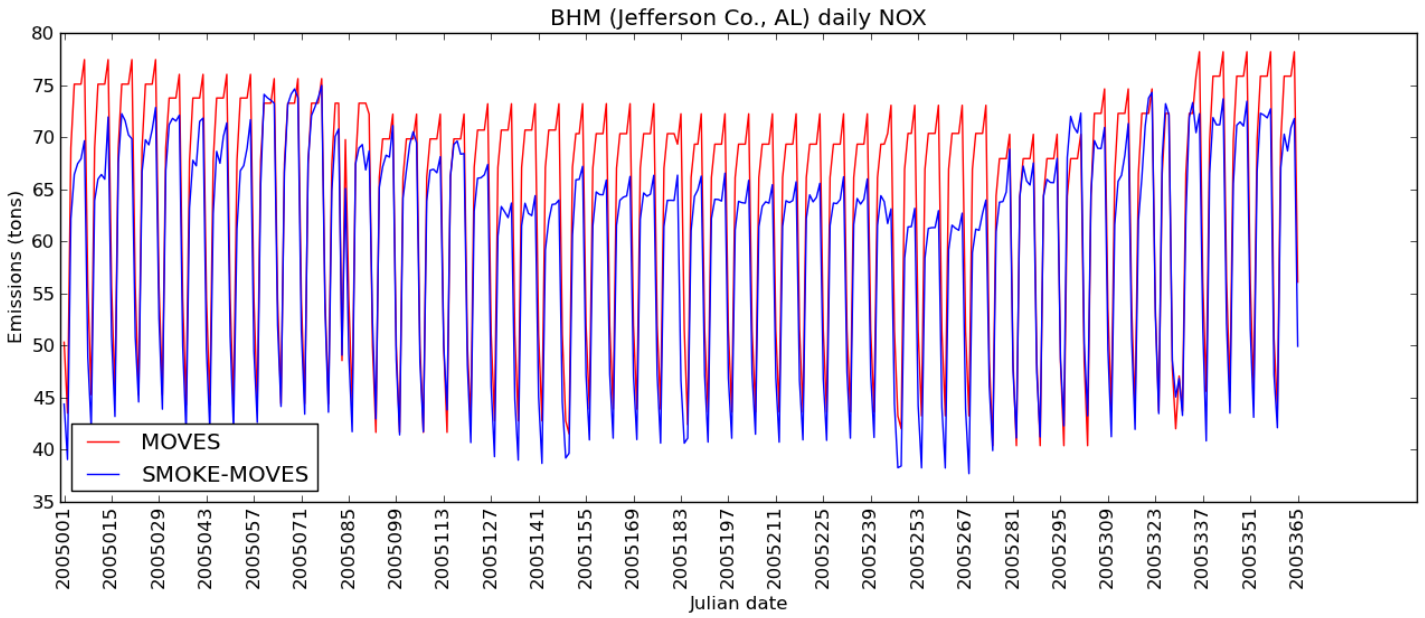
SMOKE: Off-network Processing (RPP, RPV)



SMOKE: Final Merging

- Run separately (RPD, RPV, RPP)
- RPD, RPV are run for every day using hourly gridded MCIP files
- RPP could be run for average day (representative day per month) using monthly averaged meteorological output from Met4Moves OR could be run every day using daily meteorological output from Met4Moves

Monthly Inventory vs SMOKE-MOVES

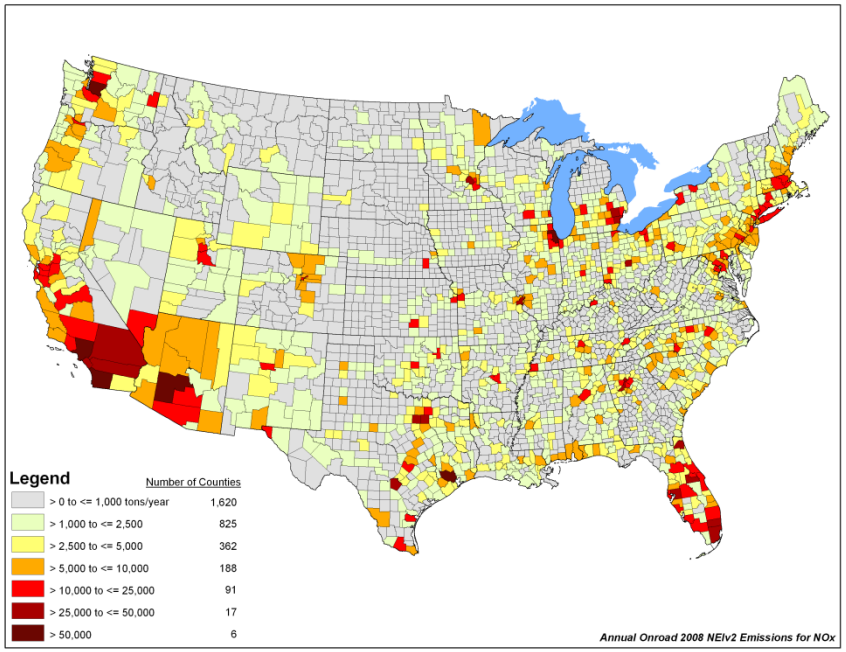


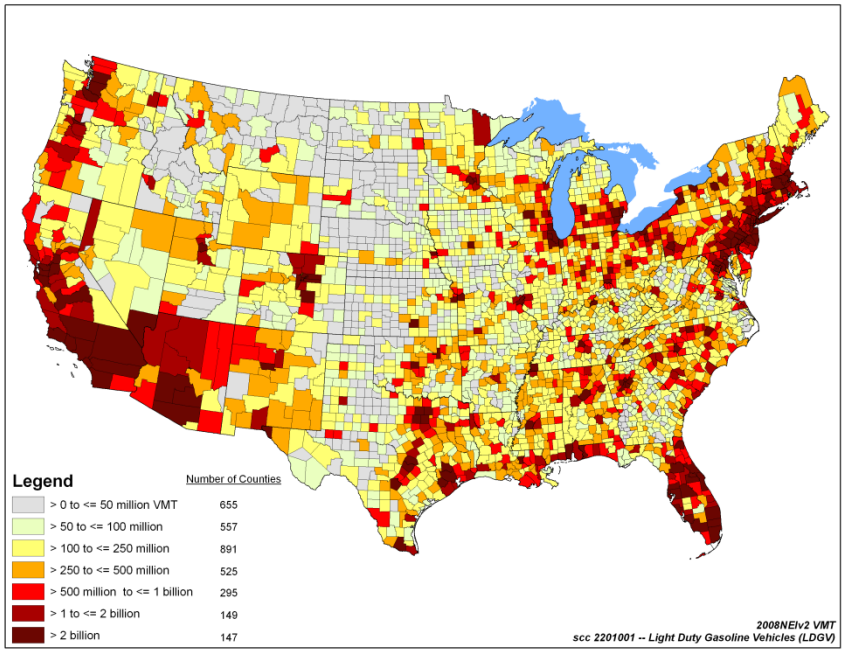
Emissions respond to day-specific temperature variations

MOVES2010b

- Support for HAPS
- Explicitly model HONO
- Refueling EF
- Draft version used in development of NEI 2008 v2

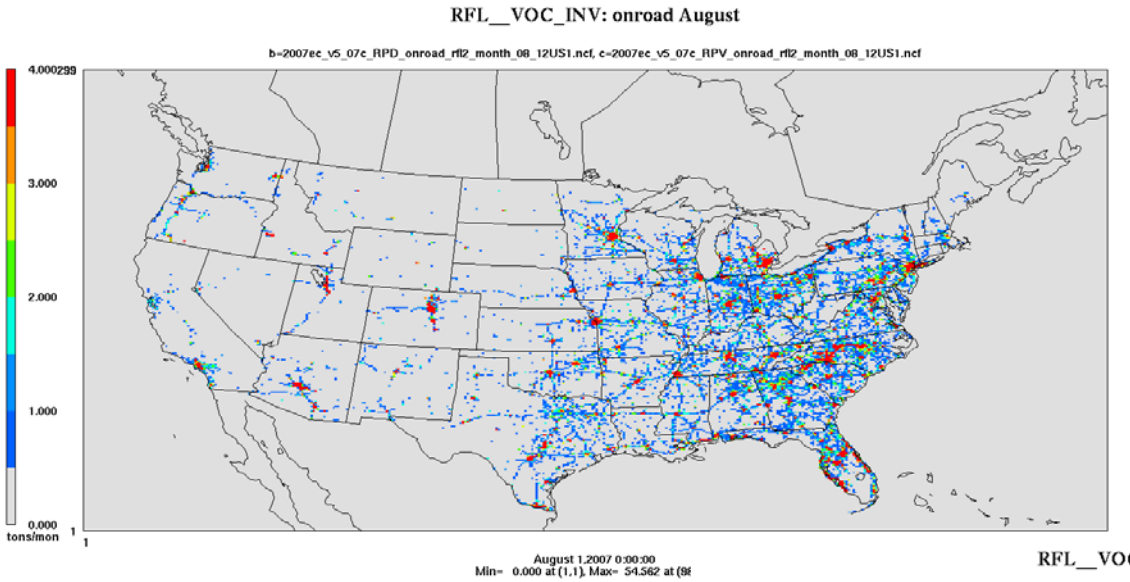
MOVES2010b: 2008 NEI v2



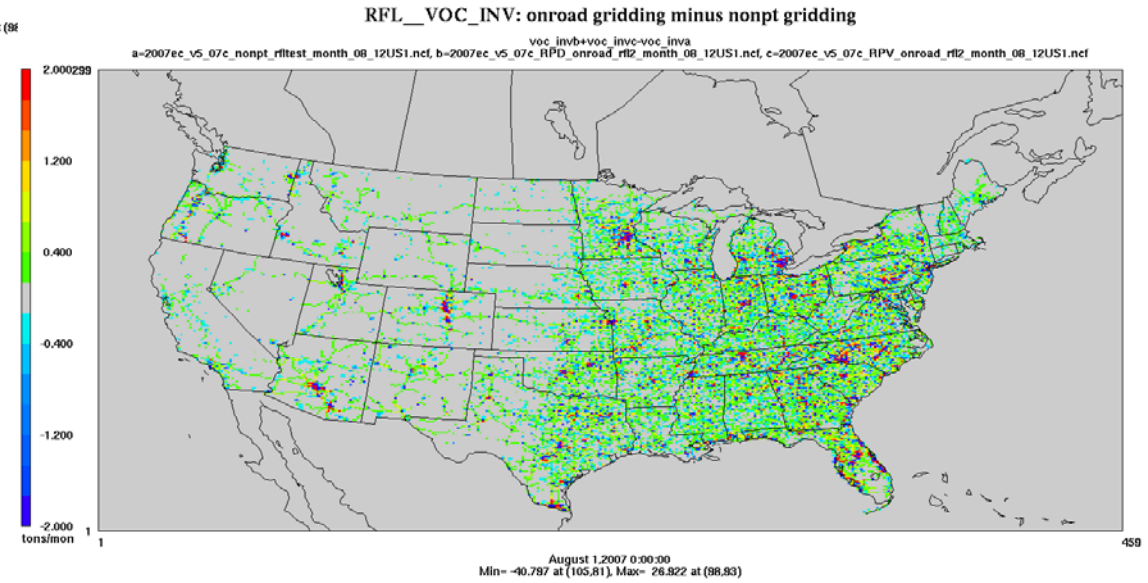


- Ran all NEI pollutants including HAPS
- Ran SMOKE-MOVES nationally
- Summed up hourly emissions to create annual and monthly inventory

MOVES2010b: Refueling



- Refueling from RPD, RPV
- Same SCCs as other modes
- SMOKE gridding based on SCC only



Recent Developments

- Improved computational efficiency of Movesmrg
- low versus high memory options
- Updates to post-processor script
  - New header for EF tables
  - Easier to add or subtract pollutants
  - Support for MOVES2010b (HONO, HAPS)
- Met4moves averaging period
  - Daily vs. Monthly ranges (SMOKE output)
  - New header for computational efficiency
- Temperature out of range of EF

Recent Developments

- Adjustment factors in Movesmrg
  - adjustment factor file (optional input)
  - applies adjustment by FIPS, SCC, pollutant, mode, and/or month
- Updated Emission Processing Inputs
  - Chemical speciation profiles and cross-reference files
  - Spatial surrogates

References

- SMOKE: http://www.smoke-model.org/
- SMOKE-MOVES User's Guide: http://www.smoke-model.org/smoke_moves_tool/SMOKE-MOVES_Tool_Users_Guide.pdf

Acknowledgement

- OTC, NESCAUM, MARAMA, SESARM
- ENVIRON International Corporation
- US EPA Office of Transportation and Air Quality (OTAQ)
- CSC