Development of 2020 NEI Onroad Emissions with SMOKE-MOVES

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GENERAL DYNAMICS
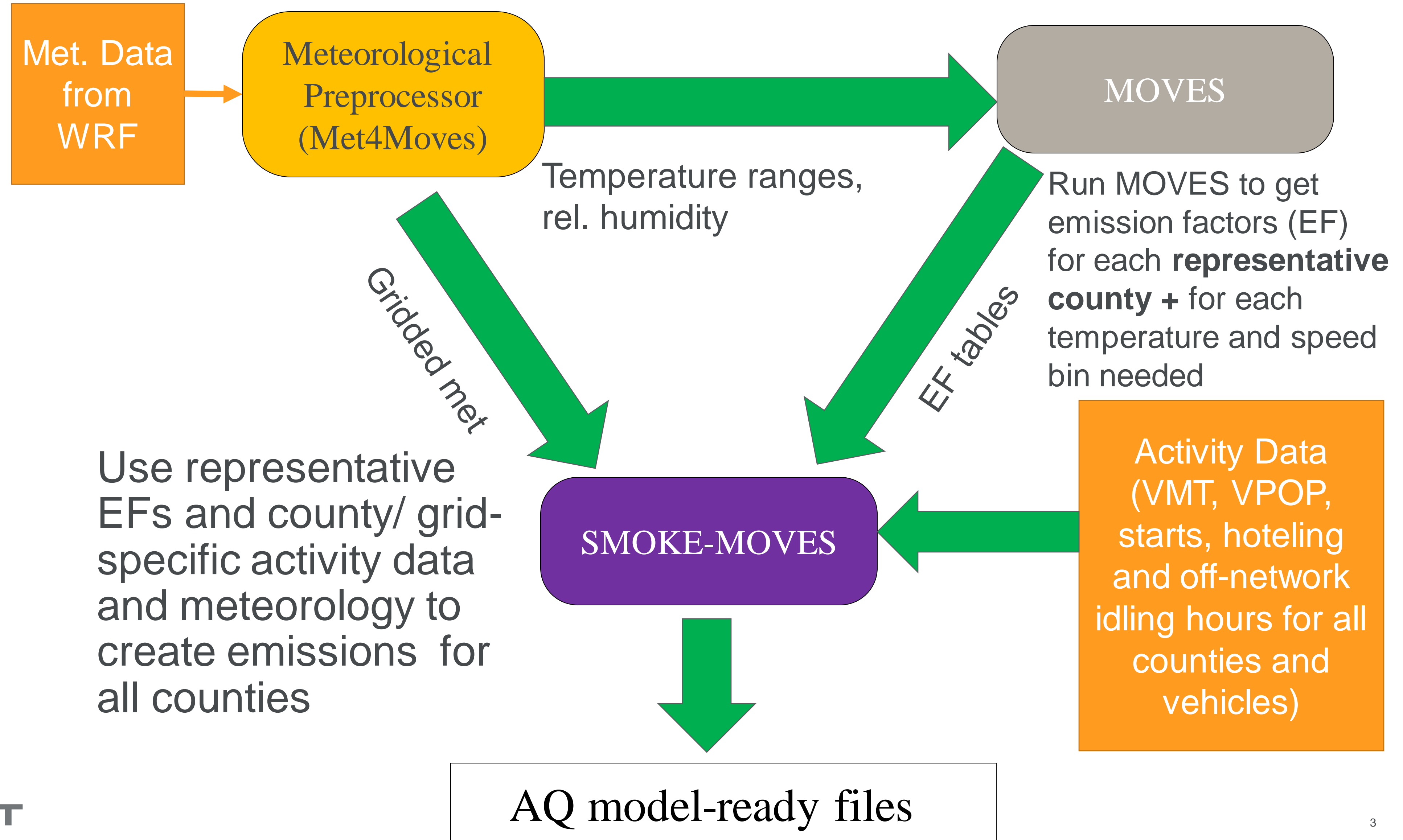Information Technology

2020 National Emissions Inventory

- Onroad emissions are prepared with MOVES and SMOKE-MOVES for each triennial NEI (2014, 2017, 2020…)

- All NEIs typically incorporate data from the Federal Highway Administration (FHWA), state and local agencies, and traffic data from various sources

- 2020 was a unique year!

- We had to account for pandemic effects on driving patterns, e.g. temporal patterns and speeds

- Allison DenBleyker talk from this session discusses the StreetLight dataset, which was the source for much of the 2020-specific data
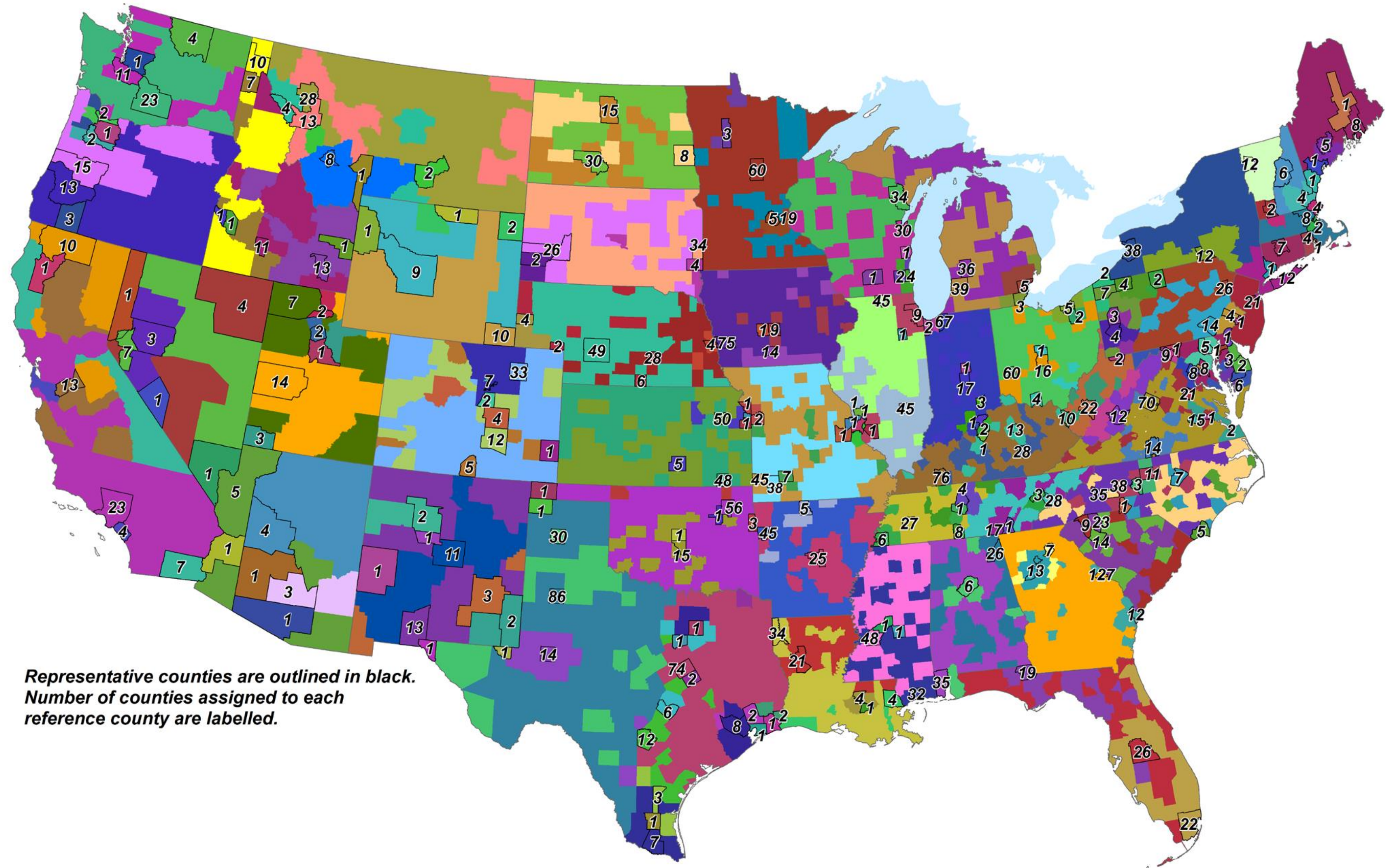

Allen, 4/11/2020
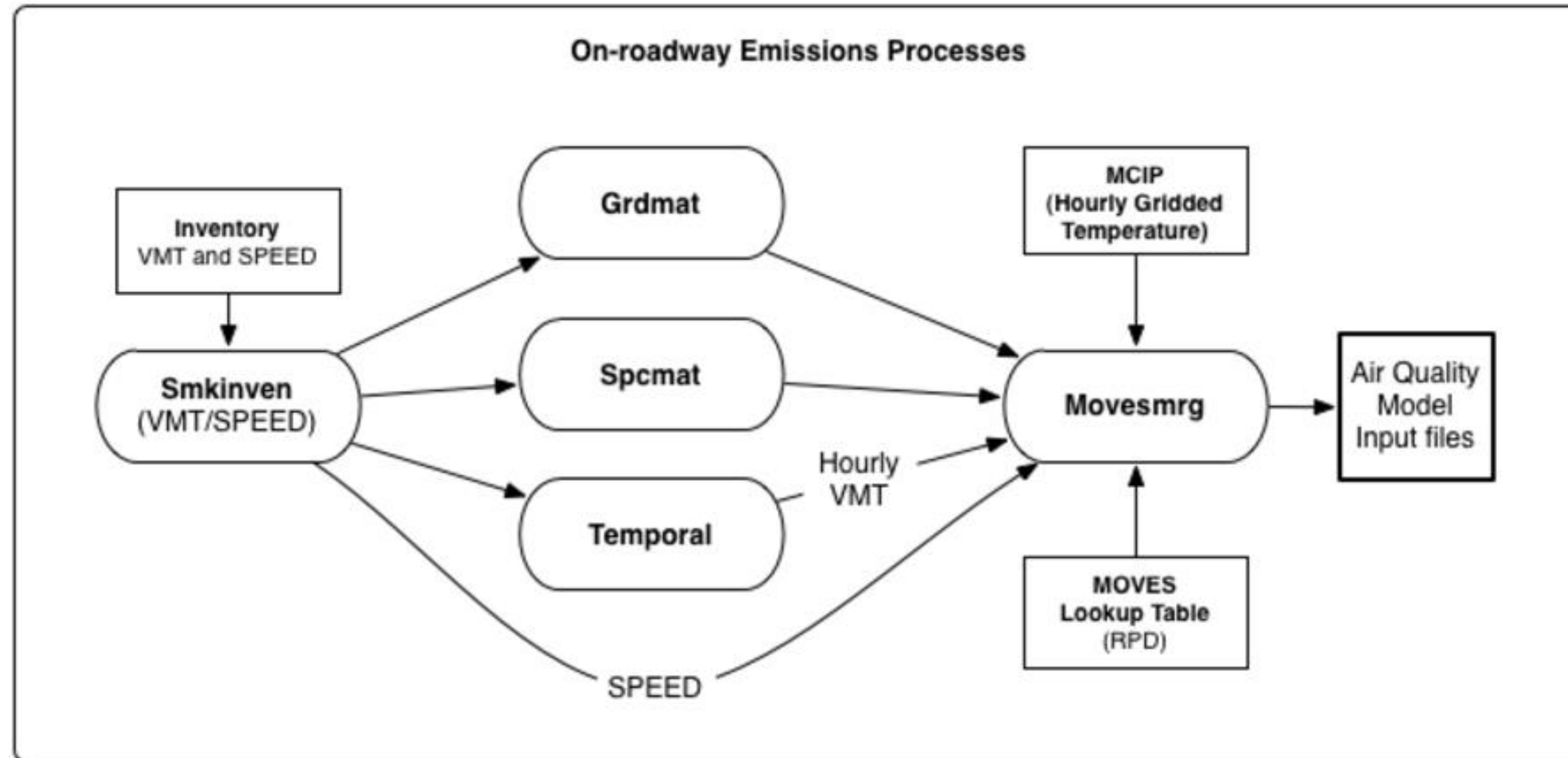
Onroad Emissions Inventory Development

Met. Data from WRF → **Meteorological Preprocessor (Met4Moves)**

Temperature ranges, rel. humidity → **MOVES**

Gridded met ↓

EF tables ↓

Run MOVES to get emission factors (EF) for each **representative county +** for each temperature and speed bin needed

Use representative EFs and county/ grid-specific activity data and meteorology to create emissions for all counties

SMOKE-MOVES ← **Activity Data (VMT, VPOP, starts, hoteling and off-network idling hours for all counties and vehicles)**

↓

AQ model-ready files

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2020 NEI Representative County Groups

- **292** representative counties (Lower 48: **254**)

- Only these 292 counties are modeled in MOVES

Representative counties are outlined in black.
Number of counties assigned to each reference county are labelled.

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Computing On-roadway Emissions Using SMOKE-MOVES

On-roadway Emissions Processes

SMOKE-MOVES Uses Standard SMOKE programs + Movesmrg
- Input "inventory" for on-roadway consists of VMT data
- Other activity data types are used for off-network emissions

Vehicle Miles Traveled in 2020

- Primarily based on FHWA data: https://www.fhwa.dot.gov/

- Also includes VMT data provided by state and local agencies

- Updated road type distributions in many states compared to past platforms (e.g. 2016v3 platform, EQUATES)

- Updated fuel distributions reflecting higher EV penetration

Annual VMT - light duty (EQUATES + 2020NEI)
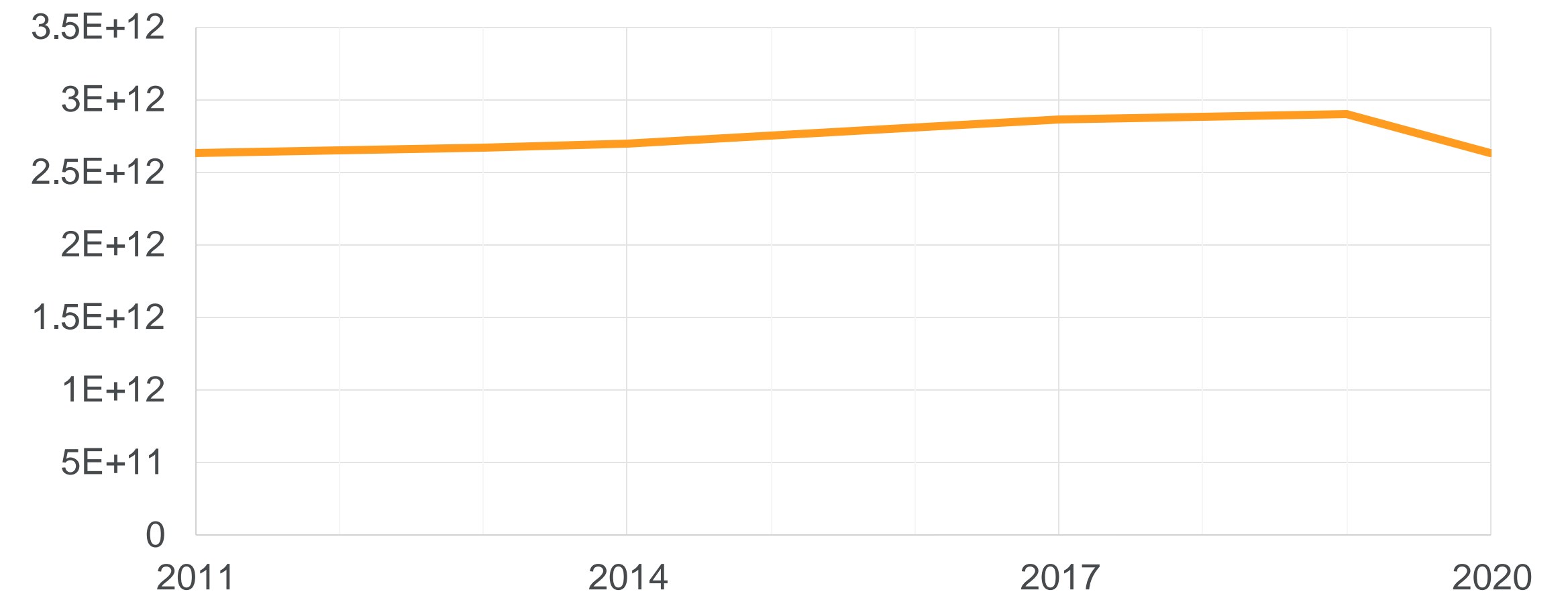
Annual VMT - heavy duty (EQUATES + 2020NEI)

VMT fuel splits (cars + light trucks)

|	2011	2014	2017	2020
gas	97.29%	97.33%	97.45%	97.22%
diesel	2.61%	2.51%	2.29%	2.29%
E-85	0.08%	0.12%	0.14%	0.14%
electric	0.01%	0.05%	0.12%	0.35%
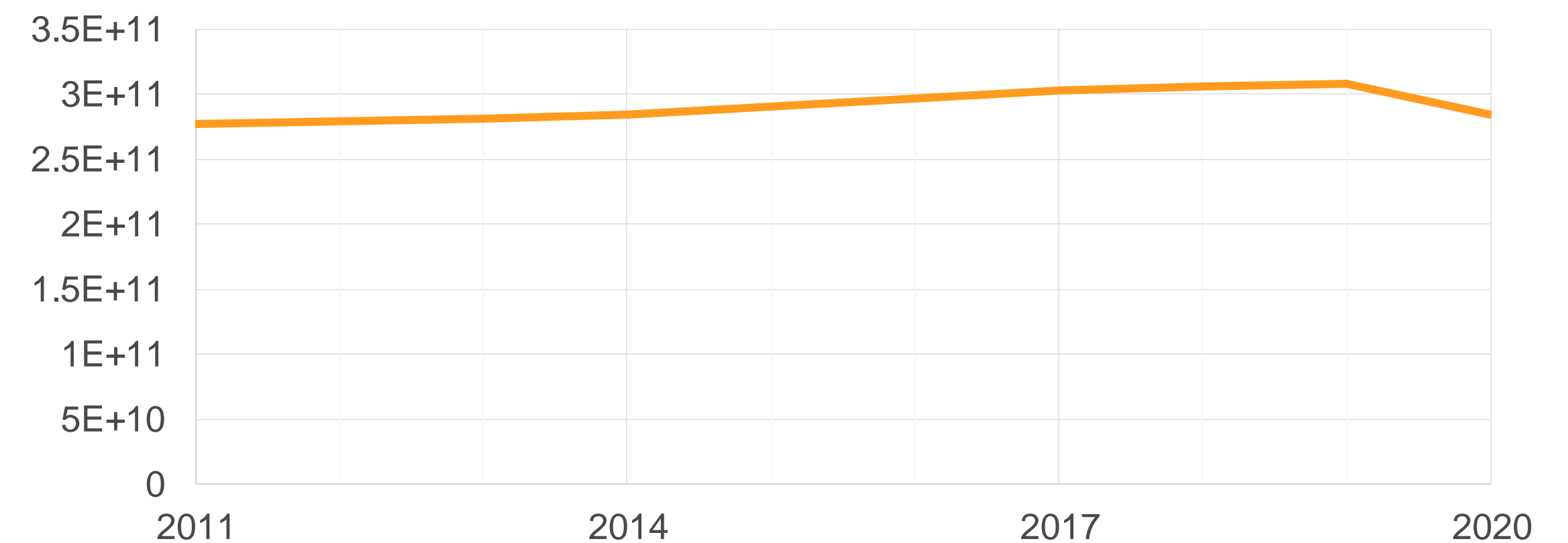
Vehicle Miles Traveled in 2020

- 2020 VMT has a very unique monthly distribution

- Data sources for monthly distributions of VMT include state and local agencies (via MOVES CDB submissions) and traffic counts from telematics data (StreetLight dataset)

- Day-of-week temporalization (same data sources) is also unique to 2020 and varies by month

- Light duty (LD) and heavy duty (HD) vehicles have different monthly patterns in 2020

2019 and 2020 VMT monthly distributions
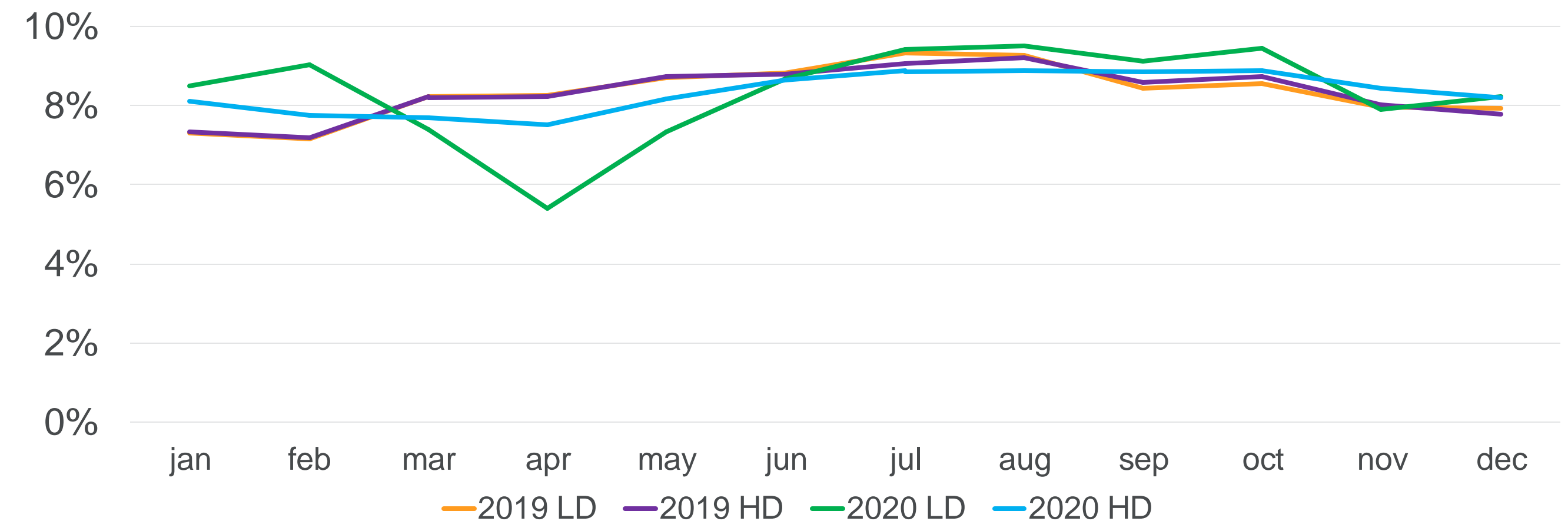
Daily total VMT - Wake County, NC

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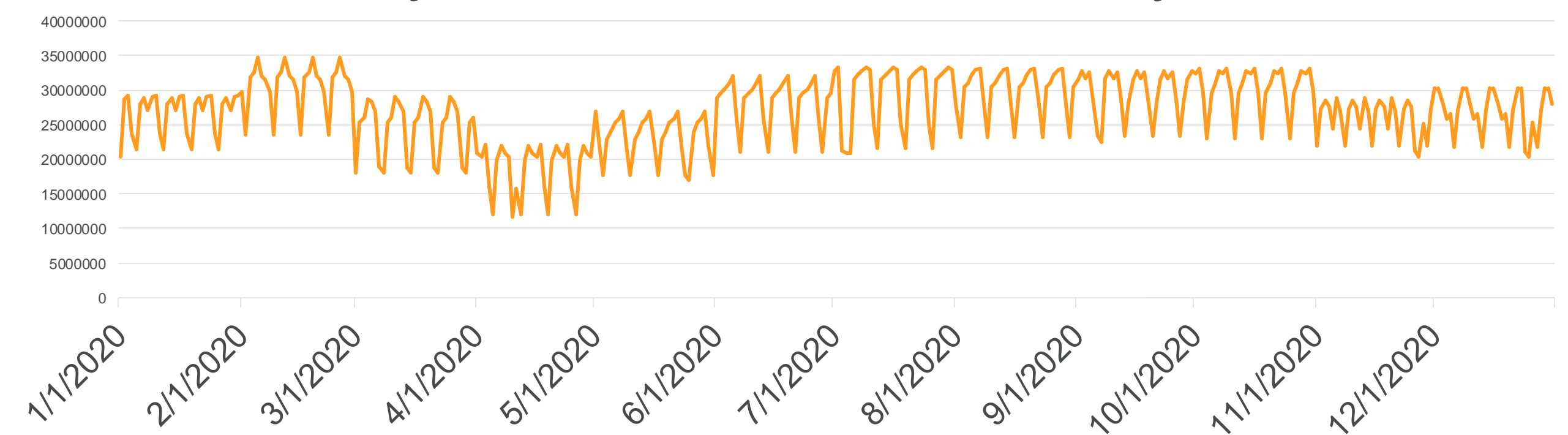
Other Types of Vehicle Activity in 2020

- VPOP based on vehicle registration data (plus S/L/T submissions)

- Hoteling hours: generally proportional to long haul truck VMT on restricted roads

- Vehicle starts calculated within MOVES

- Off-network idling hours (ONI) proportional to VMT

- Annual miles traveled per vehicle are generally lower than in 2019

| Vehicle Type	Miles per Vehicle 2019	Miles per Vehicle 2020	% change
Motorcycle	1,824	1,535	-16%
Passenger Car	11,432	10,602	-7%
Passenger Truck	11,589	10,591	-9%
Light Commercial Truck	11,330	10,343	-9%
Other Bus	38,718	25,284	-35%
Transit Bus	22,565	27,689	23%
School Bus	9,426	12,687	35%
Bus Subtotal	*15,335*	*16,995*	*11%*
Refuse Truck	21,013	18,735	-11%
Single Unit Short-haul Truck	14,483	12,976	-10%
Single Unit Long-haul Truck	18,823	17,522	-7%
Motor Home	2,221	3,559	60%
Combination Short-haul Truck	30,779	36,229	18%
Combination Long-haul Truck	83,599	54,330	-35%
All Light Duty	11,112	10,218	-8%
All Heavy Duty	24,457	22,288	-9%

Average Speed Distributions

- Emissions per vehicle factors depend on vehicle speed (among other things!)

- Average speeds are represented in SMOKE using a "speed distribution" file (SPDIST)

- Speed distributions are derived from the StreetLight dataset

- Speed distributions vary by month due to pandemic effects; less traffic = higher speeds

- Emissions are highly dependent on vehicle speed

Speed distribution: King County WA
Passenger cars, urban unrestricted, 8 AM weekday

January — April — July — October
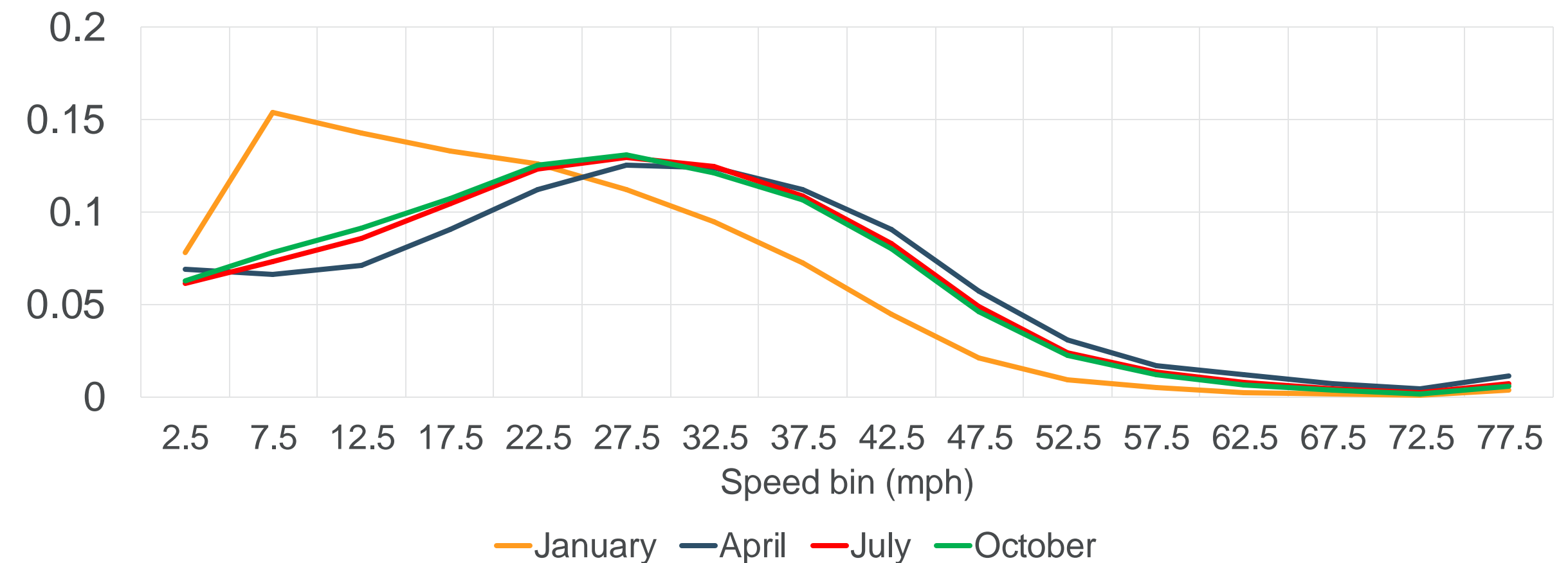
Average Emission Factors: King County WA, winter months
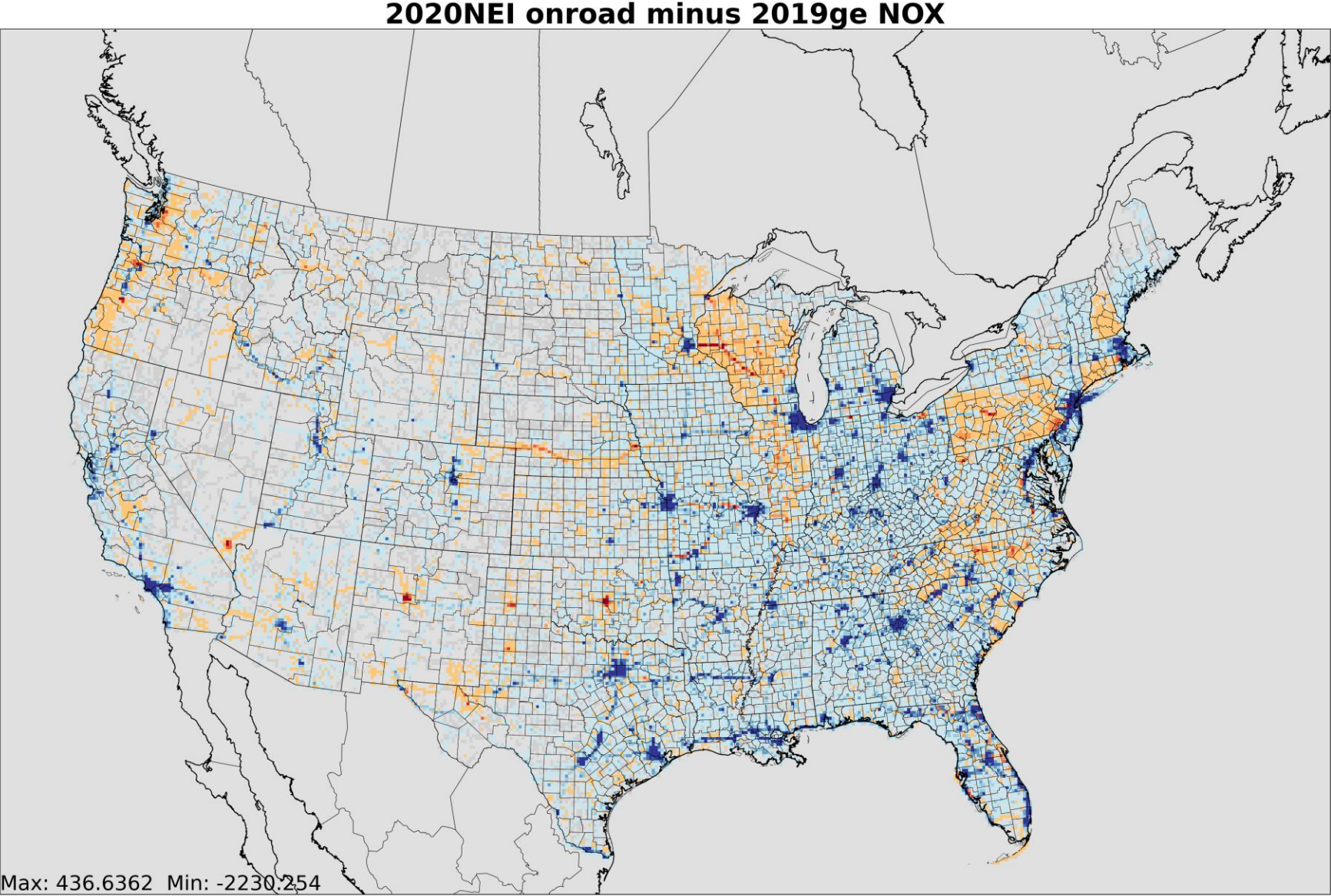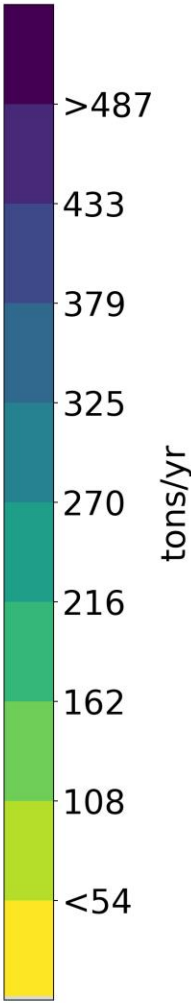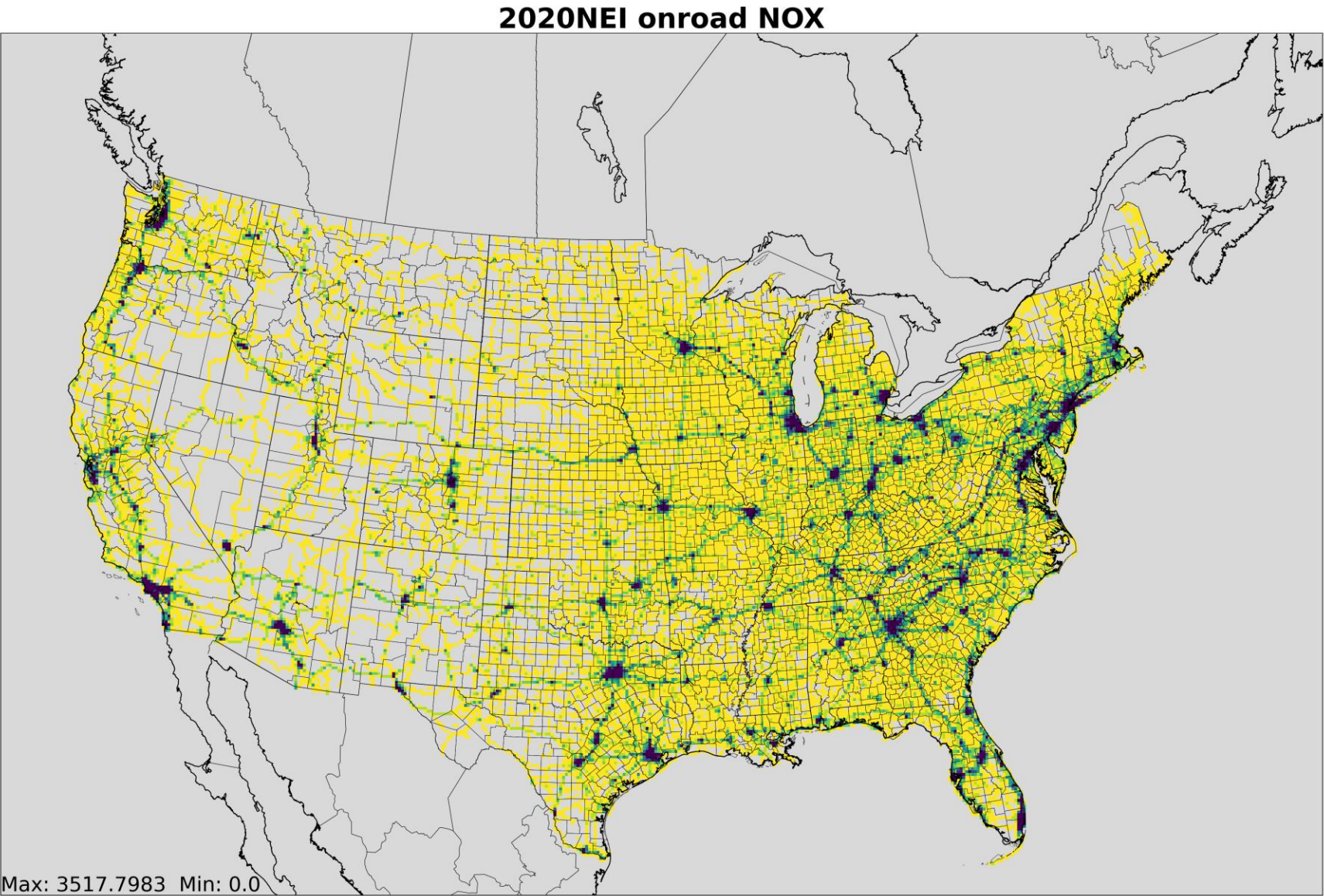Gas passenger cars, urban unrestricted

NOx — VOC
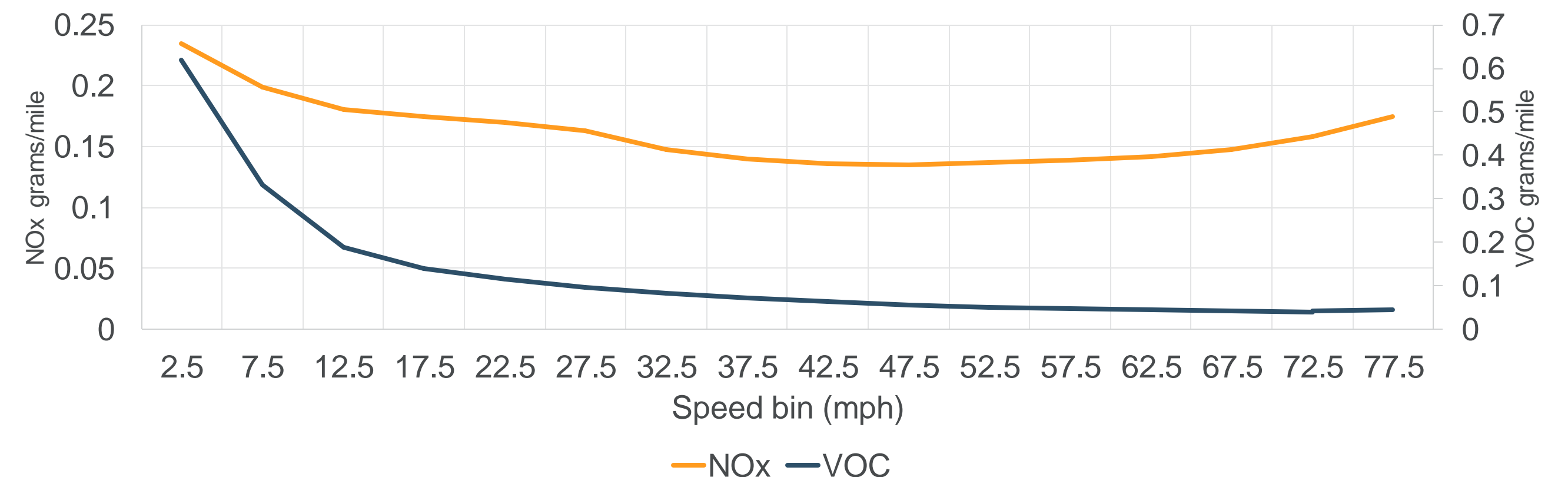
SMOKE-MOVES setup

- SMOKE version 4.9 was used

- No month-of-year temporalization of activity calculated in SMOKE

  (This is done prior to running SMOKE)

- Each month has its own speed distribution input file, day-of-week, and hour-of-day monthly profiles

  (SMOKE does not support month-specific speeds or profiles)

- The same day-of-week profiles are applied throughout each month

  (This means there is a big decrease from March 31 to April 1, for example)

- For VOC, speciation-in-SMOKE is applied for CMAQ applications, e.g. AirToxScreen

  (not relevant for NEI)

- Spatially allocated the off-network emissions using 2019 National Land Cover Database (NLCD) land use
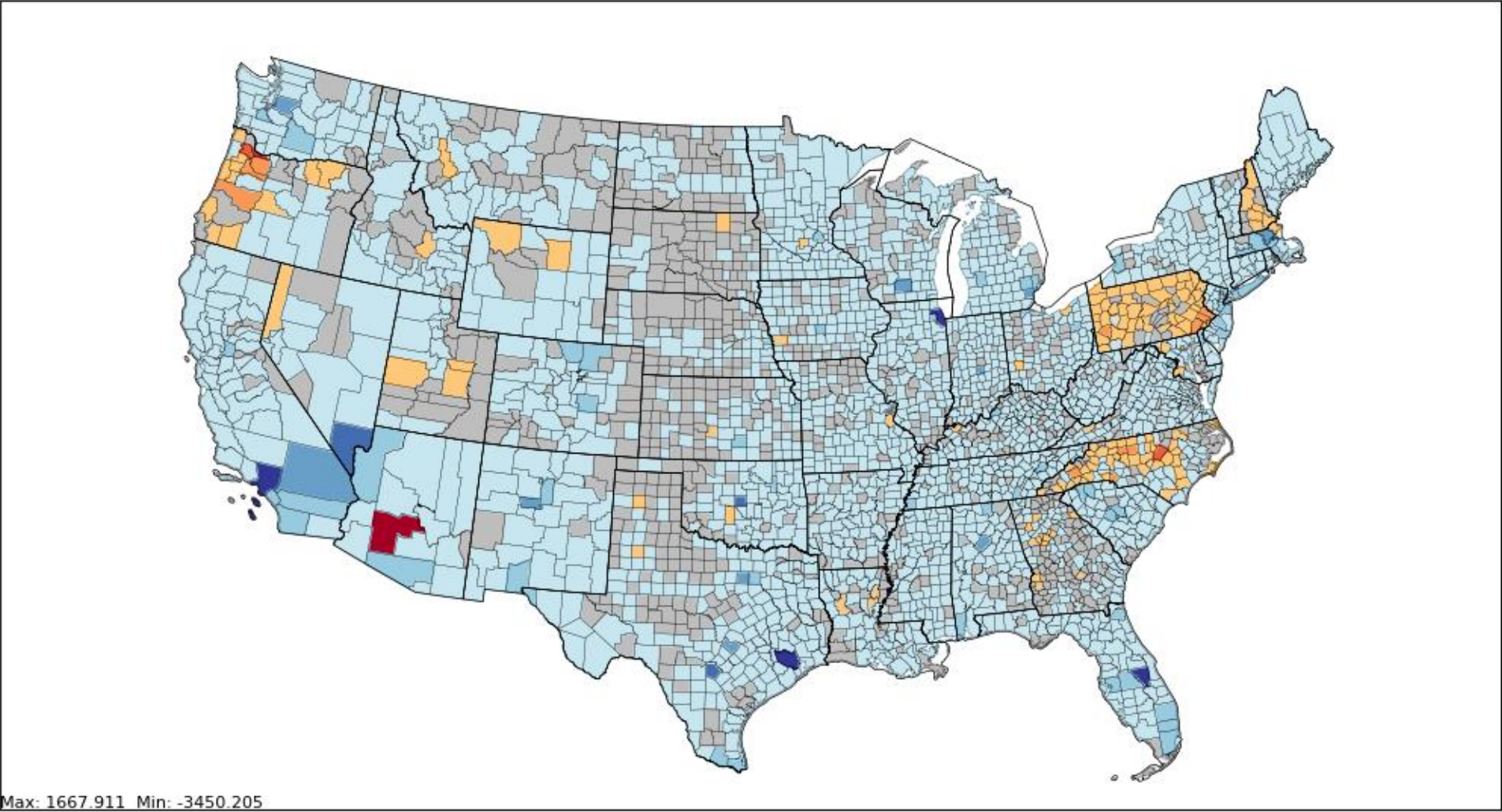
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2020NEI Onroad NOx and VOC Annual Emissions

2020NEI onroad NOX

Max: 3517.7983 Min: 0.0

2020NEI onroad minus 2019ge NOX

Max: 436.6362 Min: -2230.254

2020NEI onroad VOC_INV

Max: 1248.3665 Min: 0.0

2020NEI onroad minus 2019ge VOC_INV

Max: 328.9854 Min: -842.2745
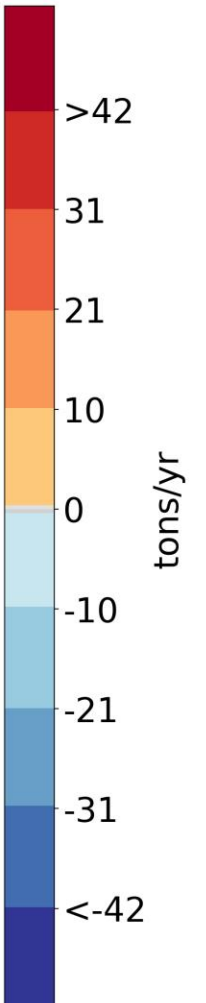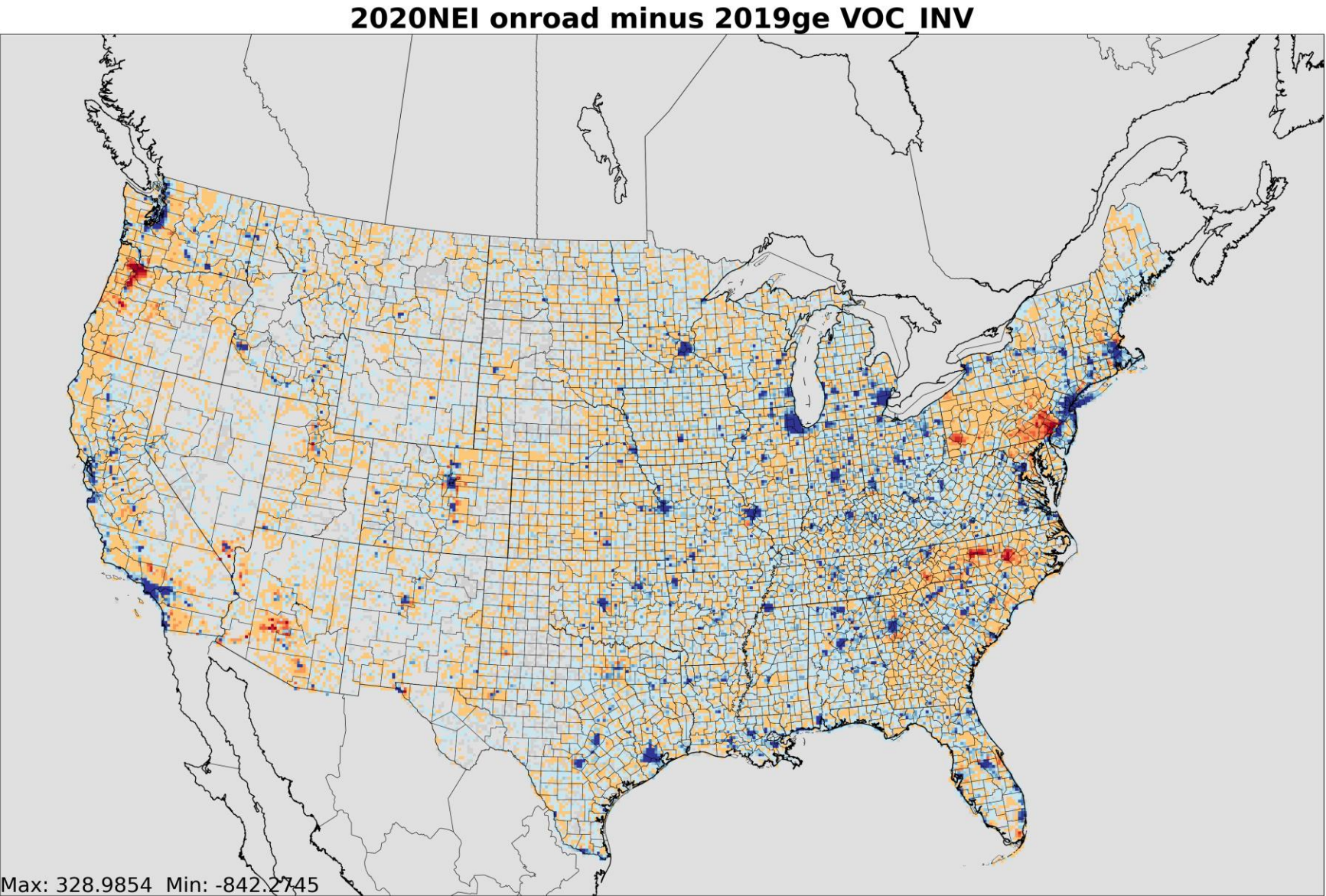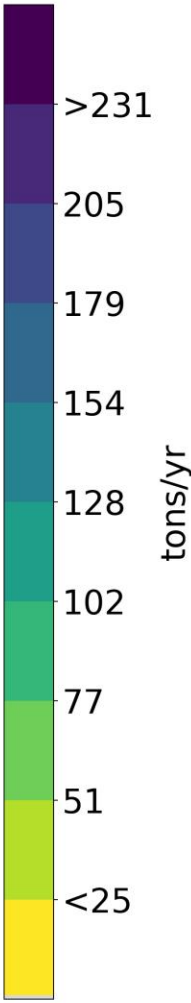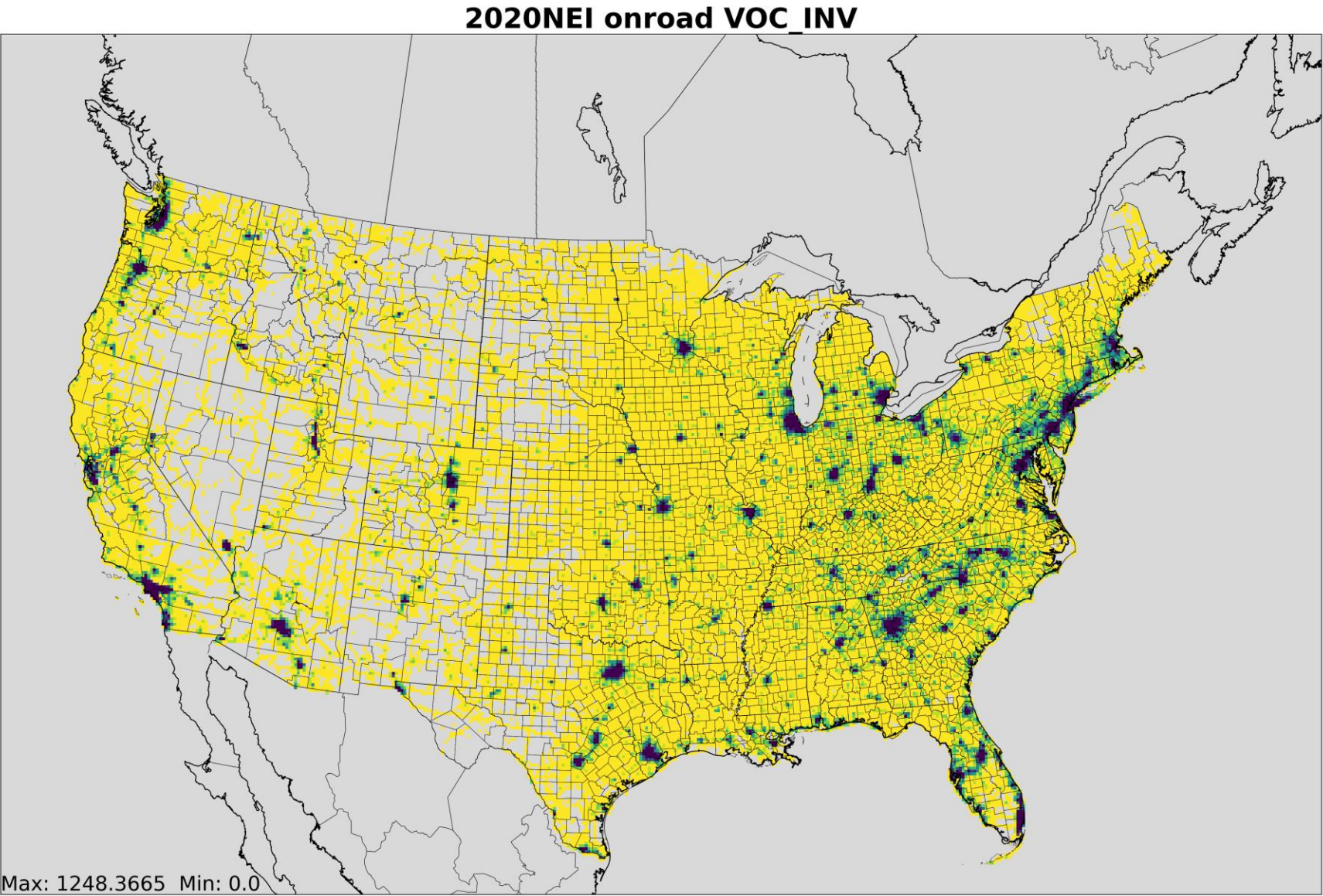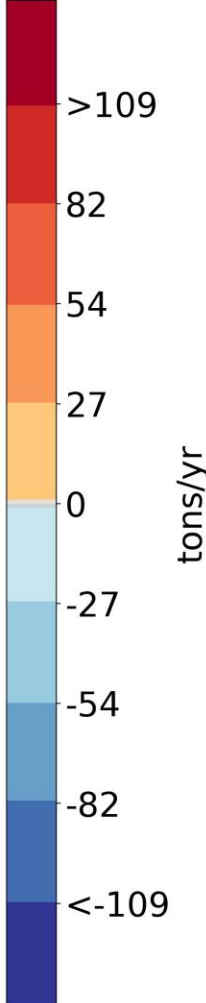
Change in Annual Emissions: light duty and heavy duty

LD gas NOx

2020NEI onroad NOX, gas LD : minus 2019ge
Max: 1667.911 Min: -3450.205
tons/year
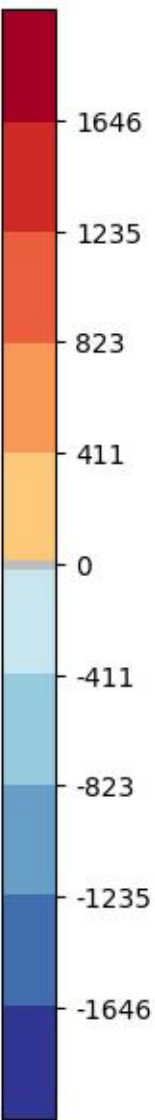
LD gas VOC

2020NEI onroad VOC, gas LD : minus 2019ge
Max: 1193.1747 Min: -3524.6604
tons/year
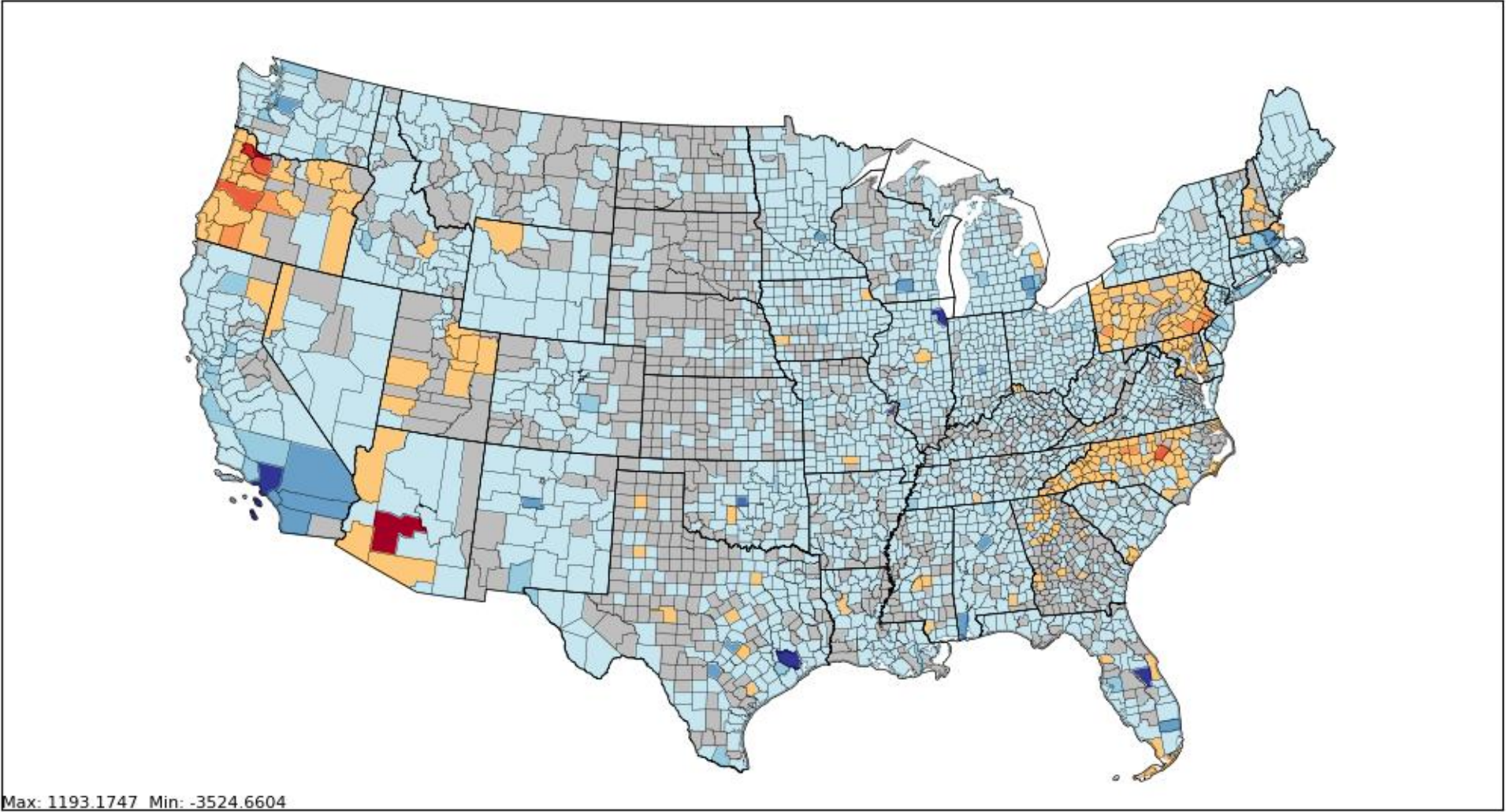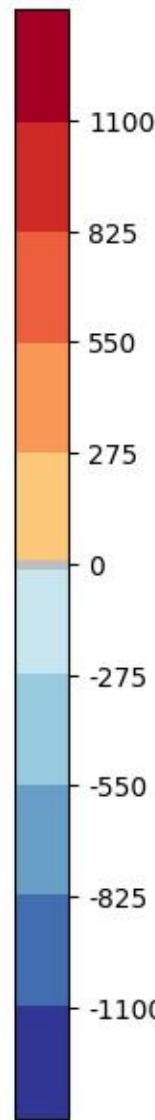
HD diesel NOx

2020NEI onroad NOX, diesel HD : minus 2019ge
Max: 2610.4111 Min: -5052.1826
tons/year
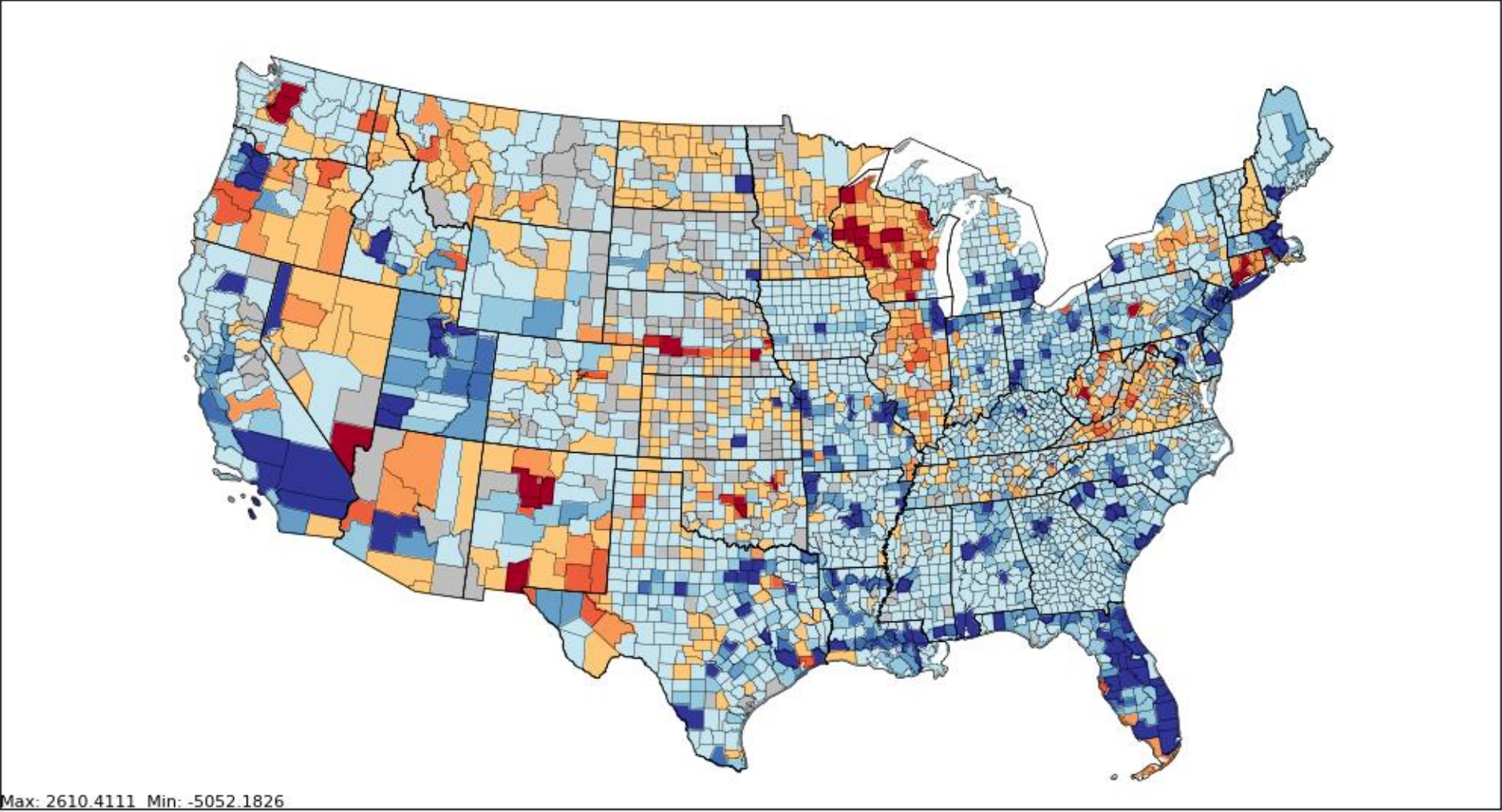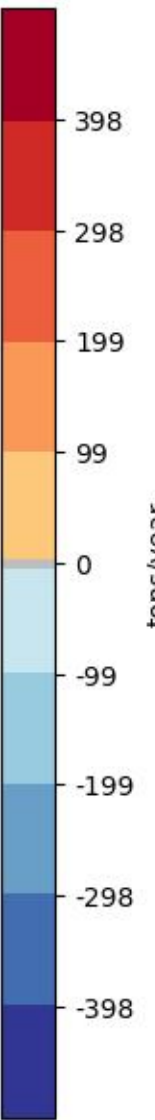
HD diesel VOC

2020NEI onroad VOC, diesel HD : minus 2019ge
Max: 95.461 Min: -337.96942
tons/year

2020NEI Onroad Monthly NOx Emissions

2020NEI onroad NOX, month_1 : minus 2019ge

tons/month

Max: 291.89487 Min: -625.87445

2020NEI onroad NOX, month_4 : minus 2019ge

tons/month

Max: 39.492466 Min: -881.1854

2020NEI onroad NOX, month_7 : minus 2019ge

tons/month

Max: 149.65773 Min: -727.8803

2020NEI onroad NOX, month_12 : minus 2019ge

tons/month

Max: 190.92998 Min: -641.3789
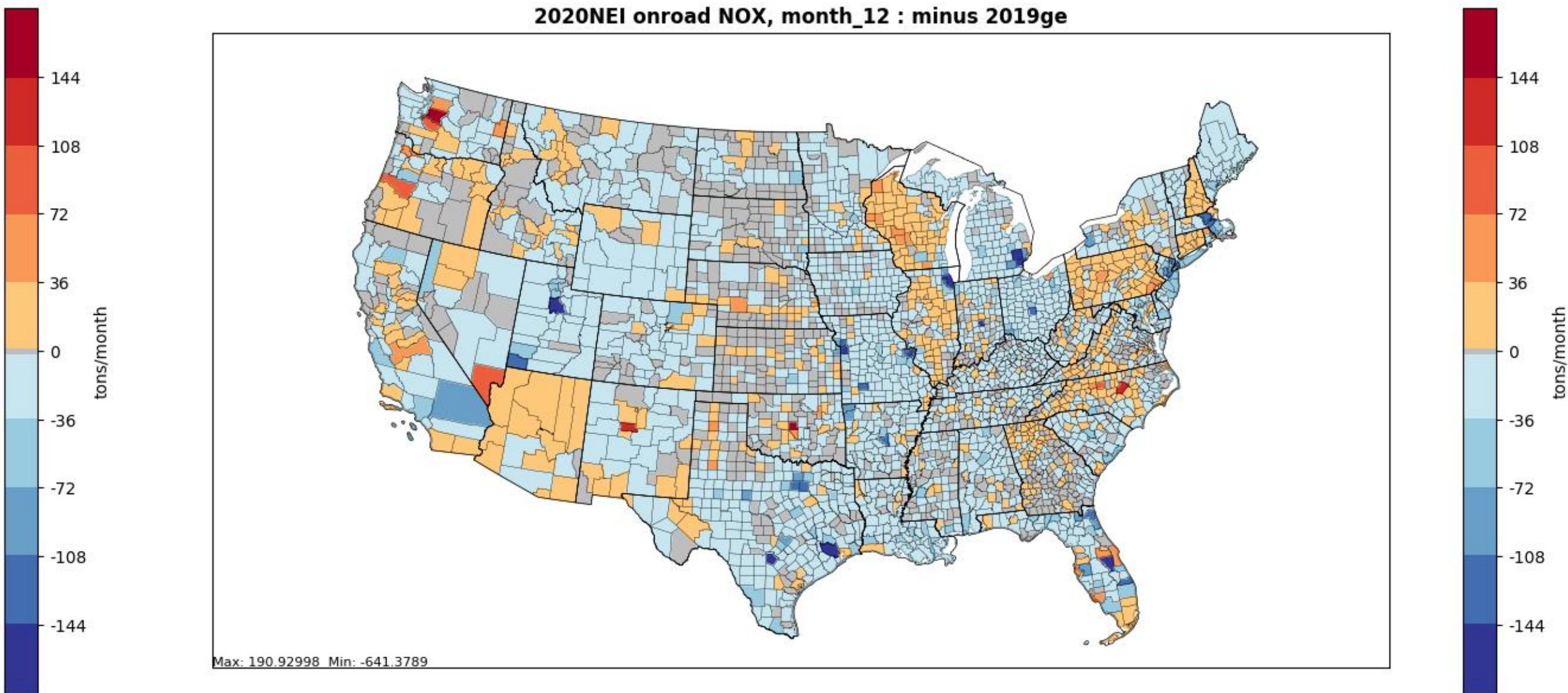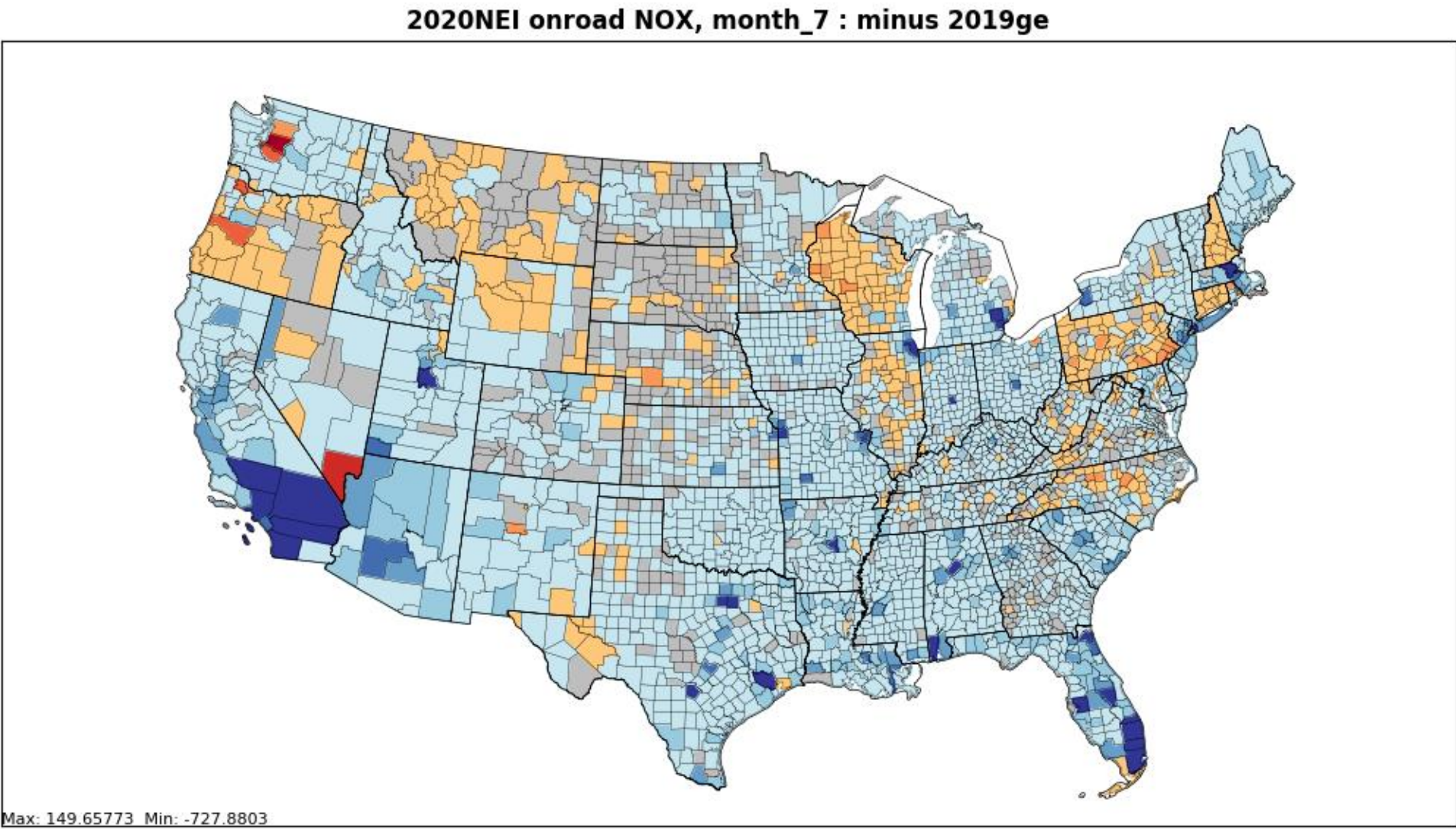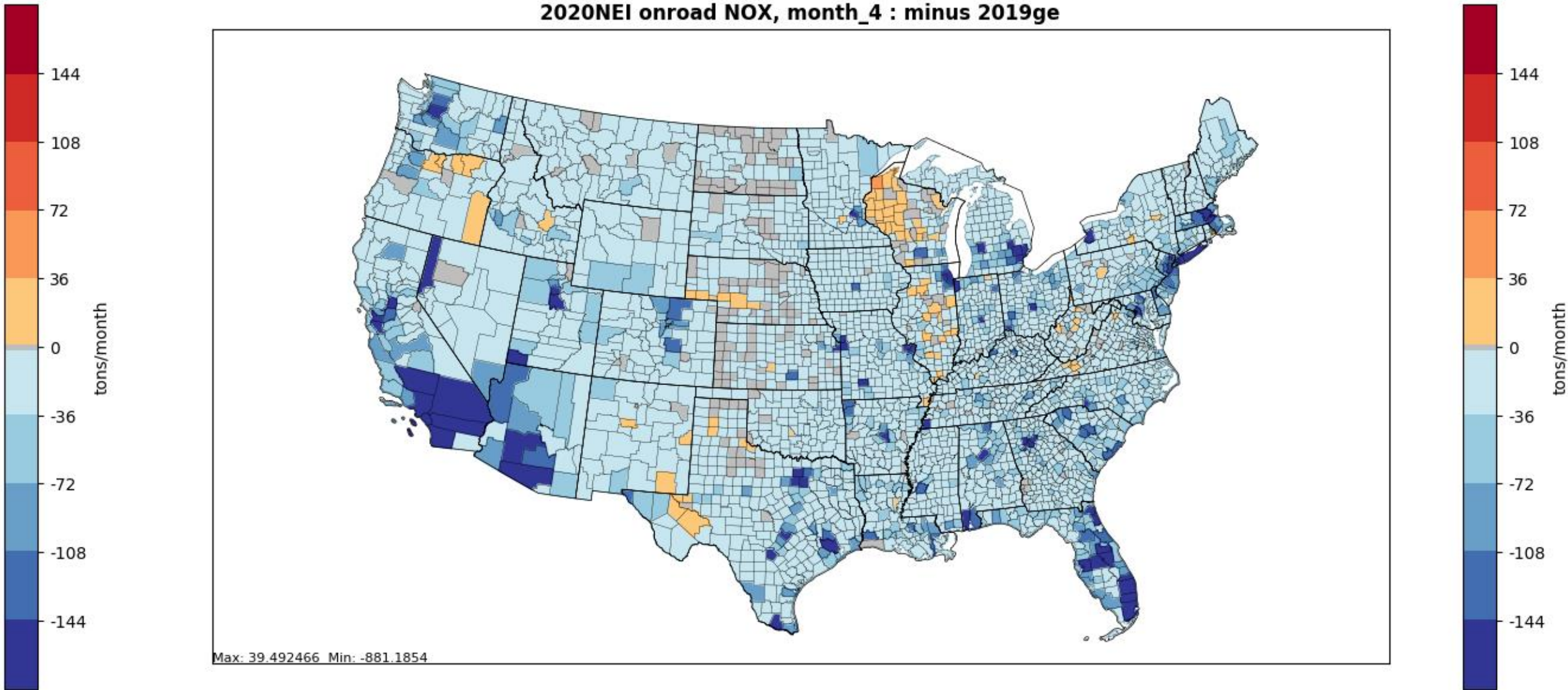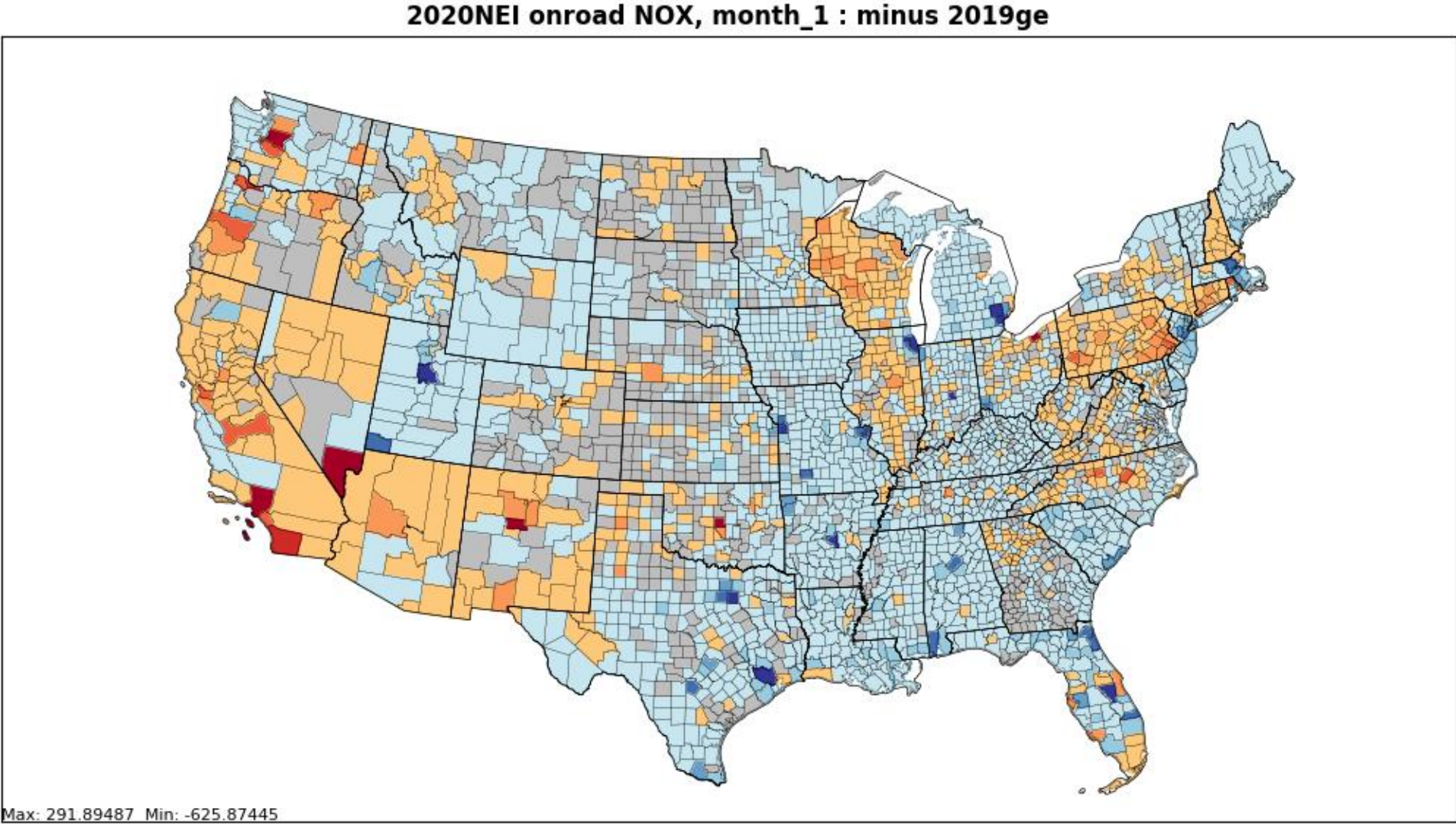
2020NEI Onroad Monthly Emissions

2020 vs 2019 emissions % change: Light Duty
NOX LD %, VOC LD %, VMT LD %
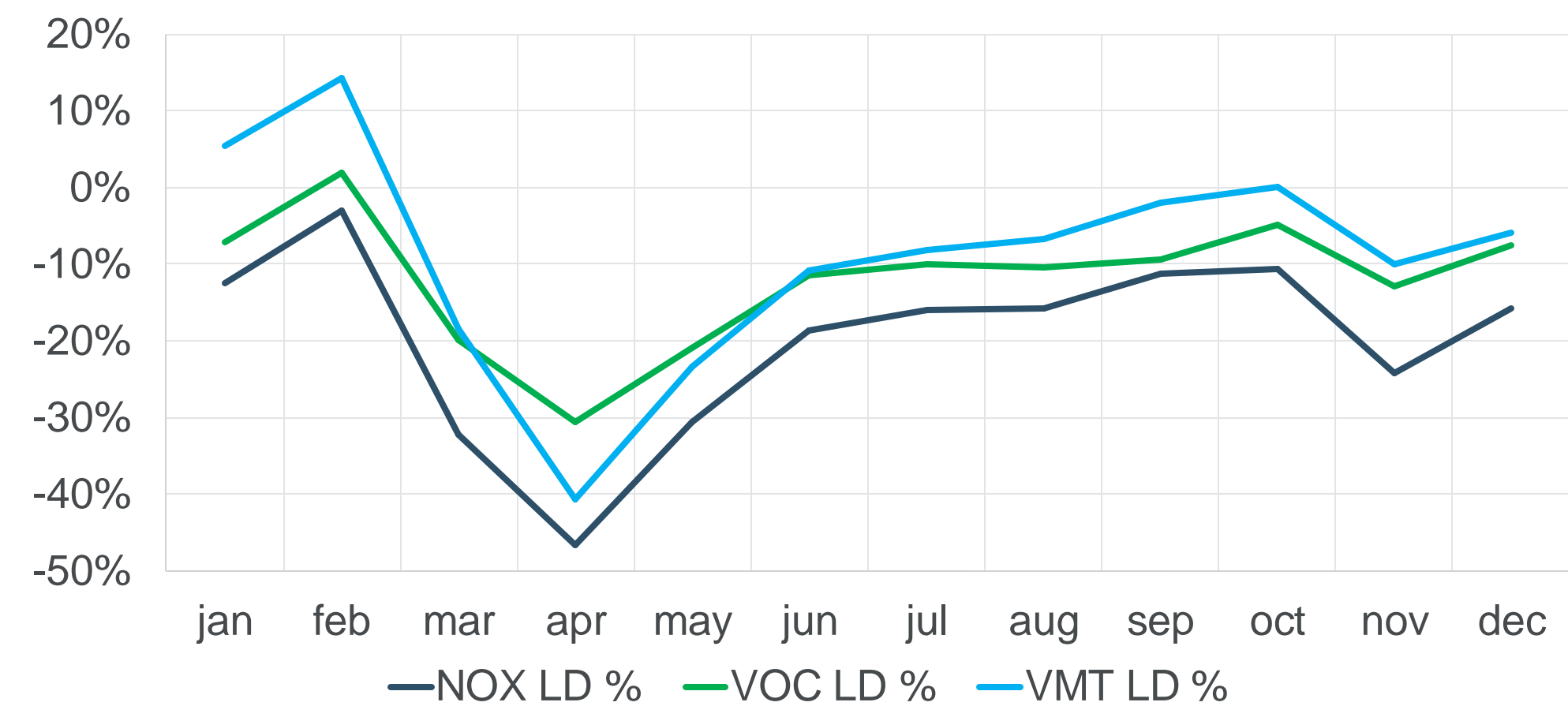
2020 NEI monthly NOx emissions and VMT
NOX 2020 HD, NOX 2020 LD, VMT 2020 HD, VMT 2020 LD
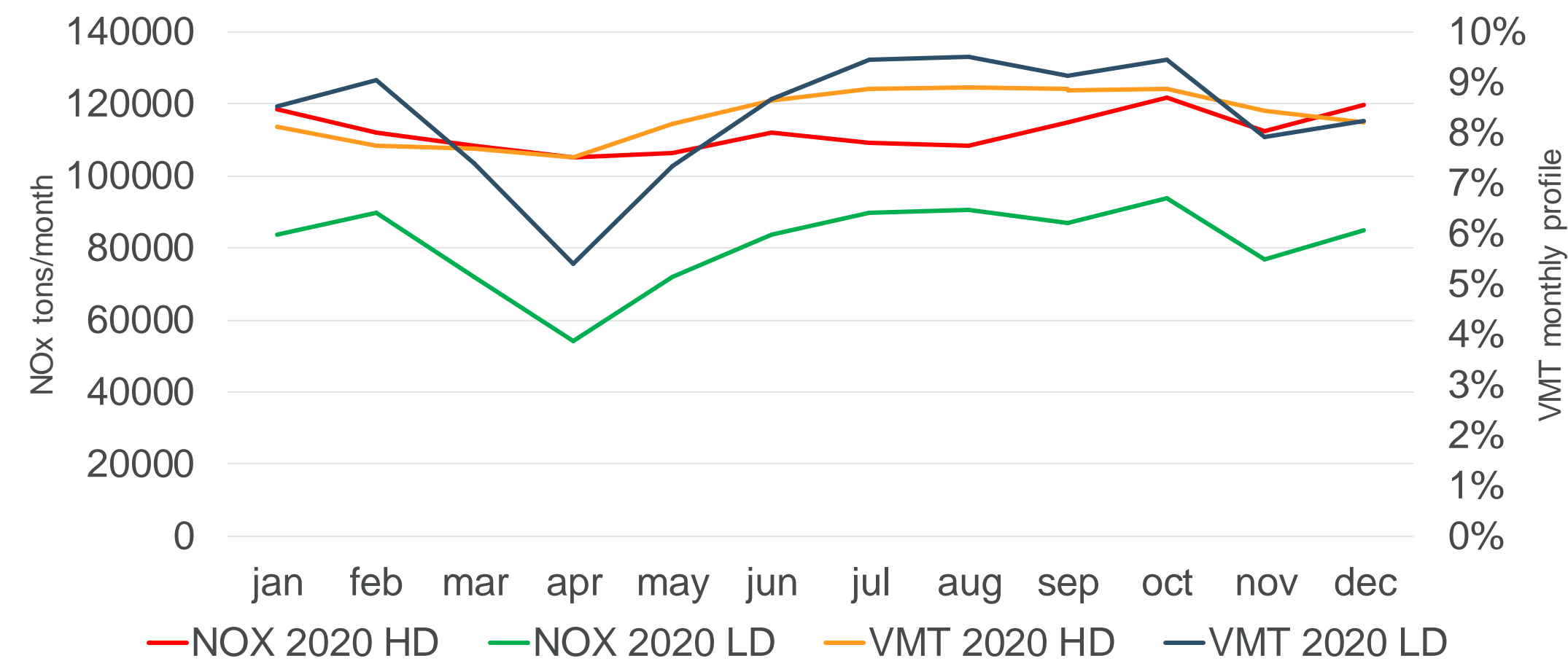
2020 vs 2019 emissions % change: Heavy Duty
NOX HD %, VOC HD %, VMT HD %
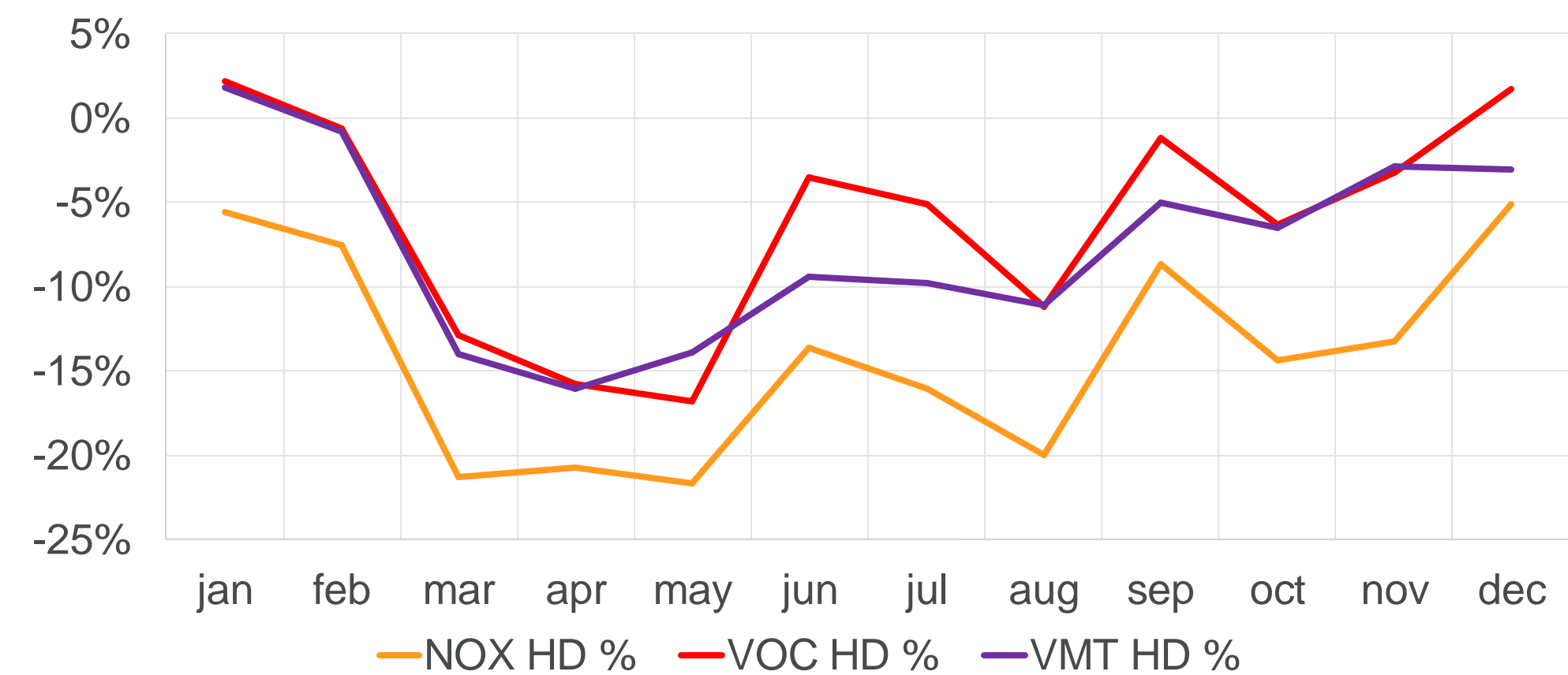
2020 NEI monthly VOC emissions and VMT
VOC 2020 HD, VOC 2020 LD, VMT 2020 HD, VMT 2020 LD
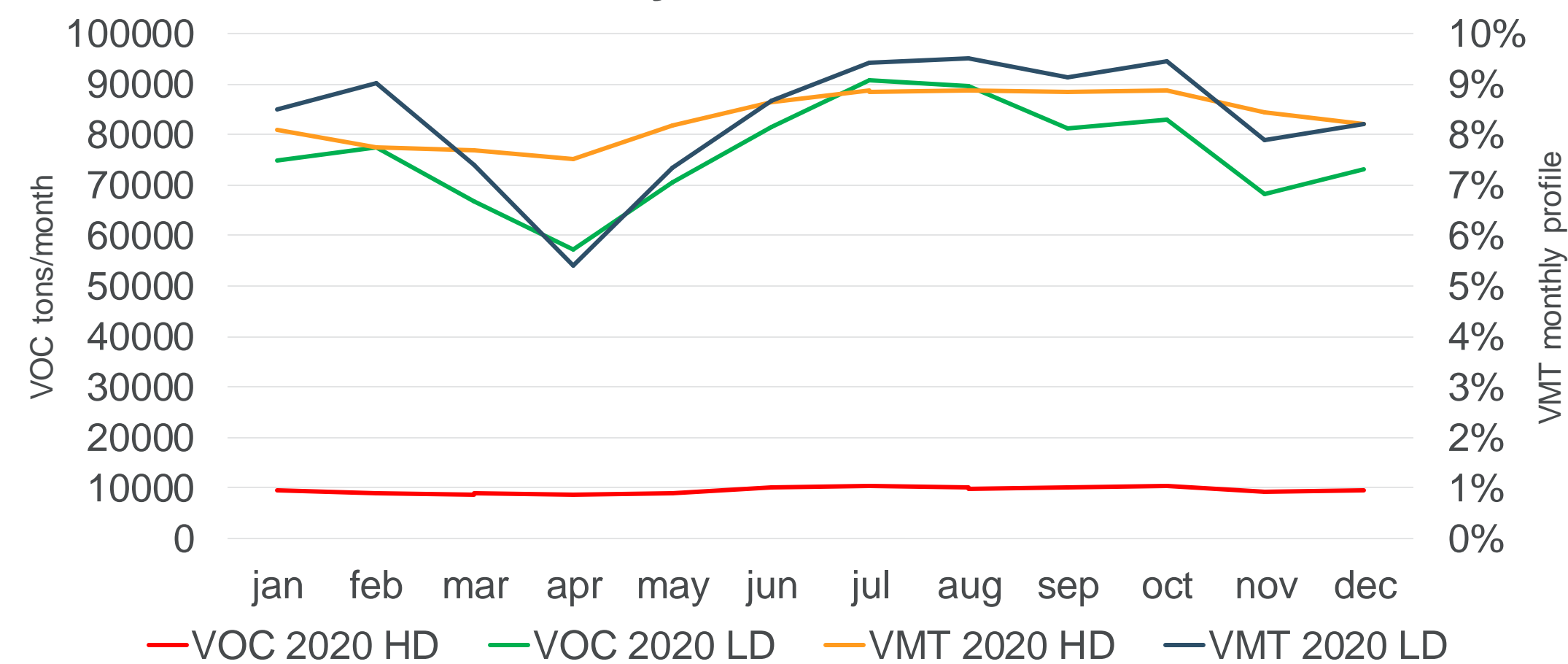
Trends on Onroad Emissions 2011-2020

NOx annual onroad emissions

light duty —— heavy duty

VOC annual onroad emissions

light duty —— heavy duty
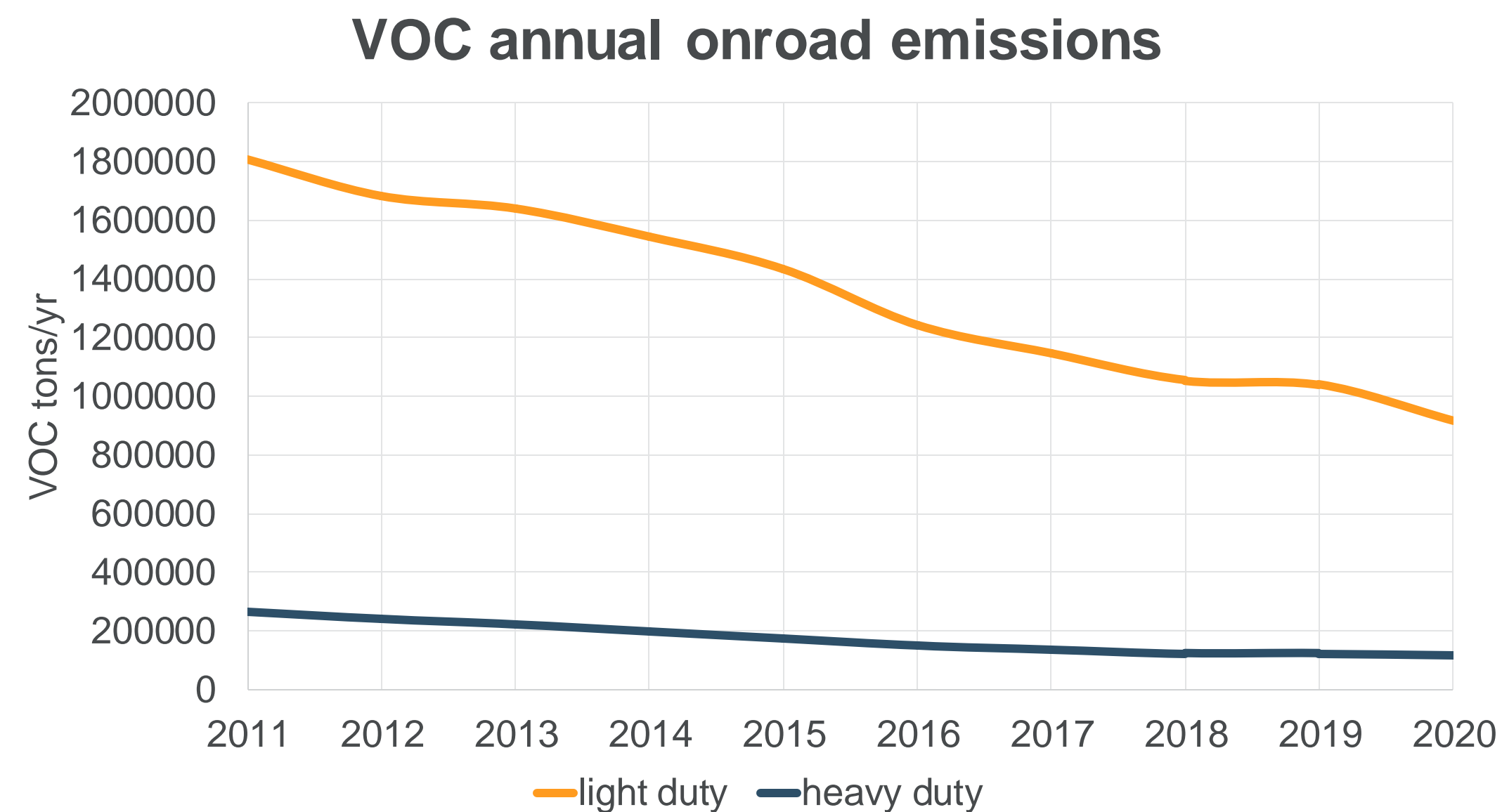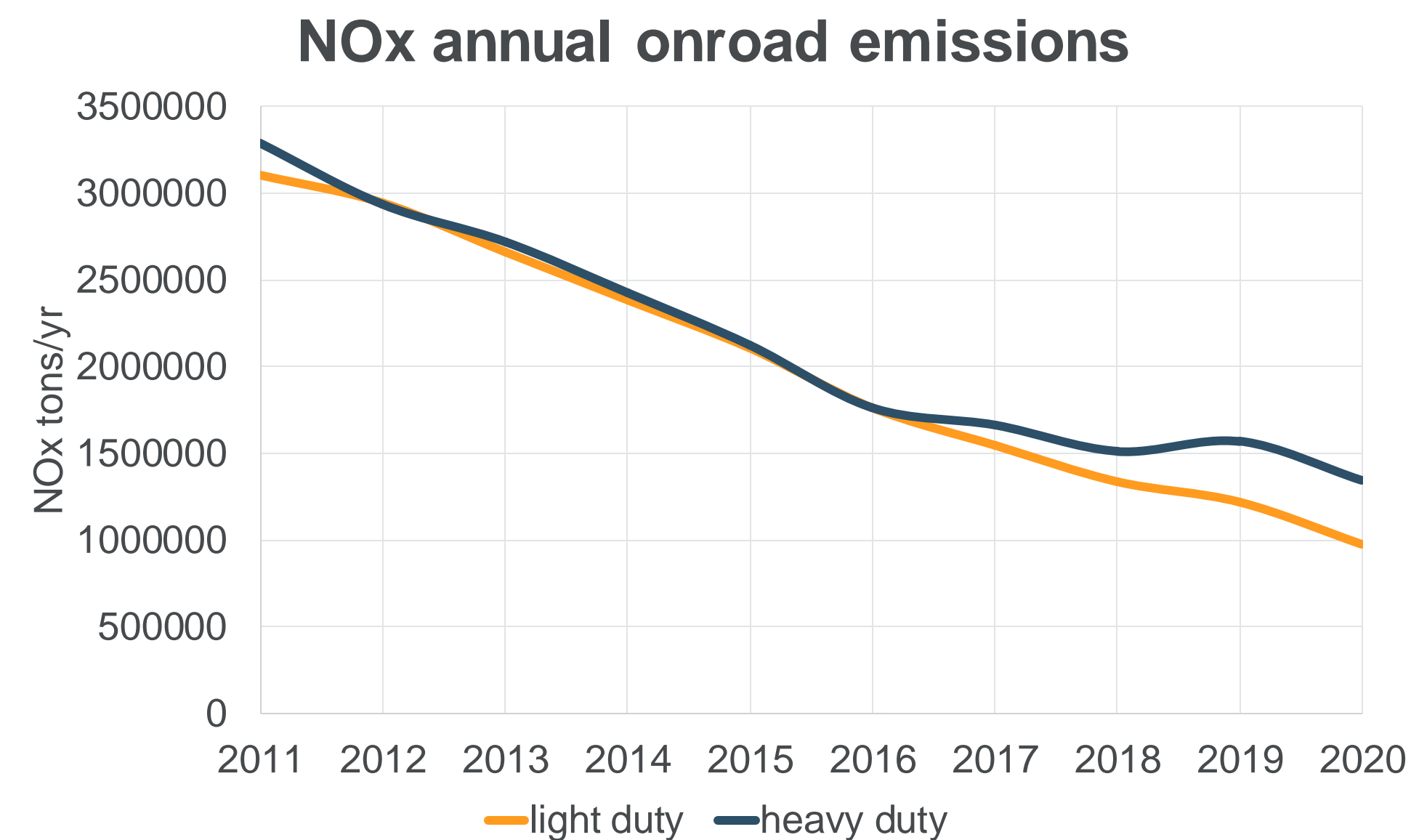
Total emissions change from year to year

	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20
NOx LD	-5%	-10%	-10%	-12%	-16%	-12%	-13%	-9%	-20%
NOx HD	-11%	-7%	-11%	-12%	-17%	-6%	-9%	+4%	-14%
VOC LD	-7%	-2%	-6%	-7%	-14%	-8%	-8%	-1%	-12%
VOC HD	-9%	-7%	-11%	-13%	-14%	-8%	-10%	0%	-6%

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Conclusions

- The pandemic presented unique challenges for modeling onroad vehicle emissions in 2020

- Monthly patterns of driving activity (e.g. lower VMT in the months following the onset of the pandemic) were very important and differed from prior years

- The use of telematics data was important to resolve temporal differences for 2020 vs other years

- The pandemic effects were far more pronounced in April than in other months

- State submissions to MOVES are always important for evaluating NEIs; 2020 is no exception

- Year-to-year emissions decrease generally higher than in prior years due to the pandemic effects

- Electric vehicles don't matter too much yet, but they will!

- Applications for modeling 2021 and beyond?