Development of a 2017 Emissions Modeling Platform

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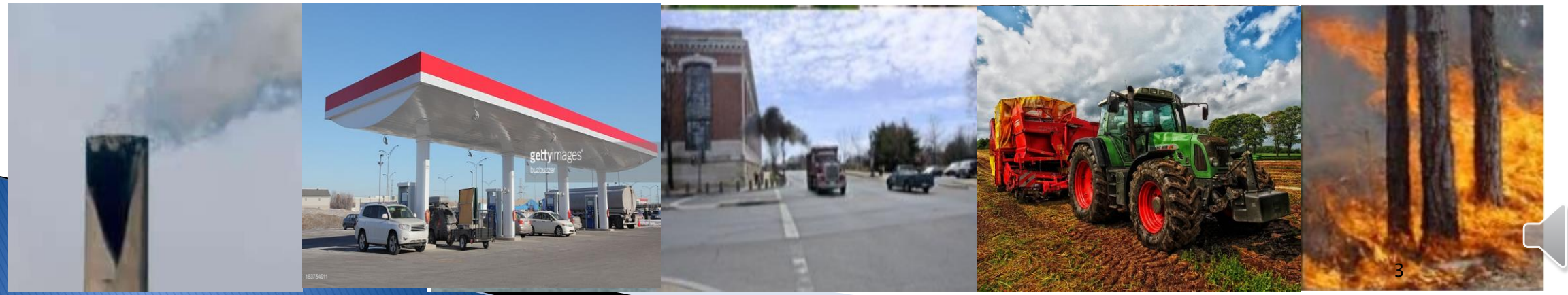
Origins of the 2017 Modeling Platform

- Purpose
  - Support modeling done collaboratively with the Centers for Disease Control and Prevention (CDC) each year for the past 15 years
    - Fused air quality surface data using downscaling files on EPA's RSIG site
    - CDC National Environmental Public Heath Tracking Indicators and Data
  - Facilitate air quality modeling related to intensive measurement studies that occurred during 2017 (e.g., Lake Michigan Ozone Study)
  - Review air quality model performance for the year 2017

- Emission Inventories
  - The platform is based on the 2017 National Emissions Inventory which was released in spring, 2020
    - https://www.epa.gov/air-emissions-inventories/2017-national-emissions-inventory-nei-data
  - A full NEI is developed every three years but large point sources are updated every year

The National Emissions Inventory (NEI)

- Data are submitted by states, locals, tribes (S/L/T) and by EPA into the Emissions Inventory System (EIS)
- Five NEI data categories – all include annual total emissions except events
  - Point (and Facility) Inventory (lat-lon locations): EGUs, point oil and gas sources, commercial and industrial facilities, airports, rail yards
  - Nonpoint (county-based): fugitive dust, agricultural, residential, gas stations, fuel combustion, nonpoint oil & gas, residential wood combustion (RWC), agricultural fires, commercial marine vessels (CMV), locomotives, biogenic
  - Onroad mobile sources (county): cars and trucks driving on roads
  - Nonroad mobile sources (county): mobile sources not on roads including recreational marine vessels, construction equipment, lawn/garden equipment, tractors
  - Events (lat-lon, day): wildland and prescribed fires



Emissions and Method Updates in the 2017 NEI

- A full triennial NEI was developed for the year 2017
  - Based on 2017-specific data received from state, local, and tribal agencies coupled with EPA-developed data specific to 2017
- Point source emissions represent actual 2017 values
  - Process was improved for augmenting hazardous air pollutants (HAPs)
- Fire emissions estimates were improved
  - 2017-specific fire location and duration data used
  - VOC estimation improved for wild and prescribed fires consuming duff-fuels
  - Grass and pasture fires are now in day-specific events data category instead of nonpoint
  - VOC and HAP emission factors were improved for agricultural fires (nonpoint)
- Methods and updates for other categories on following slides

2017 NEI Mobile Source Emissions Development Methods

- Emissions from aircraft and ground support equipment at airports are now based on Federal Aviation Administration (FAA)'s Aviation Environmental Design Tool (AEDT)
- Commercial Marine Vessel (CMV) emissions developed using a bottom-up approach based on Automated Identification System (AIS) data
- Locomotive and rail yard emissions developed by Collaborative group
- Onroad emissions based on MOVES2014b with state/local (S/L) input submissions
  - Use 2017-specific data (e.g., vehicle miles traveled, vehicle populations, and age distributions) from states and from Coordinating Research Council (CRC) A-115 project
  - Speeds and temporal profiles from CRC A-100 where S/L submissions not sufficient
  - Tribes provided some onroad emissions but they are not used in the modeling platform
- Nonroad emissions are based on MOVES2014b
  - Includes improved equipment populations via updates to population growth estimates
  - Spatial allocation improvements from 2016v1 for ag. and construction equipment applied

2017 NEI Nonpoint Improvements

- Input templates are now used for many nonpoint sectors
  - EPA now supports SLTs providing inputs rather than emissions
  - Increases consistency in the methods used to compute the emissions
- 2017-specific activity data used for all nonpoint emission categories
- Updated the activity data source for commercial cooking emissions
- Residential fuel combustion updated with new default fuel sulfur content and updated consumption data
- Agricultural tilling assumptions were updated
- Land clearing debris emissions now based only on rural portions of counties
- Industrial and Commercial/Institutional (ICI) fuel combustion methods updated
- Residential wood combustion activity data updated based on national survey and local data
- Livestock animal counts were updated
- Fertilizer emissions computed using improved version of CMAQ and related inputs
- Road dust emissions estimates used improved quantification of paved vs unpaved roads
- Oil and gas emissions calculation approaches were improved and new processes reflected
- Biogenic emissions were computed based on a new land cover database

2017 Emissions Modeling Platform Updates

- Mexico nonpoint and point emissions updated to 2016
- Spatial Surrogates updated to 2017
  - Surrogate grids for 12km and 4km cover the extent of the 36US3 grid
  - County changes for 2017 NEI incorporated
    - (e.g., Oglala Lakota in SD)
  - 2017-specific oil and gas surrogates
  - CMAS Center soon to release updated PostgreSQL-based version of the Surrogate Tool
- Sparse Matrix Operator Kernel Emissions (SMOKE)
  - CMAS Center released SMOKE version 4.8 on October 15, 2020
  - Includes updates to onroad and biogenic processing, plume rise, speciation-related reports, source apportionment tools, and AERMOD interface programs

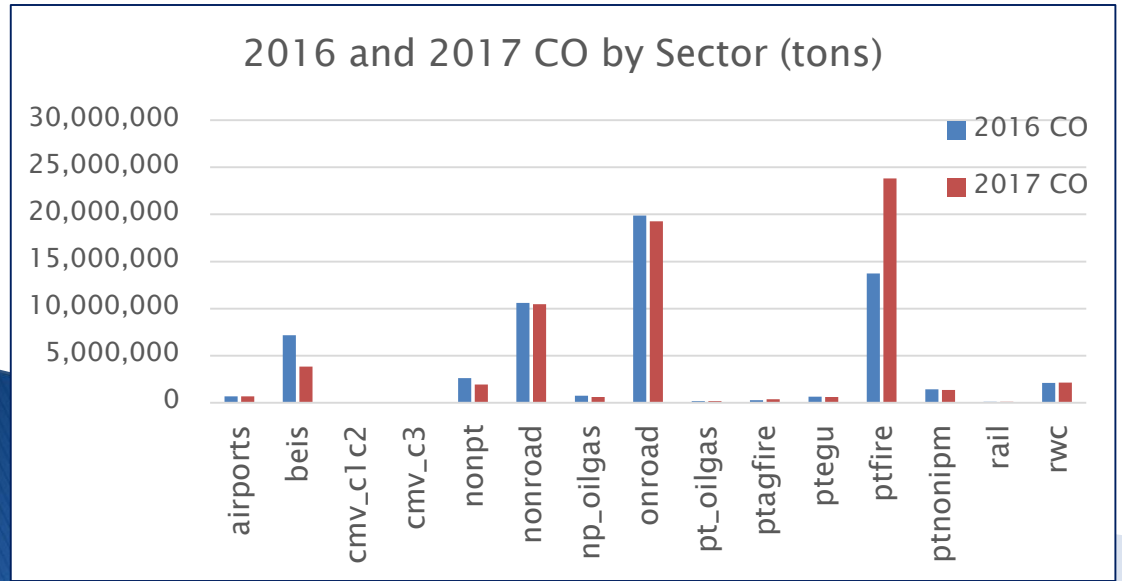
2017 Platform Speciation Updates

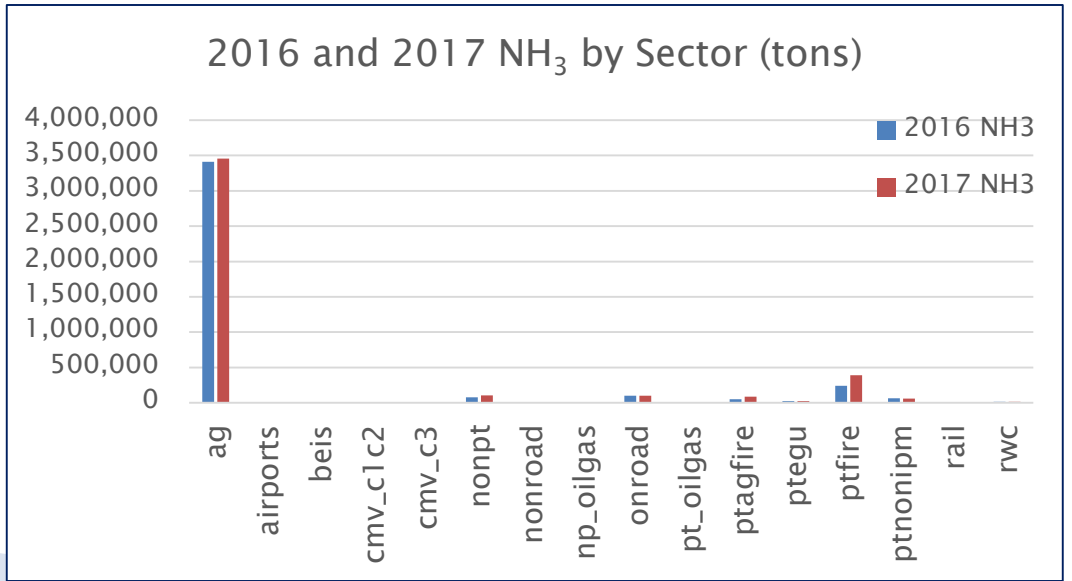
- Incorporated profiles from SPECIATE 5.0 and a few from SPECIATE 5.1 (GSPRO updates)
  - WY county-specific Oil and Gas
  - Updated California Air Resources Board consumer and commercial products (TOG)
  - Sugar Cane Burning (TOG)
  - Diesel Evap composite (TOG)
  - WY and UT produced water pond profiles for some point sources
  - New CMV profile that combines NEI HAP/VOC ratios for chemical mechanism HAPs (e.g., naphthalene, benzene, acetaldehyde, formaldehyde) with MOVES diesel nonroad profile
  - Gap filled updated rice and wheat straw burning (TOG)
  - Updates made for the 2016 platform were used also for 2017 (e.g., corrected fires PM2.5 profile)
- Updated speciation cross reference data (GSREF updates)
  - Year-specific oil and gas combination profiles based on the Oil and Gas Tool estimates of VOC from flares and from the process not controlled by the flare
  - Oil and gas miscellaneous engines
  - Corrections to several VOC assignments
- Speciation Tool 5.0 was released by the CMAS Center October 1, 2020
  - Update CB6 mechanism mapping to CB6r3_ae7- see Speciation Tool 5.0 User's Guide, Table 1
  - Accounts for vapor pressure and results in mapping some species to IVOC, AACD, FACD, and APIN

National and Sector changes in Emissions 2016 to 2017

Pollutant	2016fh* (tons)	2017gb* (tons)	2017-2016 (tons)	2017-2016 (%)
CO	53,053,119	61,565,002	8,511,883	16%
NH_3	3,989,136	4,239,722	250,586	6%
NO_x	9,880,090	9,646,266	-233,824	-2%
PM_{10}	10,321,339	10,613,193	291,853	3%
$PM_{2.5}$	3,713,836	4,392,588	678,752	18%
SO_2	2,569,647	2,468,645	-101,002	-4%
VOC	14,188,893	16,038,825	1,849,933	13%

** National emission totals are for the contiguous U.S. and do not include biogenic emissions*

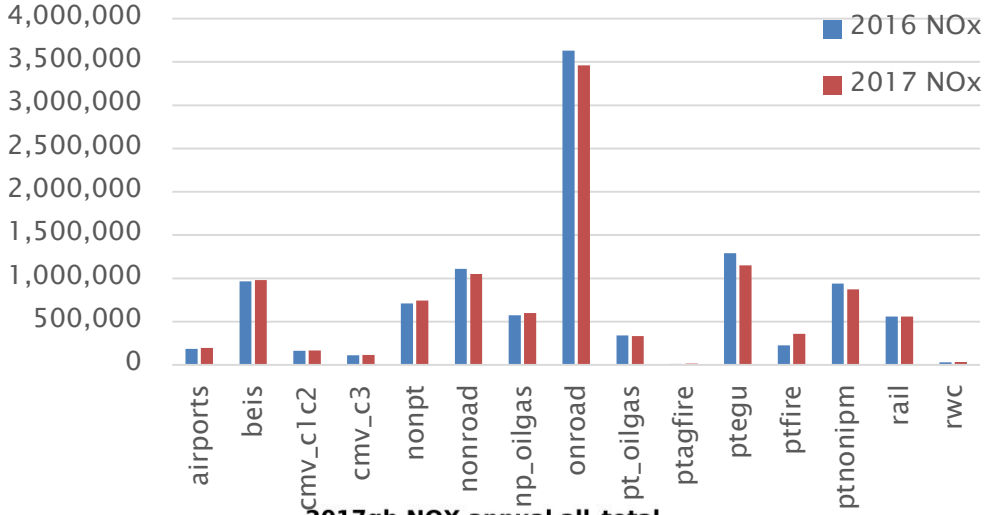


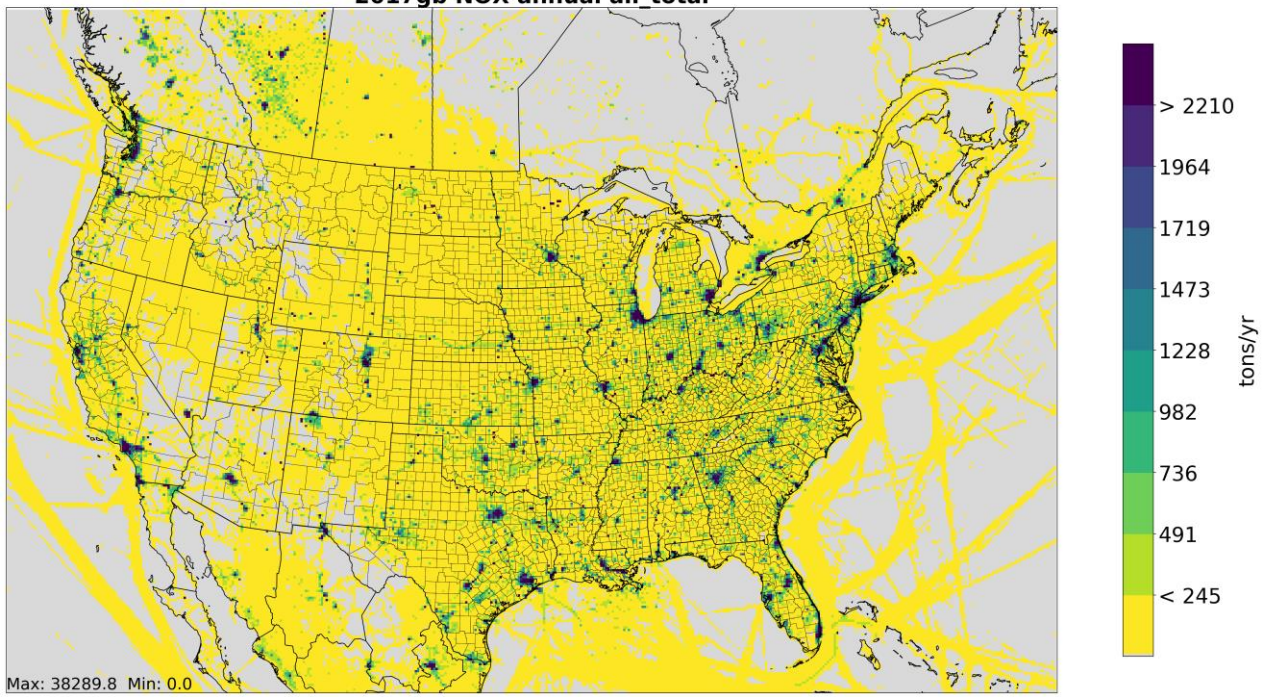


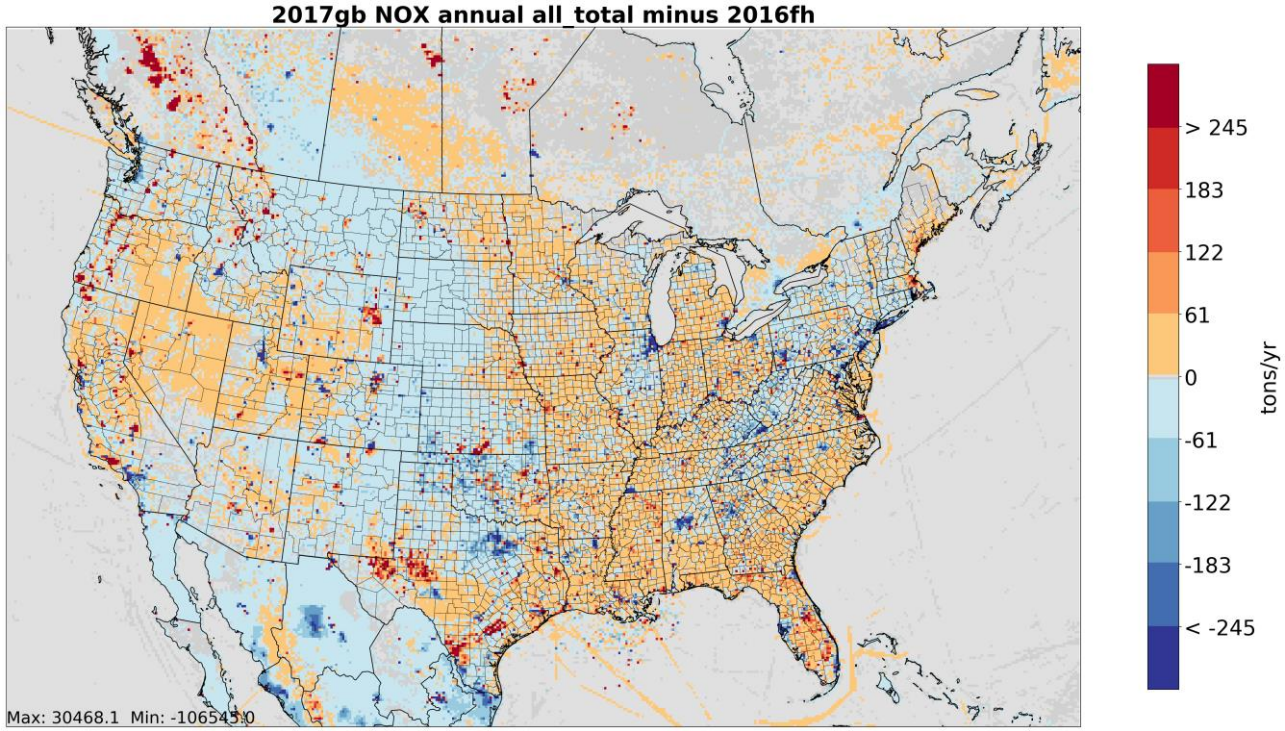
Maps of Emission changes in 2017

- Gridded emissions maps developed of total emissions and by each *emissions modeling sector* for U.S. emissions listed below
  - **afdust** = area fugitive dust; **ag** = agricultural; **airports** = aircraft + ground support; **beis** = biogenic; **cmv_c1c2** = category 1 and 2 (small-medium) commercial marine vessels (CMV); **cmv_c3** = category 3 (large) CMV; **nonpt** = other nonpoint; **nonroad** = mobile not on roads; **onroad** = mobile on roadways; **np_oilgas** and **pt_oilgas** = nonpoint and point oil and gas; **ptagfire** = agricultural fires as points; **ptegu** = electric generating units; **ptfire** = wildland and prescribed fires; **ptnonipm** = non-EGU point; **rail** = line haul locomotives; **rwc** = residential wood combustion (RWC)
  - 2017 emissions are compared to the 2016v1 platform (case name=2016fh)
- County-level comparison maps were developed for some sectors with emissions values compared to 2016 and 2014
- Some maps are shown in this presentation, but additional maps are available from ftp://newftp.epa.gov/air/emismod/2017/maps/

Total NO_x and Changes from 2016

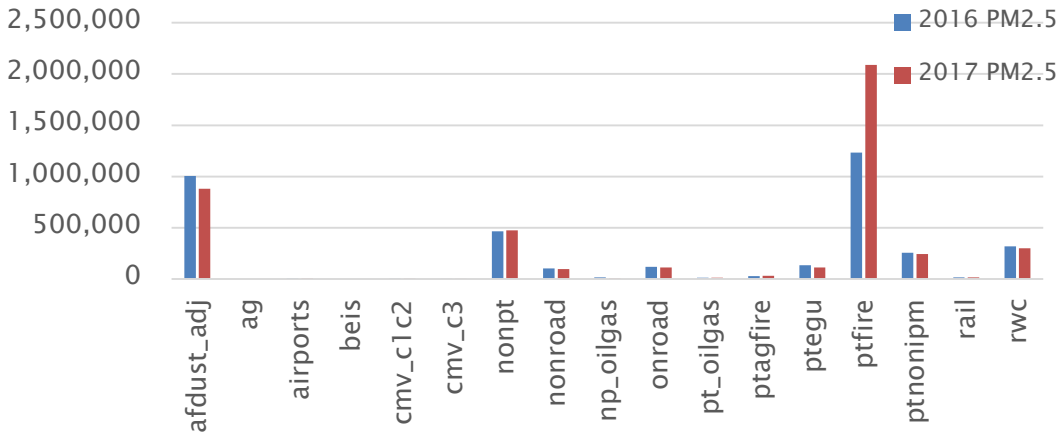


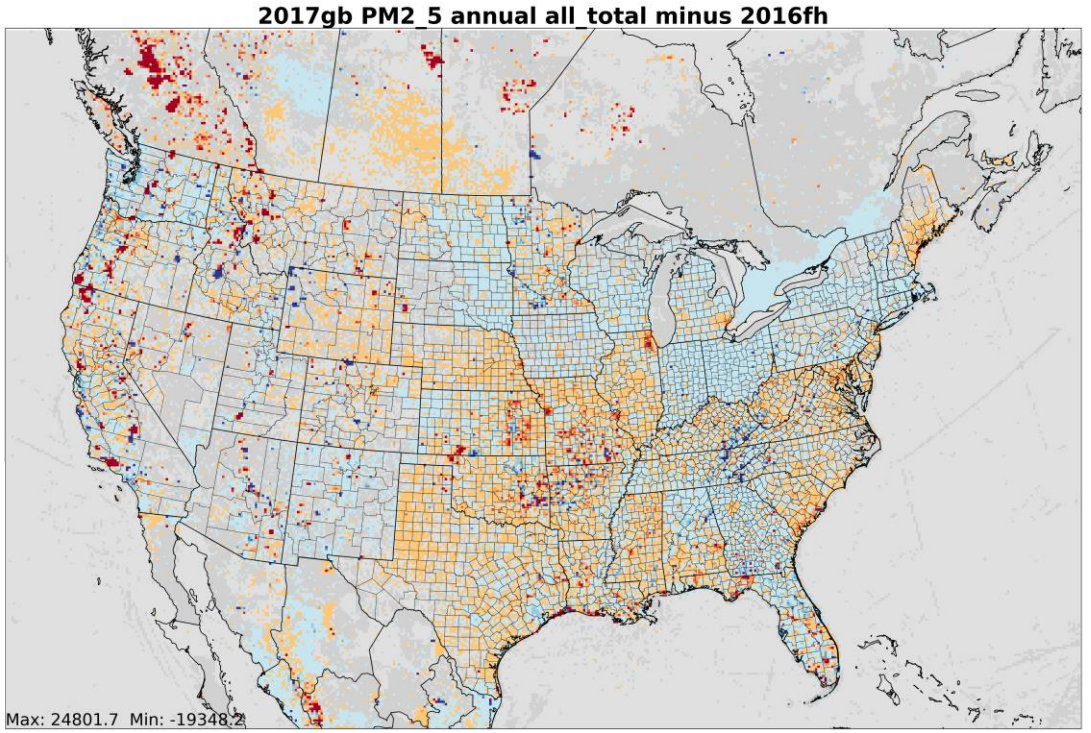


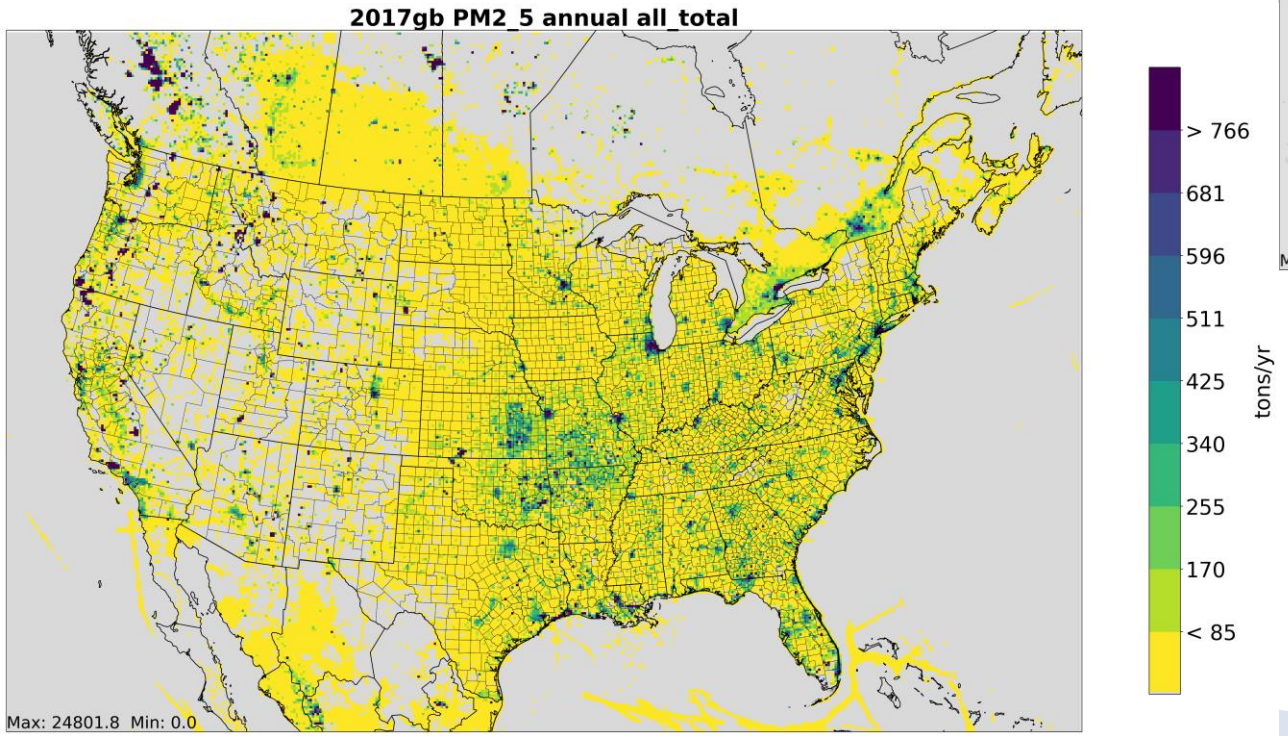


NO_x emissions are primarily from onroad, EGU (ptegu), nonroad, non-EGU point, biogenic (beis) and locomotive emissions. Many sectors decreased in 2017, but a few sectors such as beis and oil and gas sources increased.

Total $PM_{2.5}$ and Changes from 2016

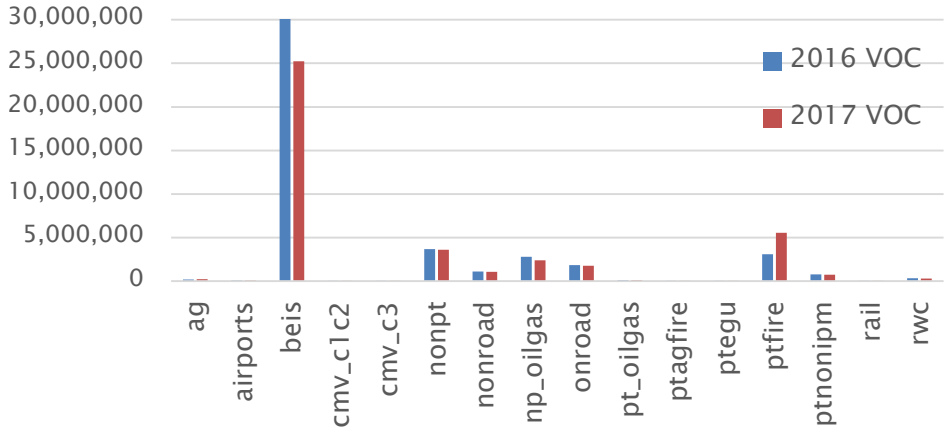


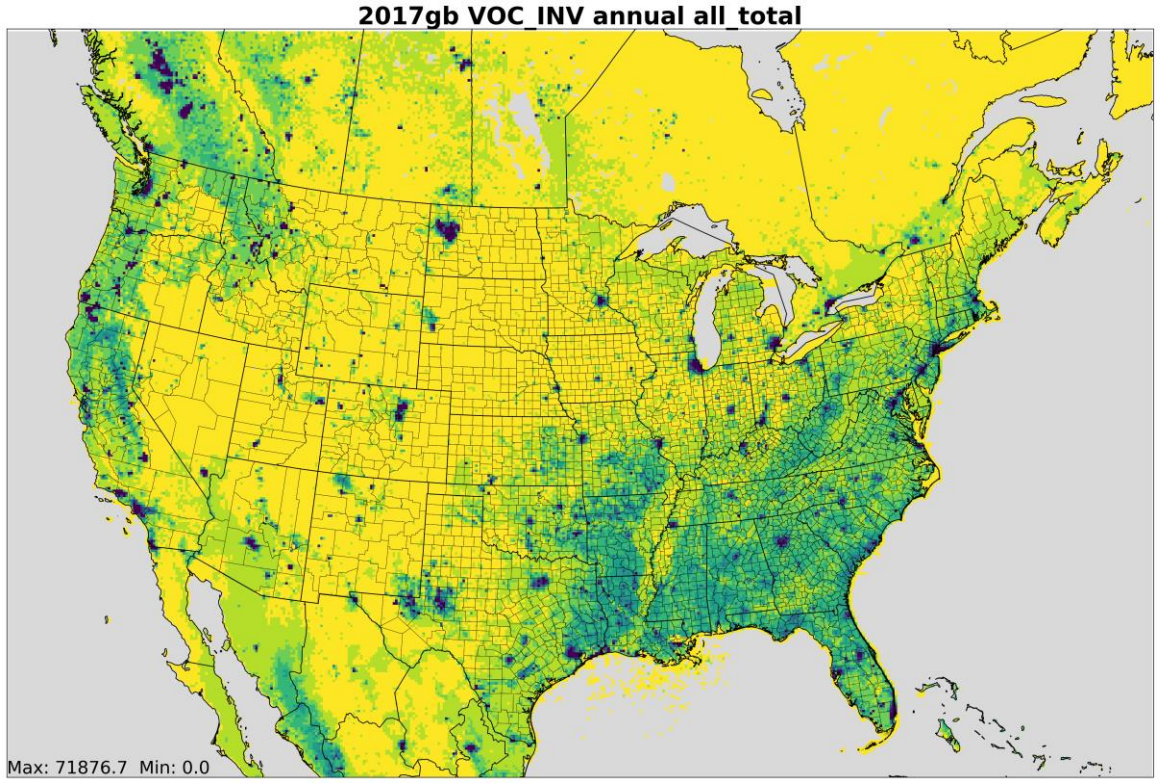


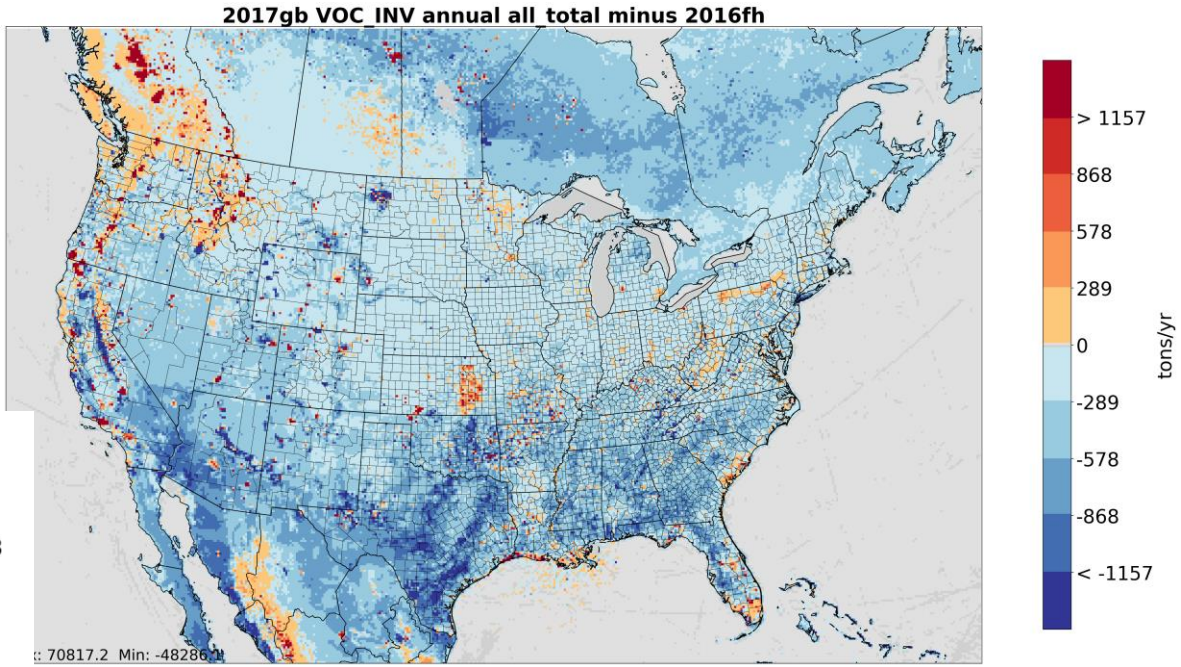


$PM_{2.5}$ emissions are primarily from wildland and prescribed fires (ptfire), fugitive dust (afdust), res. wood combustion (rwc), and other nonpoint (nonpt) sources. Fires, in particular, were higher in 2017 than in 2016.

Total VOC and Changes from 2016







VOC emissions are primarily from biogenic* (beis) and fires, plus nonpoint (nonpt), onroad and nonroad sources. Most of the reductions in 2017 are from biogenic and mobile sources, along with changes from fires and oil and gas.

* 2016 biogenic VOC is over 42M tons; anthropogenic VOC is important to ozone formation in many non-attainment areas

Acknowledgements and Data Availablity

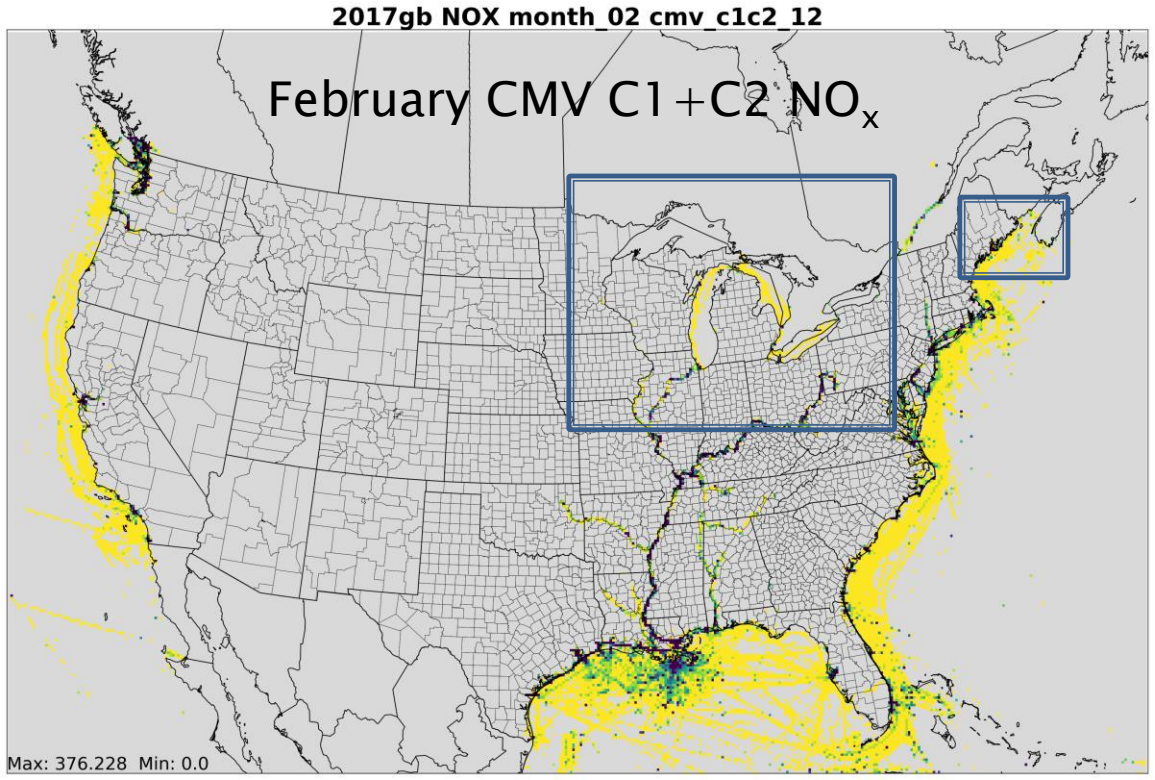
- Development of the 2017 NEI and the associated modeling platform was accomplished by many EPA staff and dozens (if not hundreds) of state, local, and tribal agency staff
- Persons involved in development national NEI emissions data sets not listed as co-authors include:
  - EPA: Michael Aldridge, Jesse Bash, Laurel Driver, Joe Mangino, George Pouliot, Ron Ryan
  - Non-EPA: Mark Janssen (LADCO), Matt Harrell (IL)
- 2017 emissions modeling SMOKE inputs and related data are available from ftp://newftp.epa.gov/air/emismod/2017/
- 2018 point sources: ftp://newftp.epa.gov/air/emismod/2018/
- Contact eyth.alison@epa.gov with questions

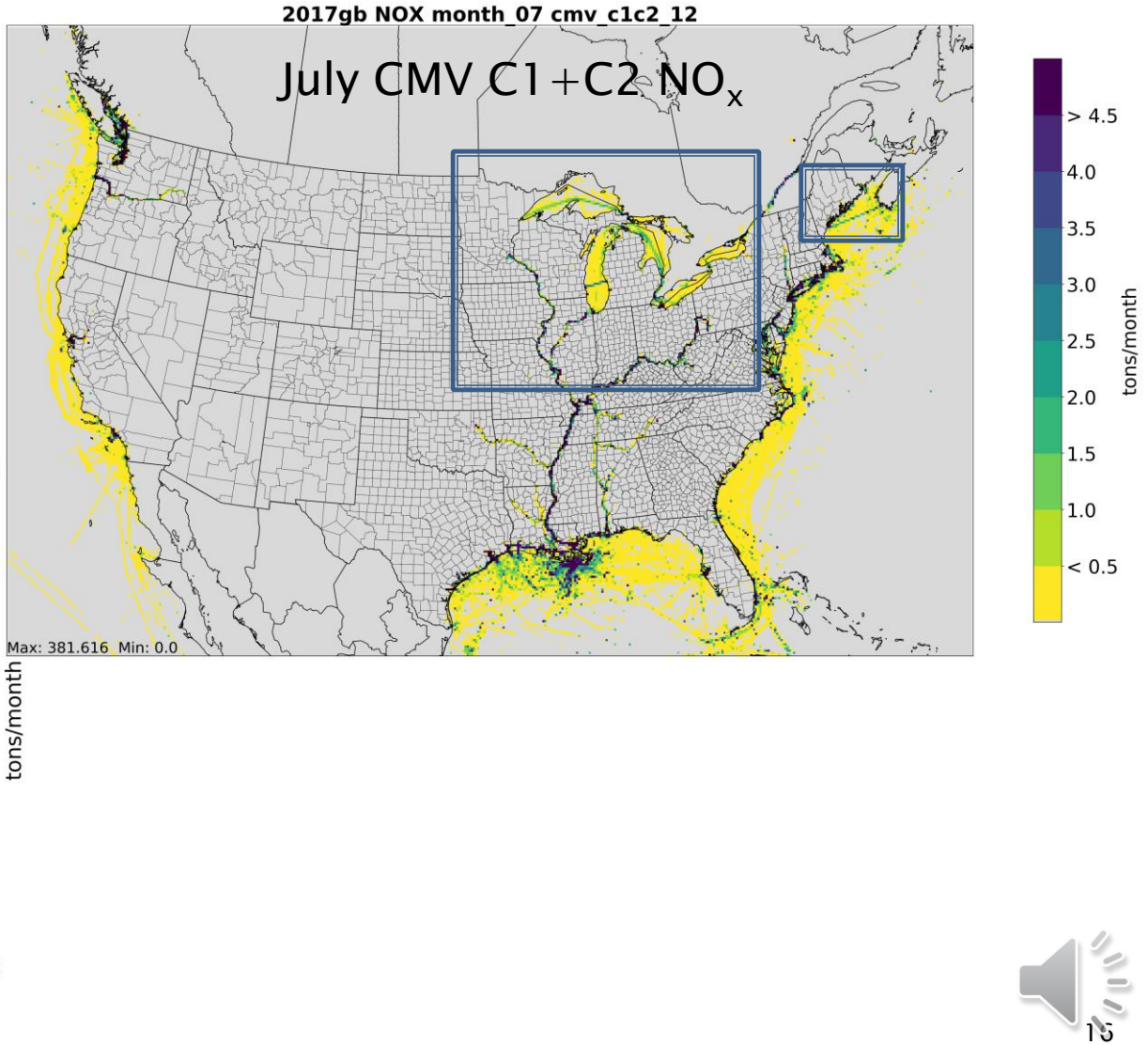
Sector-specific Changes and Maps

CMV Emissions Reflect Changes by Hour and Over Seasons

The CMV inventory is based on five-minute interval data summed up to various temporal resolutions (e.g., hourly for air quality modeling)

The reduced winter traffic in the upper Mississippi, Great Lakes and Maine are noticeable

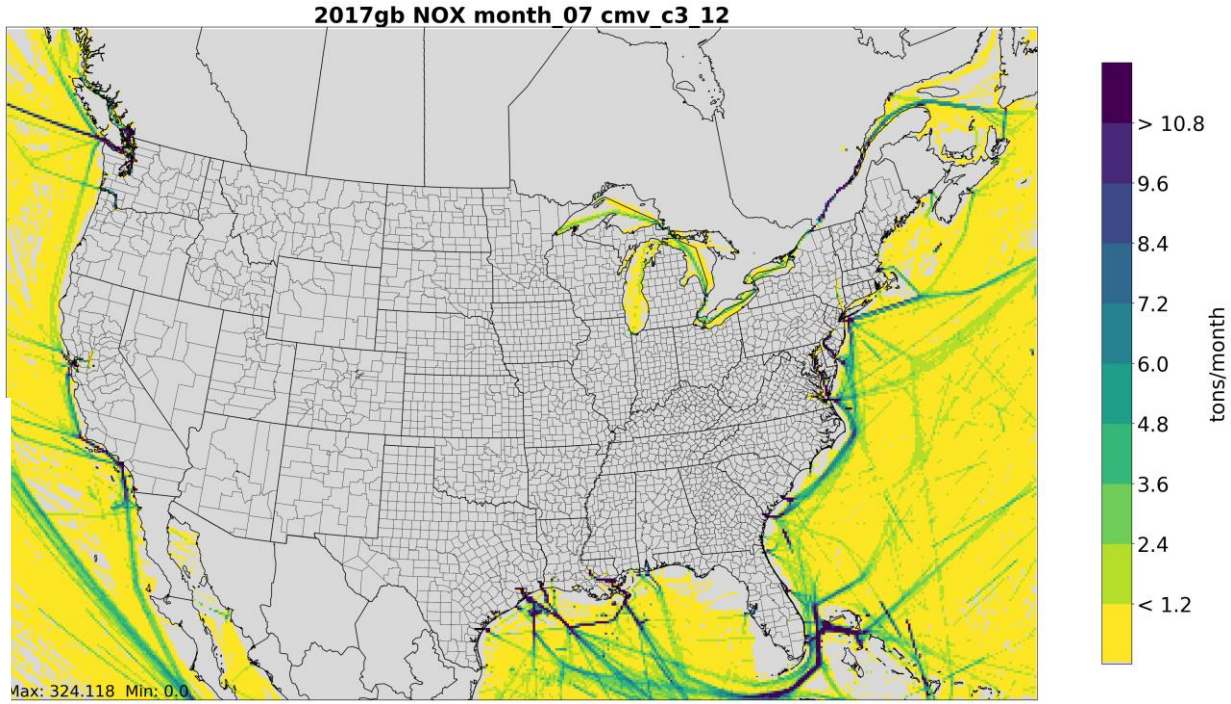


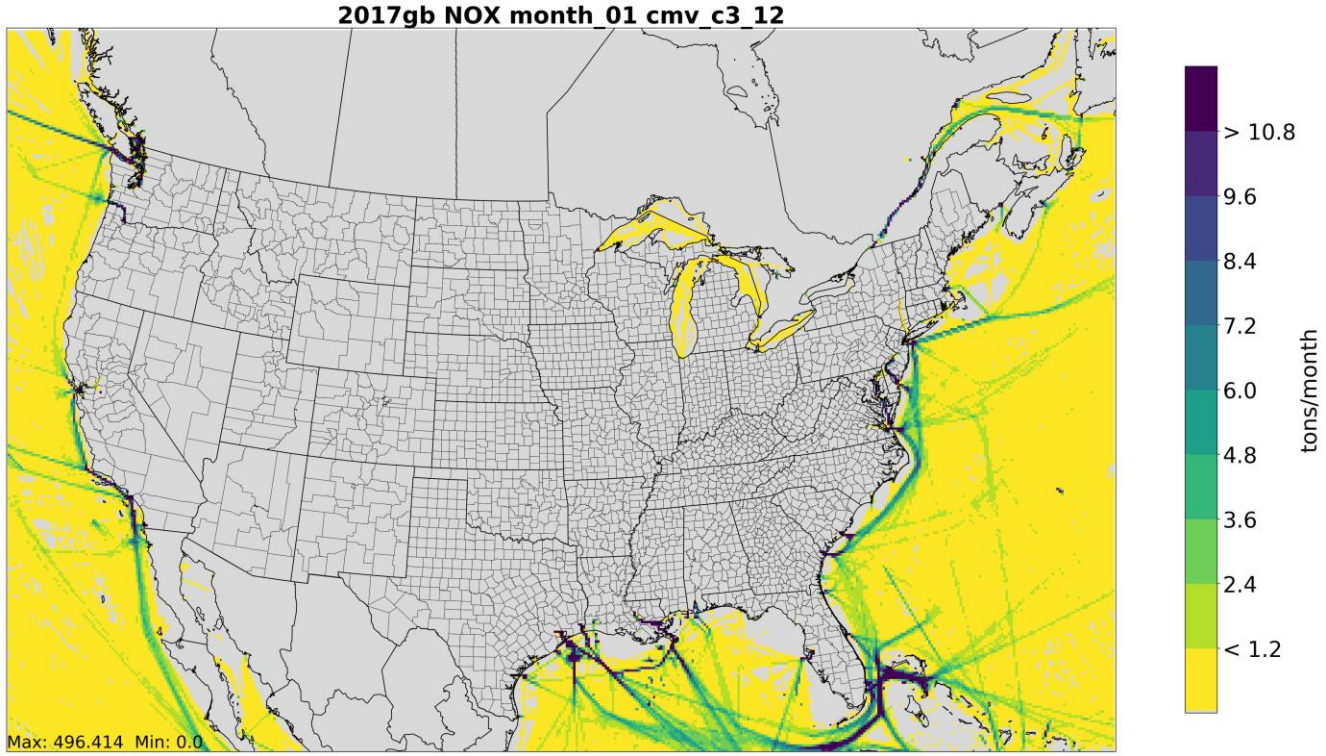


CMV C3 changes by season

There are some seasonal differences for CMV C3 but they are not as notable as those for C1C2.

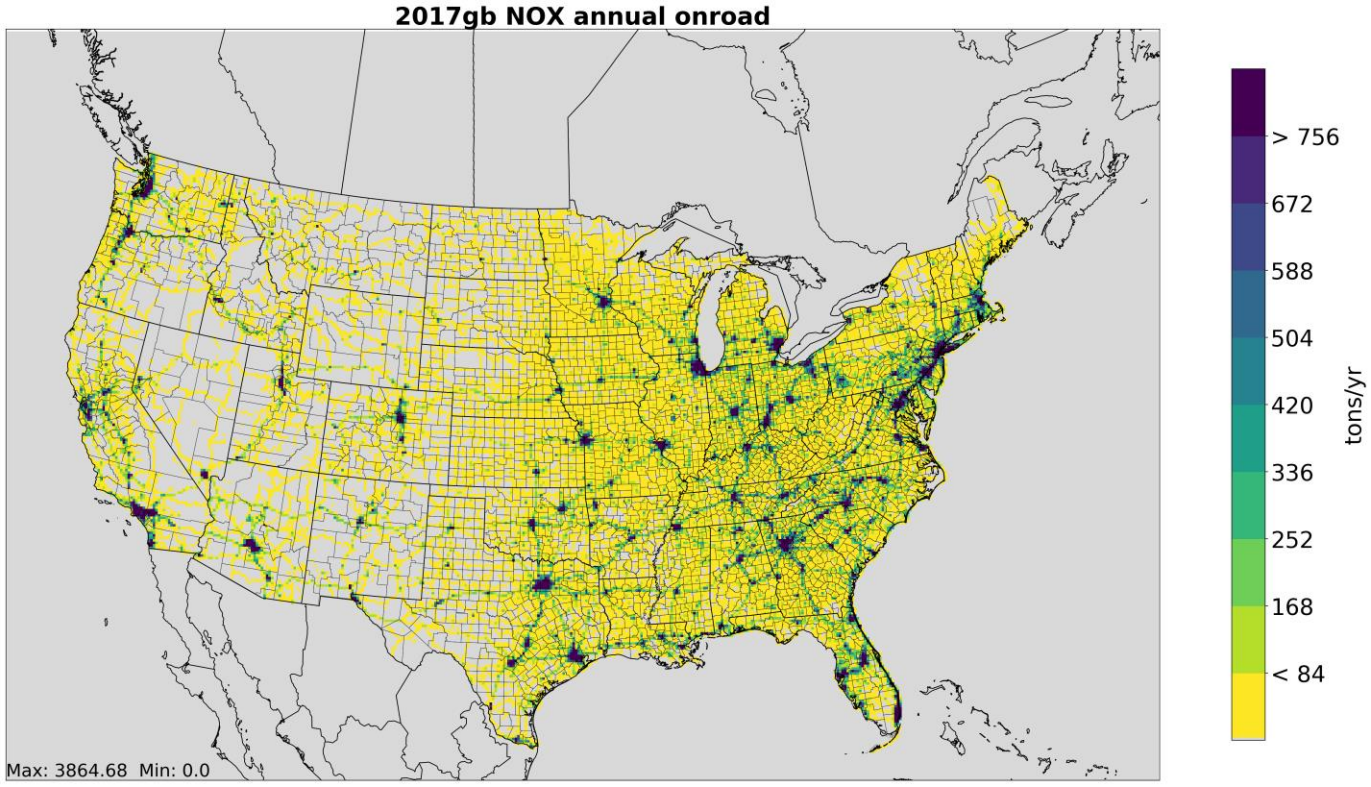
Weekday/weekend and holiday effects were noted.

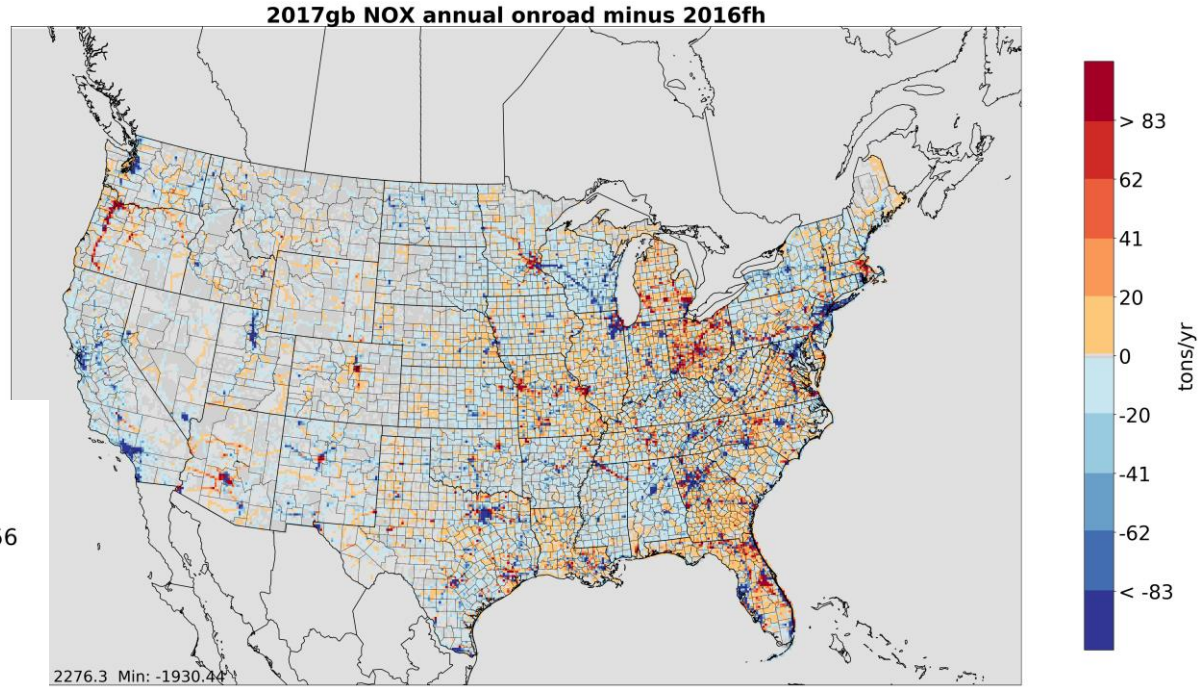




Onroad NO_x and Changes from 2016

A number of onroad inputs changed from 2016 to 2017 including vehicle miles traveled, age distributions, and speeds, causing emissions to go up in some counties and down in others

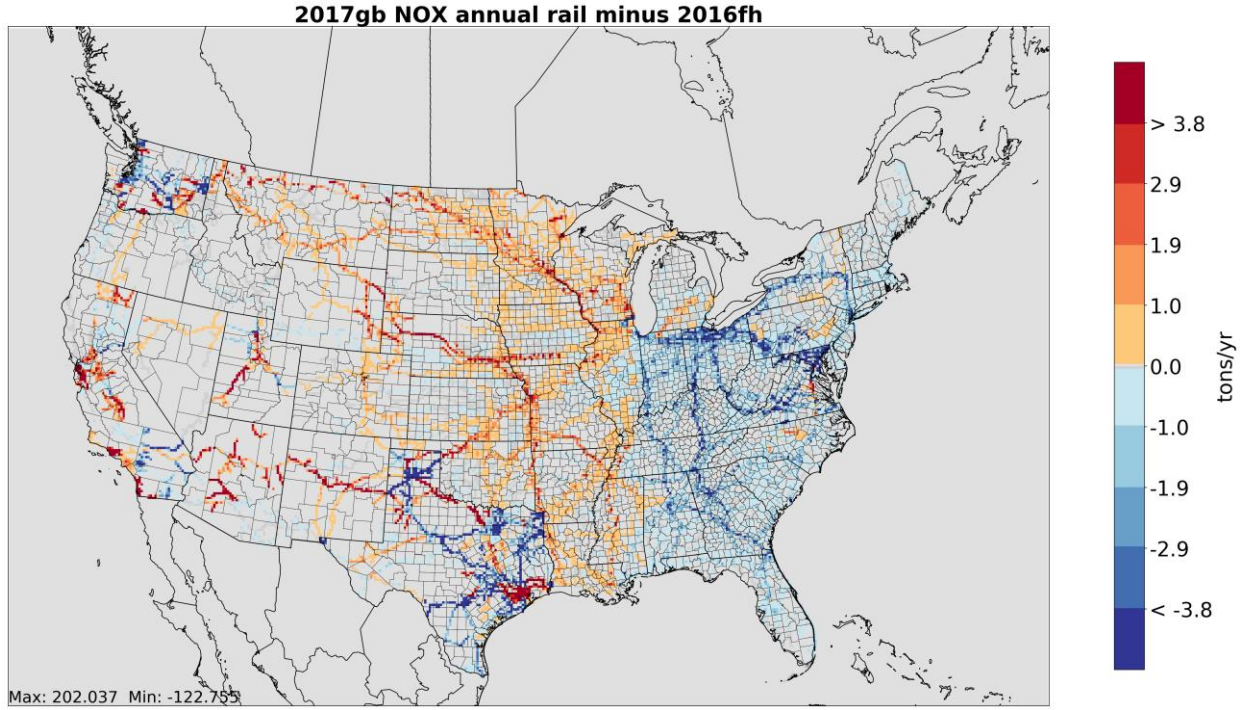


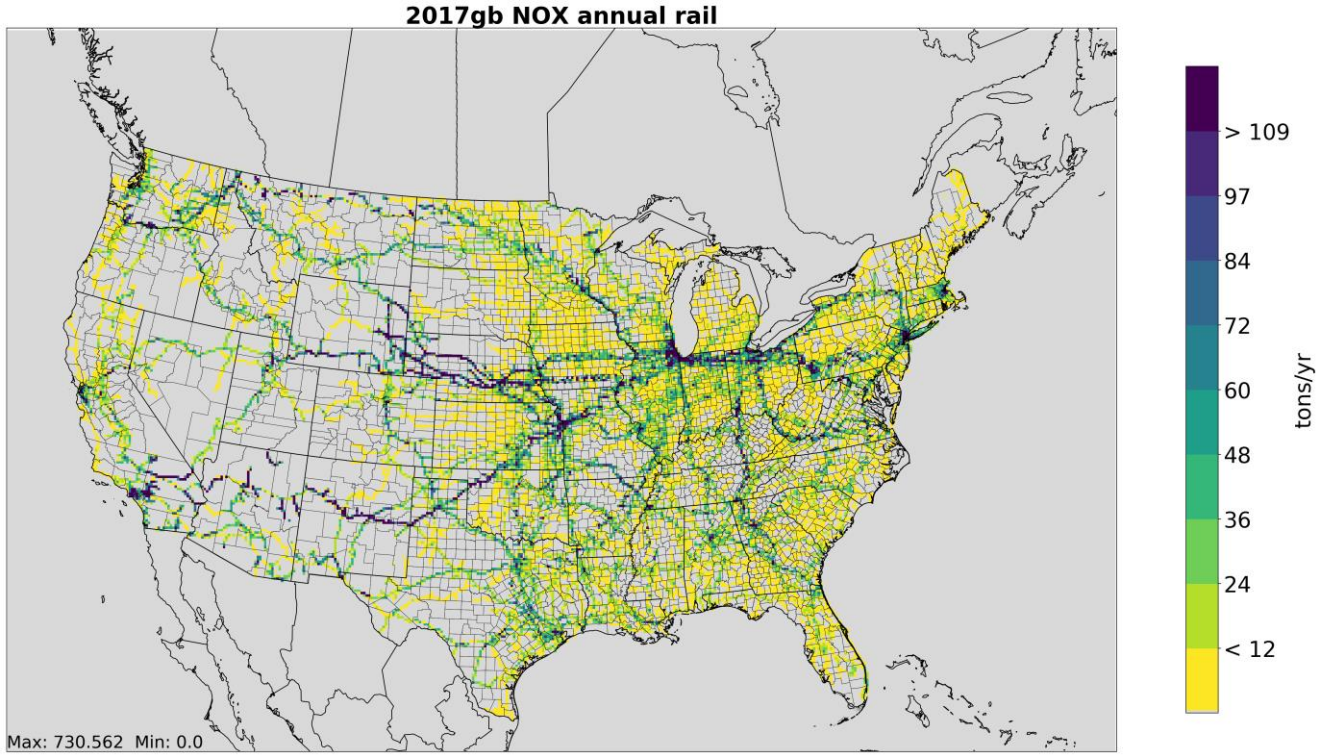


Rail NO_x and Changes from 2016

Rail traffic levels and fuel use increased nationally by about 4%, but fuel efficiency increased and more cleaner engines penetrated the fleet. Inventory includes passenger and some commuter trains.

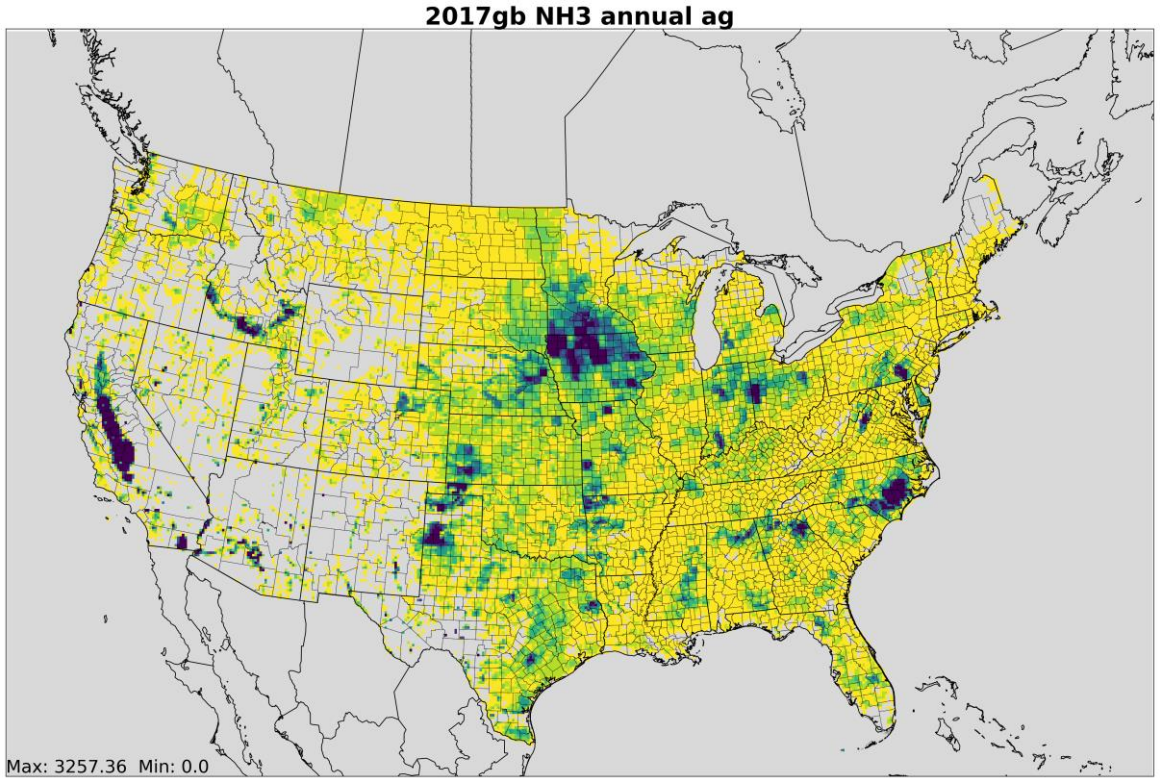
Operational changes by some railroads substantially reduced fuel use in the eastern U.S.

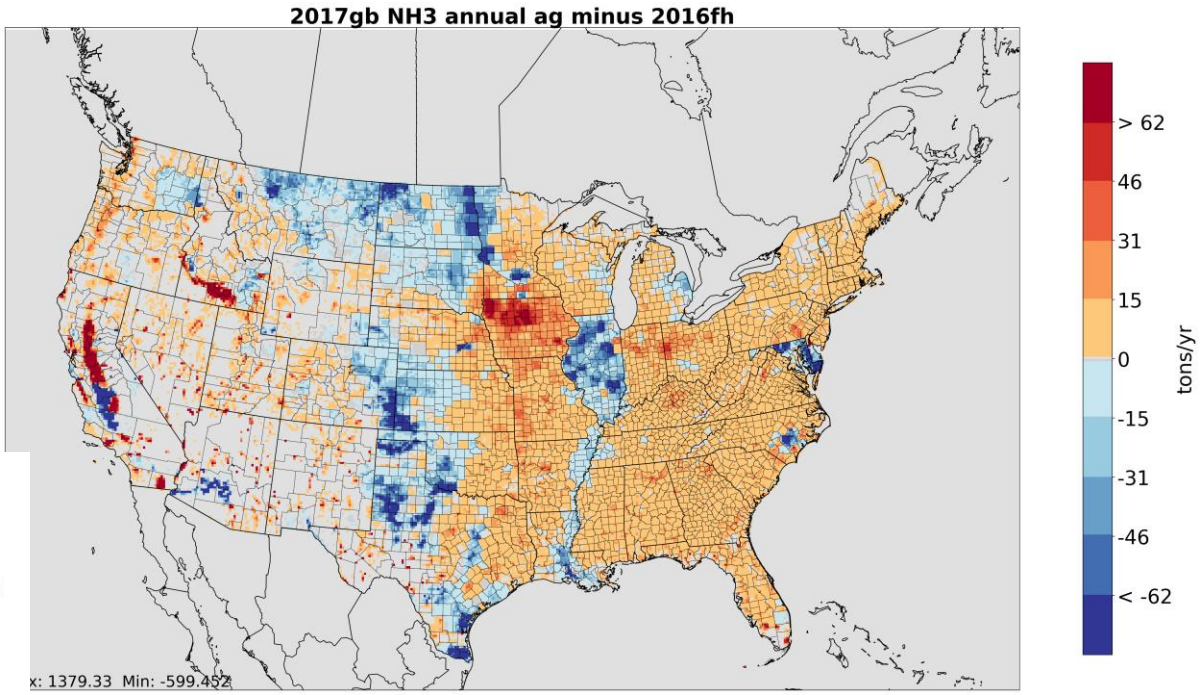




Agricultural Ammonia Emissions and Changes from 2016

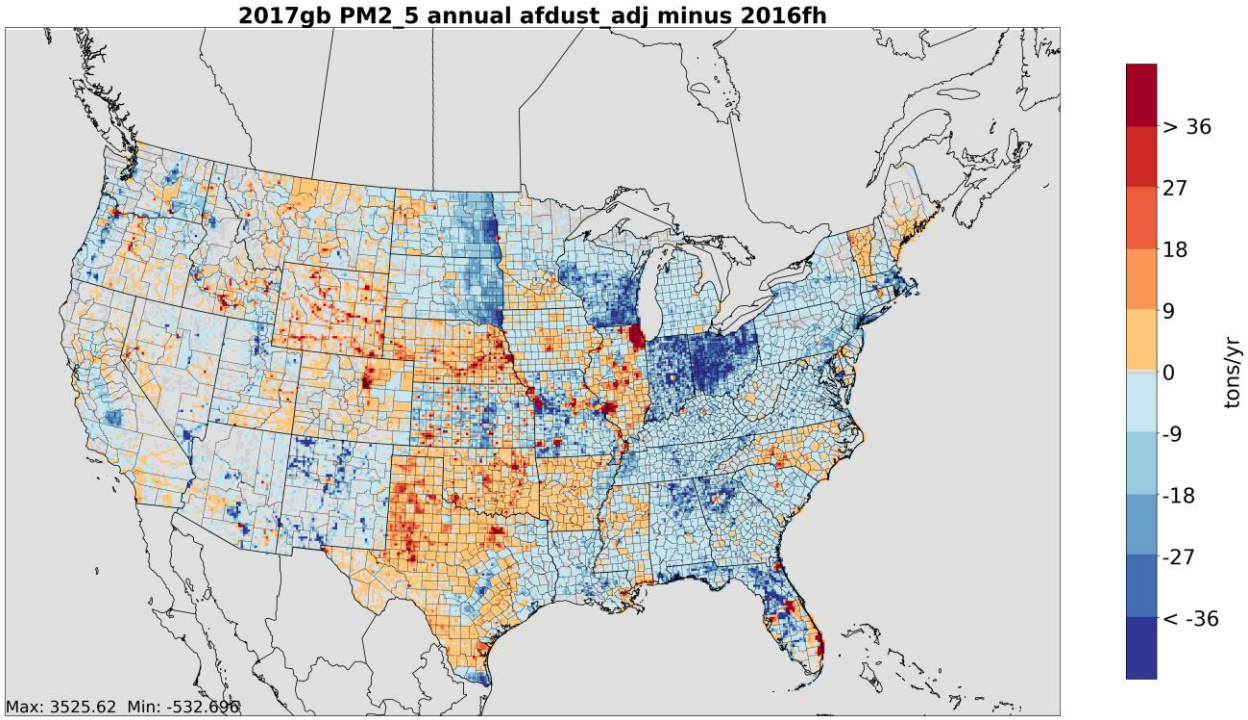
Corrections to livestock counts and improved fertilization methods and inputs, along with 2017 NEI state submissions, resulted in notable agricultural ammonia emissions changes in agricultural areas in 2017.

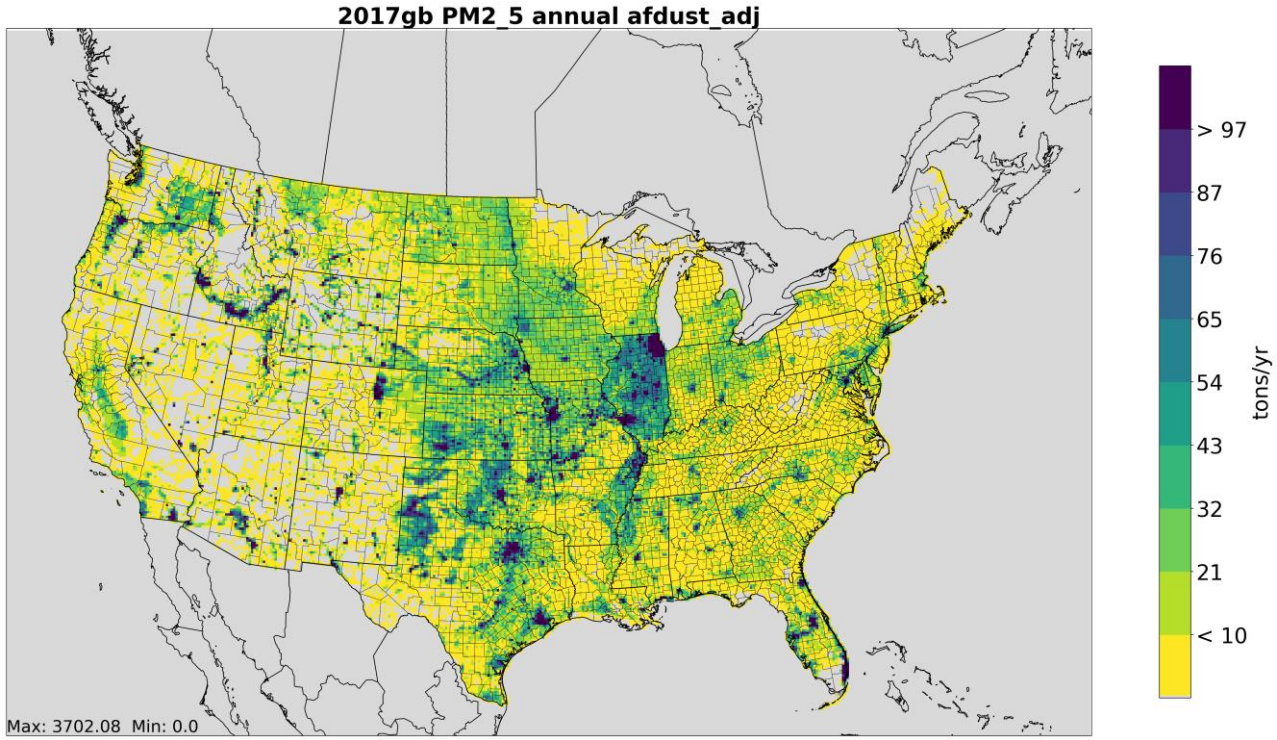




Fugitive Dust Emissions and Changes from 2016

The 2017 NEI includes updated fugitive dust methods, including improved quantification of paved versus unpaved roads and precipitation changes. These updates resulted in varied increases and decreases in fugitive dust emissions in 2017 across the US.

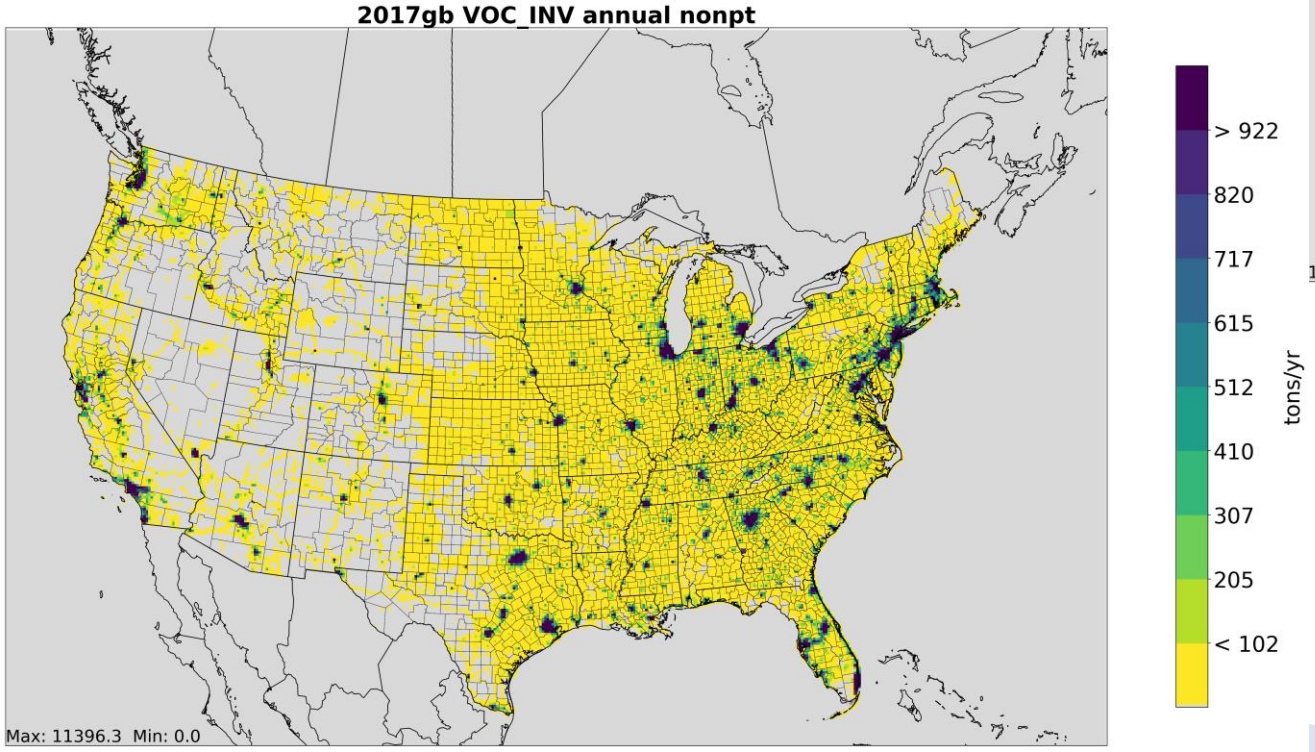


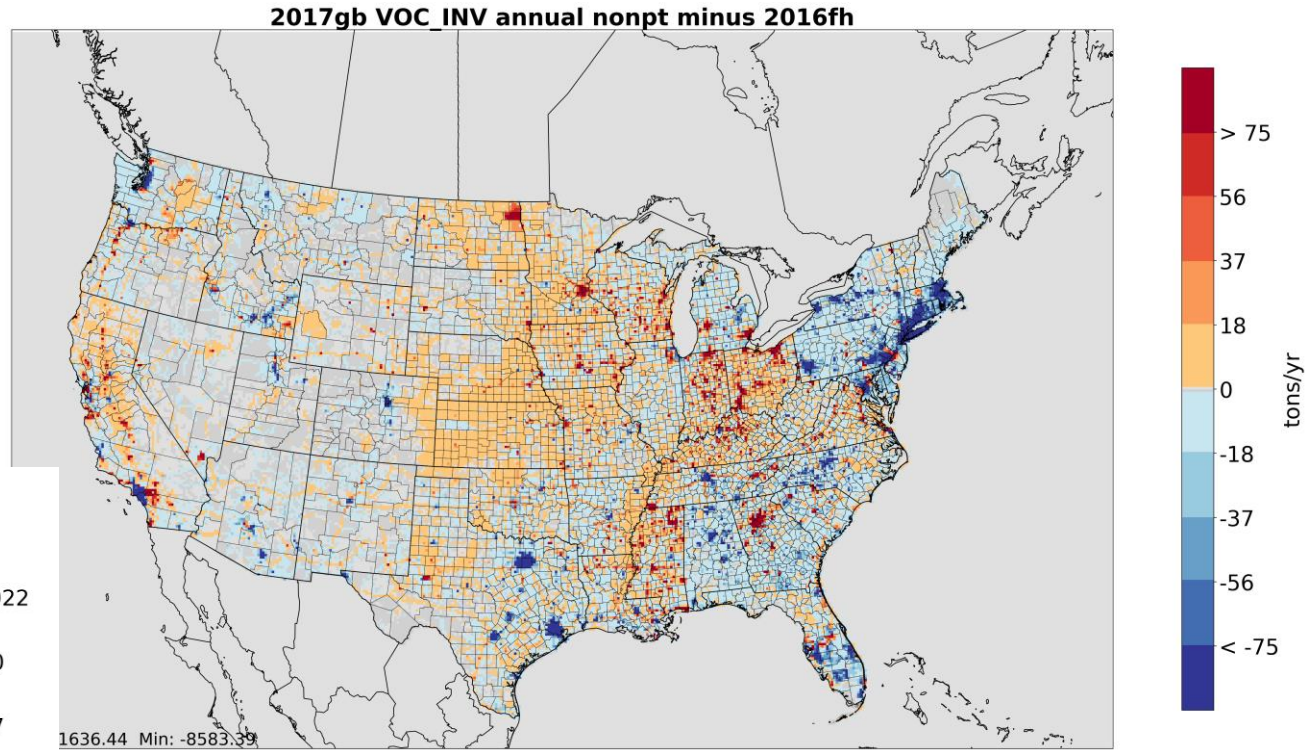


Nonpoint VOC emissions and Changes from 2016

Changes in nonpoint include an updated activity data source for commercial cooking, new default sulfur content and consumption data for residential fuel combustion, and updated methods for ICI fuel combustion.

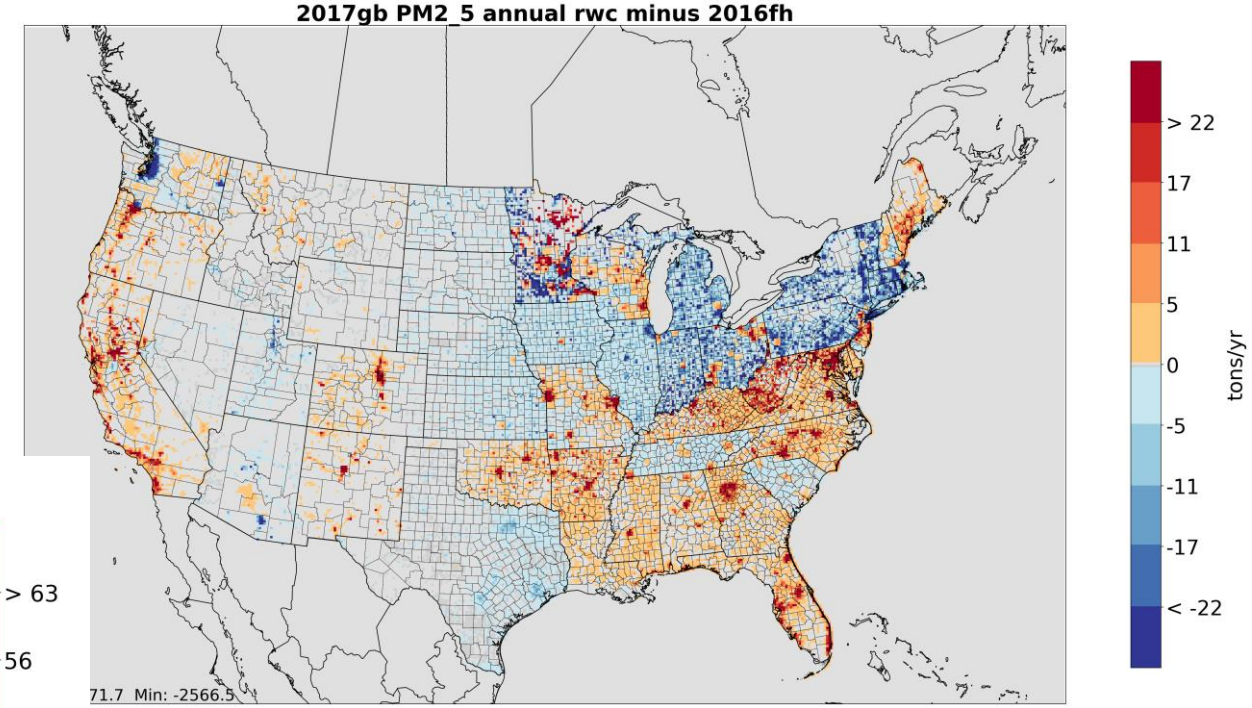
The aggregate result of these changes varies by location, with both increases and decreases depending on impacted area.

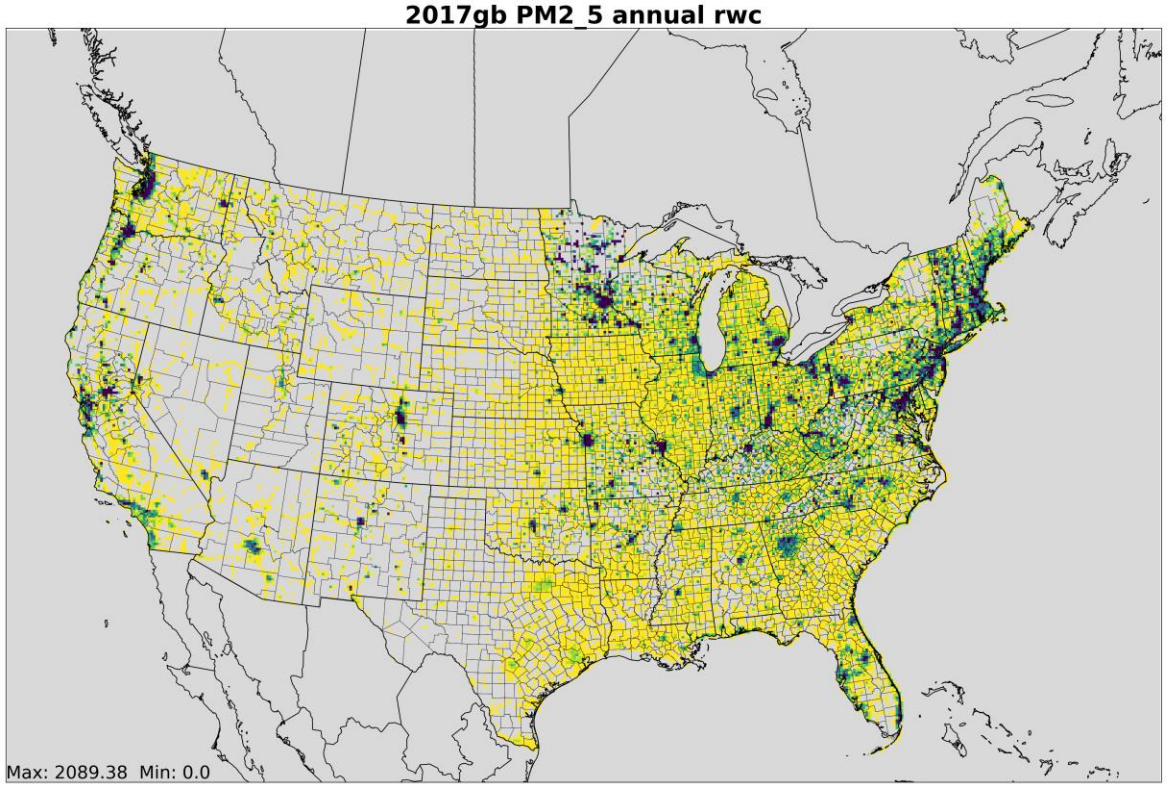




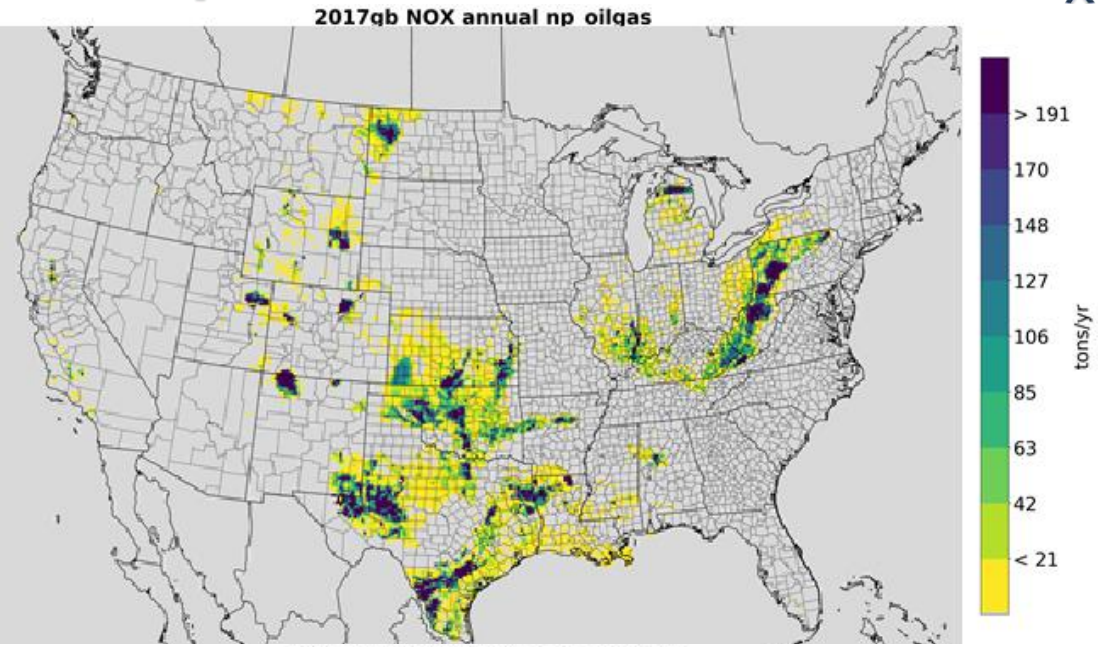
Residential Wood $PM_{2.5}$ and Changes from 2016

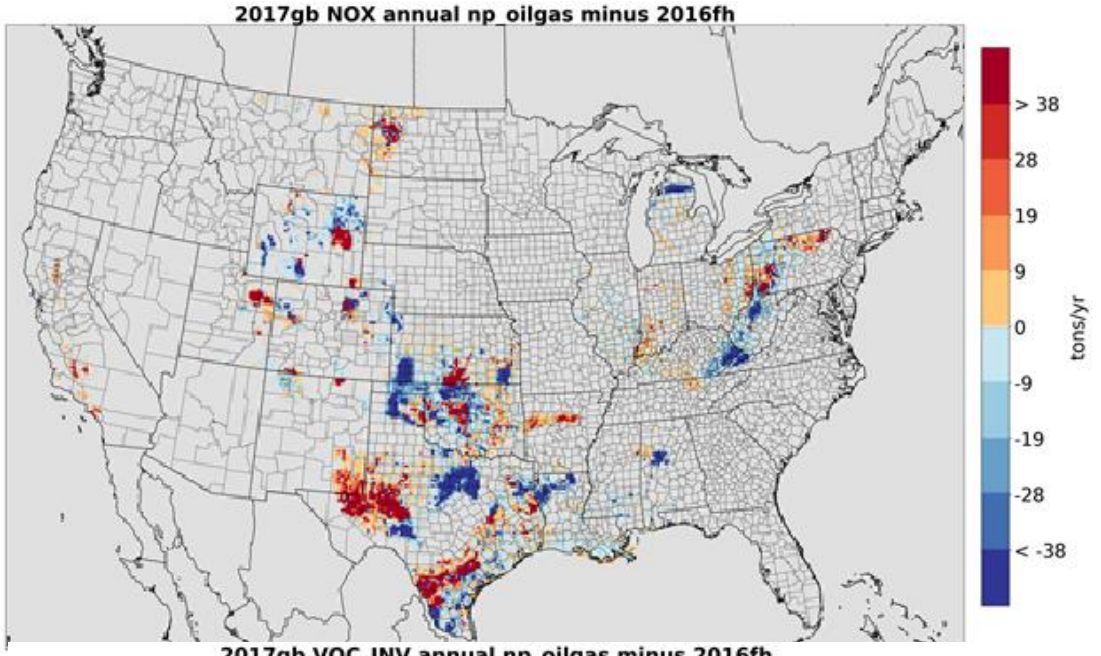
A new national survey to update appliance counts in the 2017 NEI plus local activity data resulted in considerable decreases in RWC emissions in much of the Northeast U.S.; increases throughout the Southern U.S. are due to recreational fire pits.

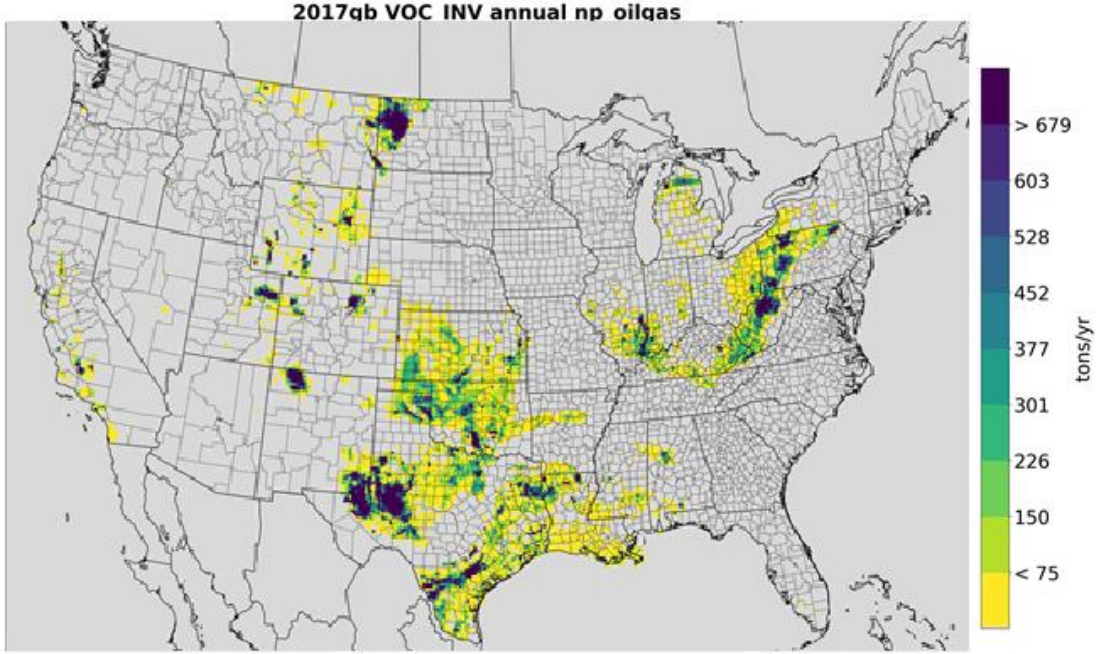


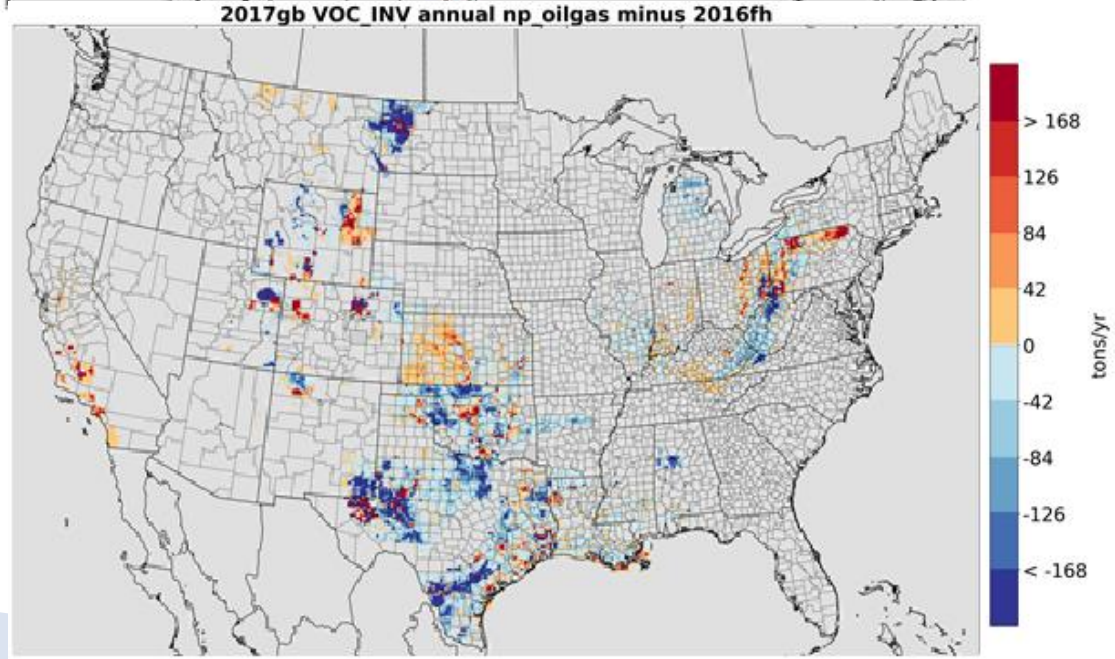


Nonpoint Oil and Gas NO_x/VOC and changes from 2016





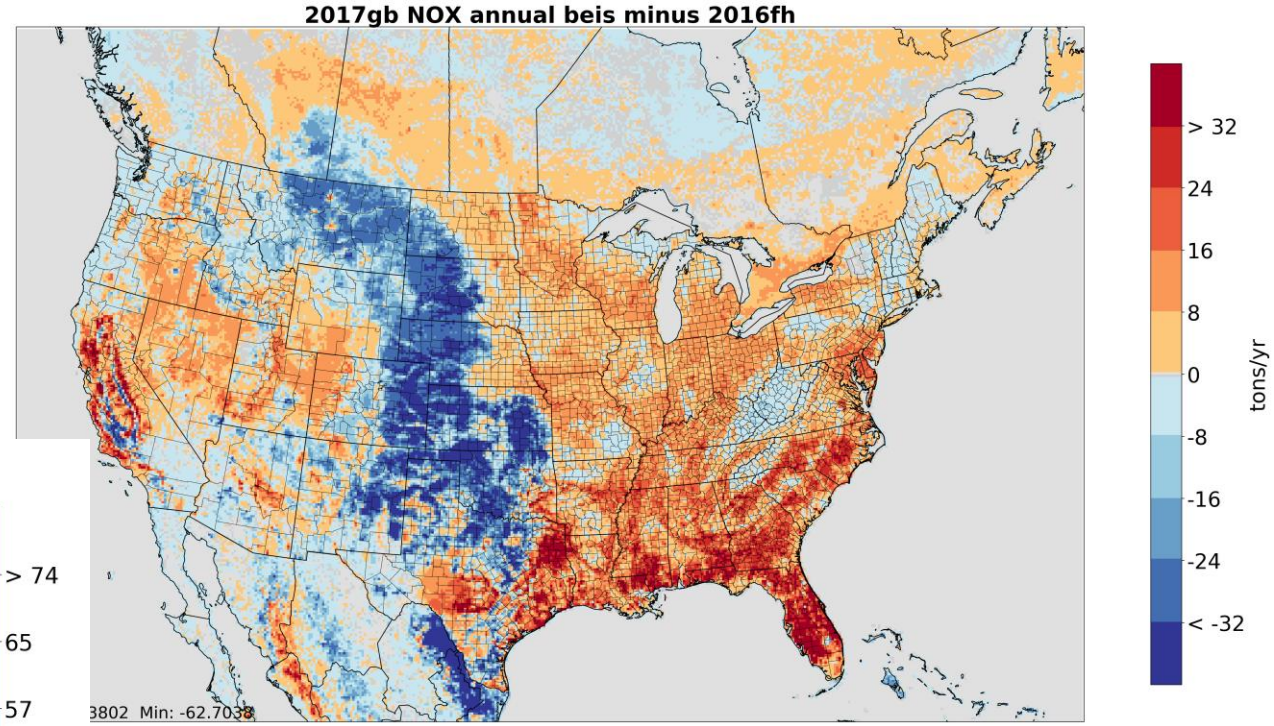


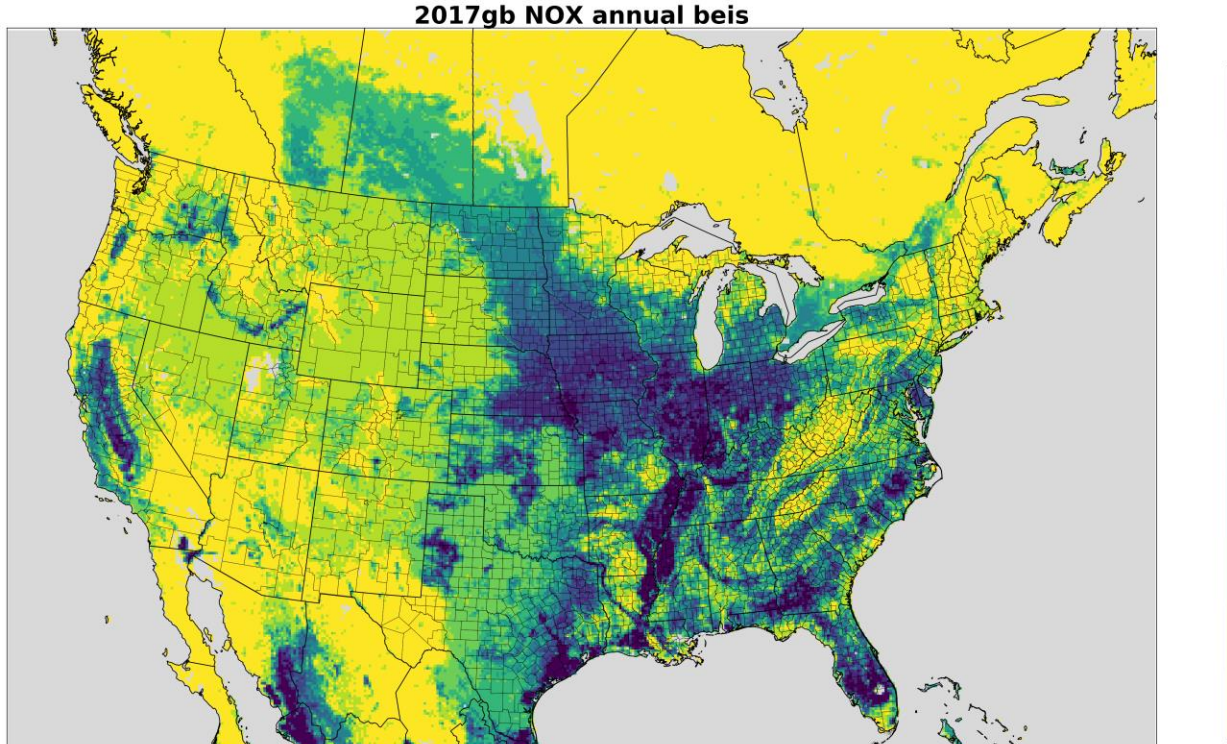


Changes in production, exploration and emission factors plus updates to the oil and gas tool caused oil and gas emissions in some areas to increase and other areas to decrease, along with state submissions to the 2017 NEI.

Biogenic NO_x Emissions and Changes from 2016

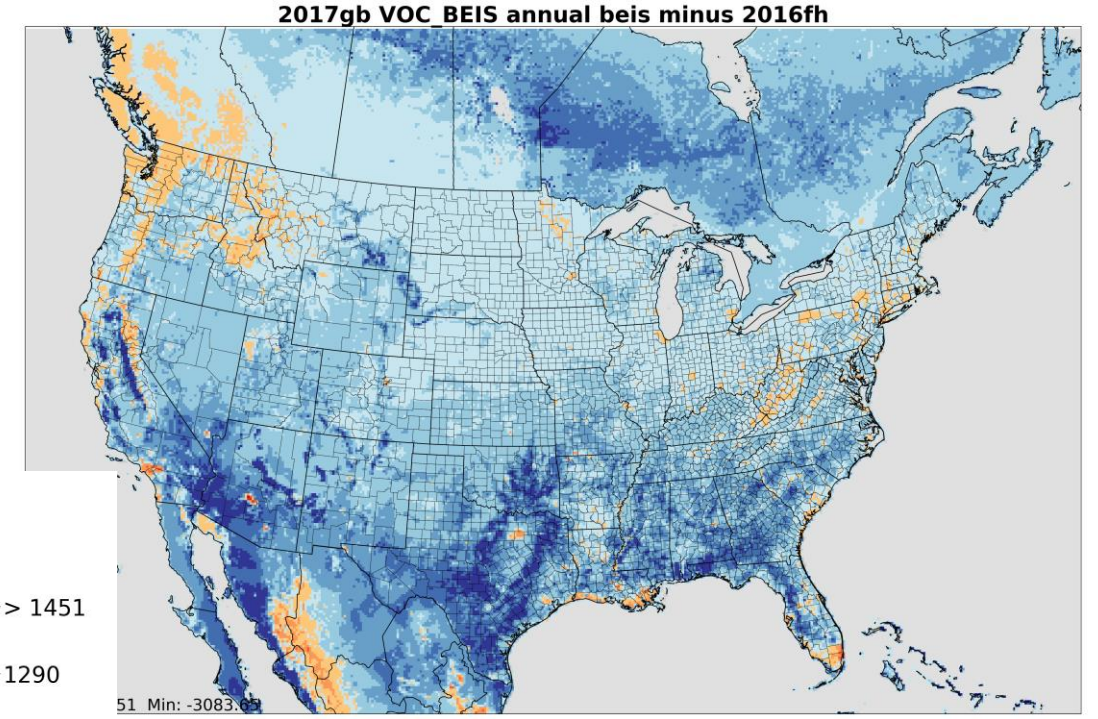
Updates in land use data, biomass factors, and emission factors caused changes in biogenic NOx emissions. Shrublands and grasslands are better characterized in the Biogenic Emissions Landuse Dataset version 5 (BELD5) and impact NOx.

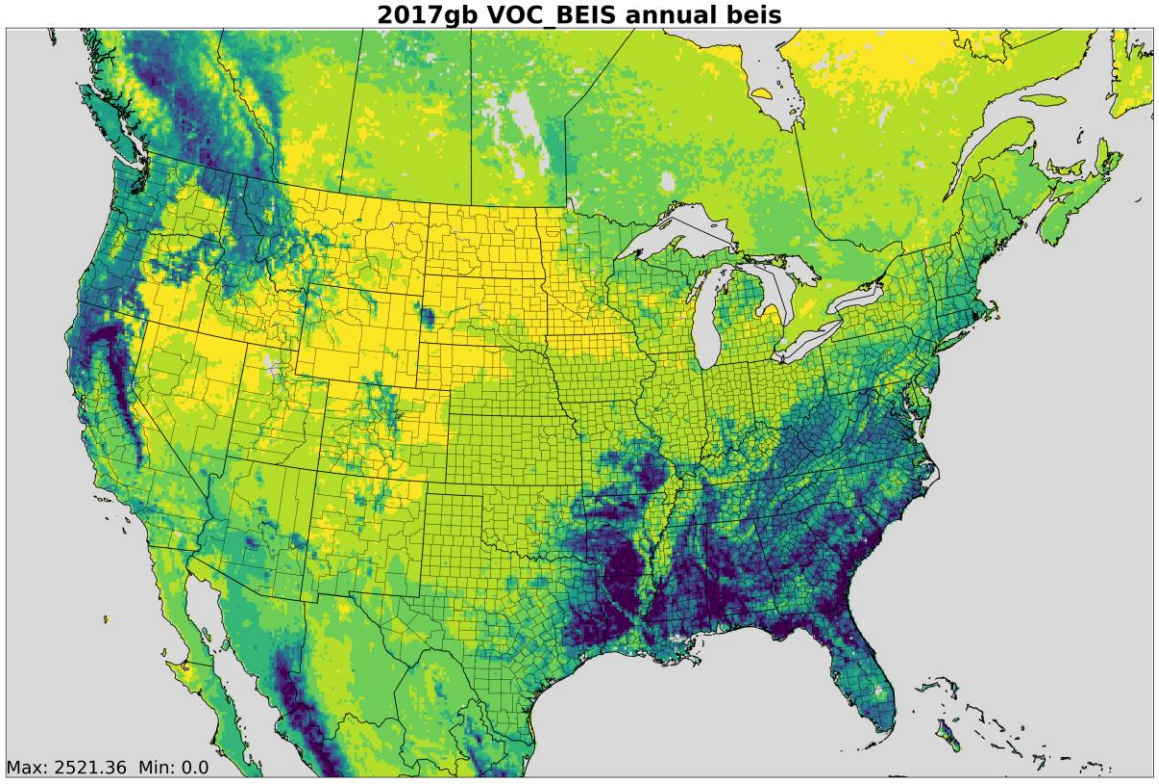




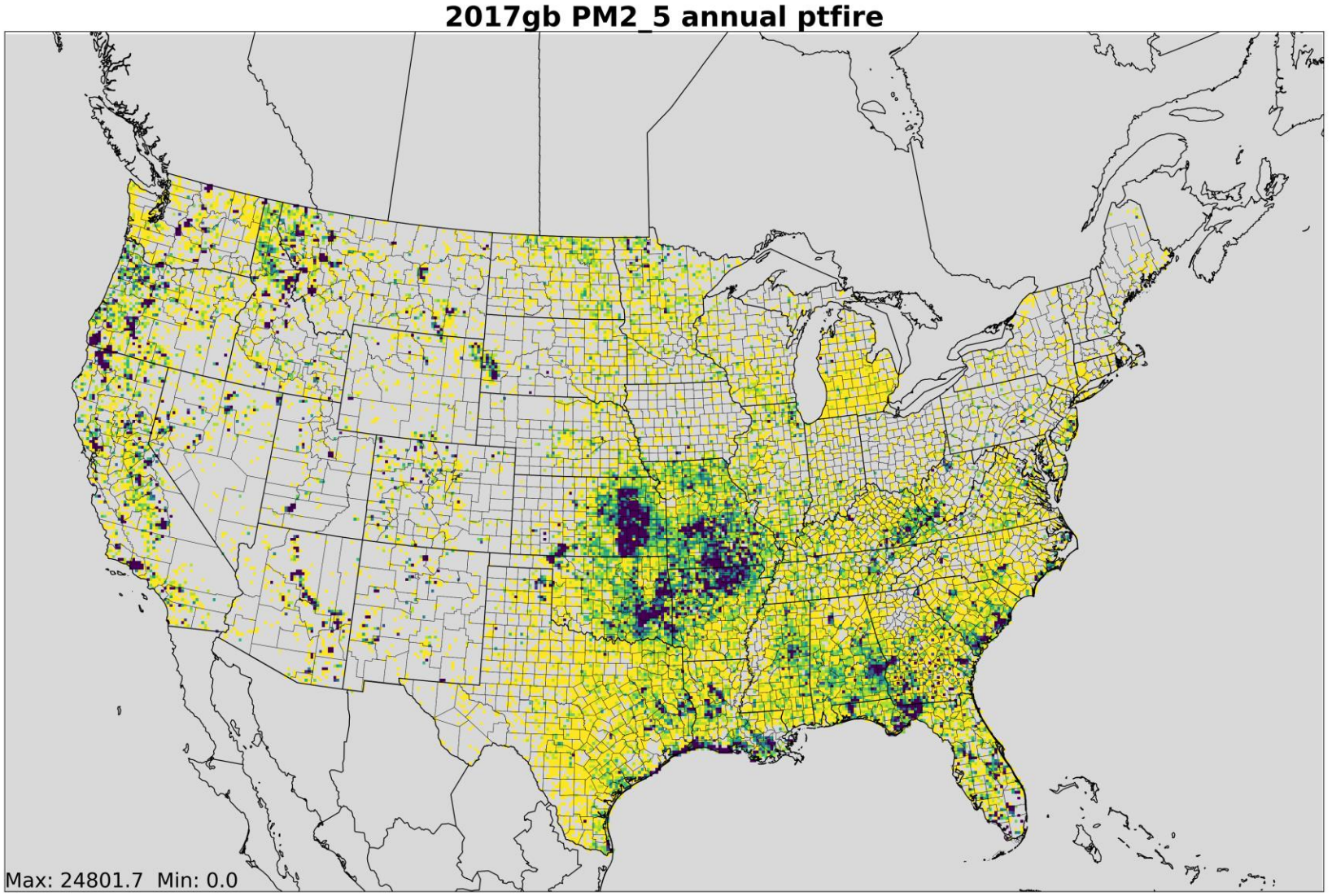
Biogenic VOC Emissions and Changes from 2016

Updates in land use data, biomass factors and emission factors caused changes in biogenic VOC emissions.





Wildland and Prescribed Fire $PM_{2.5}$ Emissions



2017 was a busy year for fires. (8M acres wildland, 14M acres prescr.)

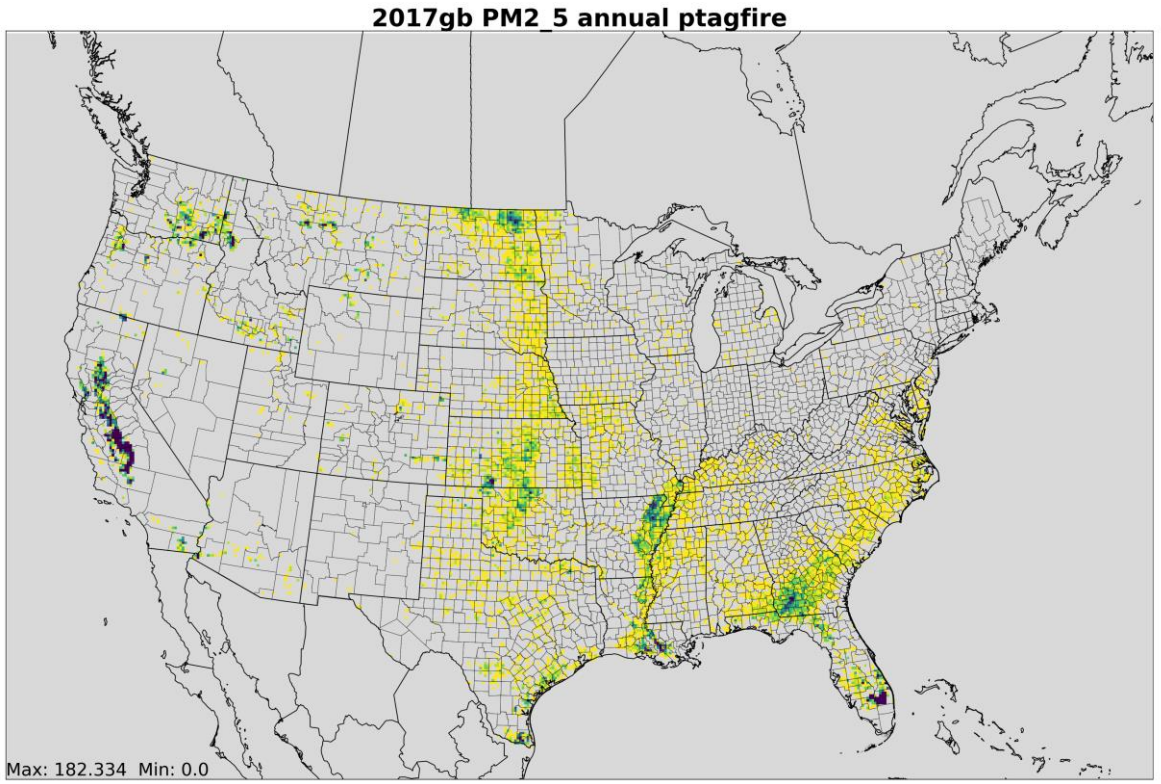
There were many wildland fires in the western states.

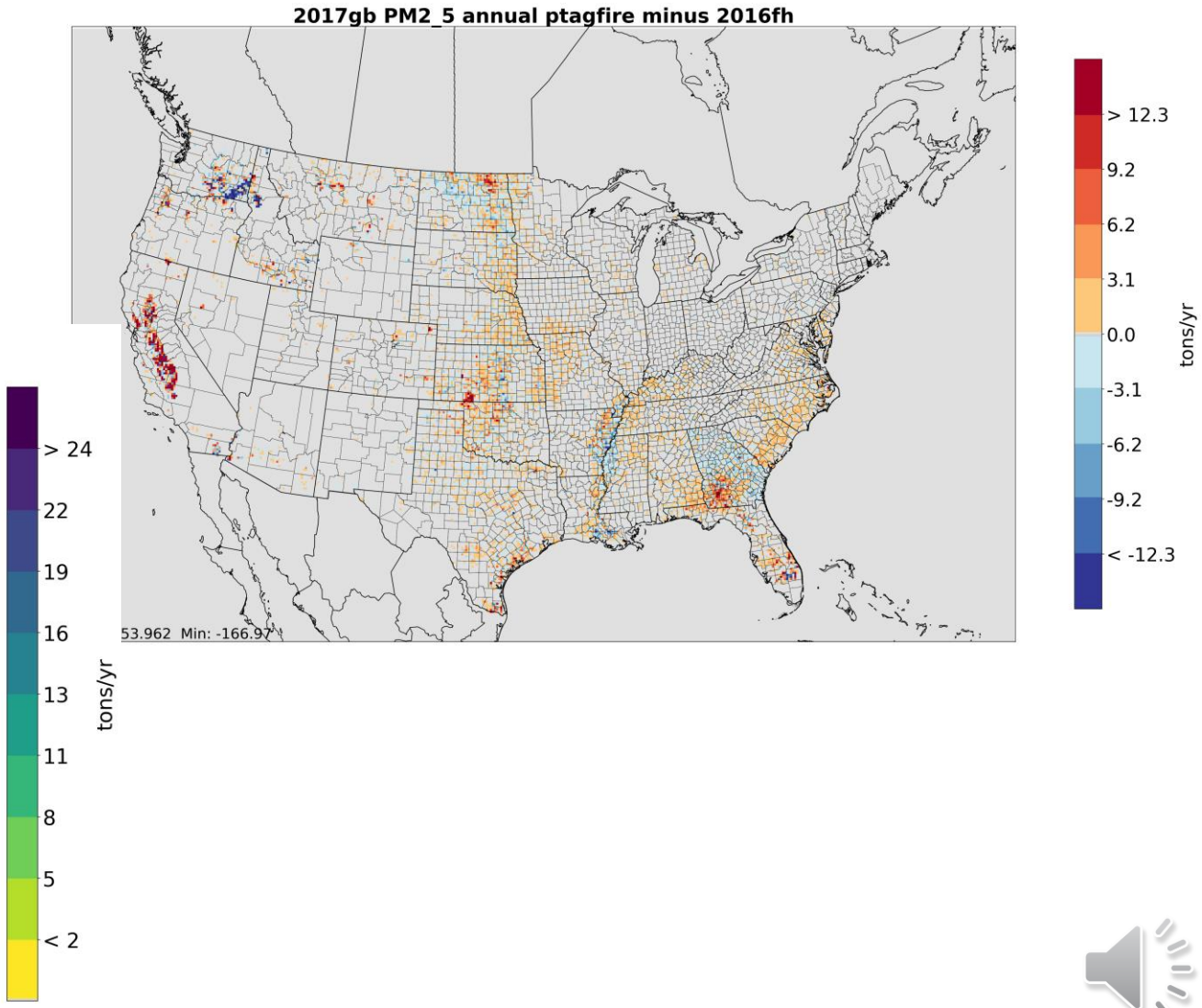
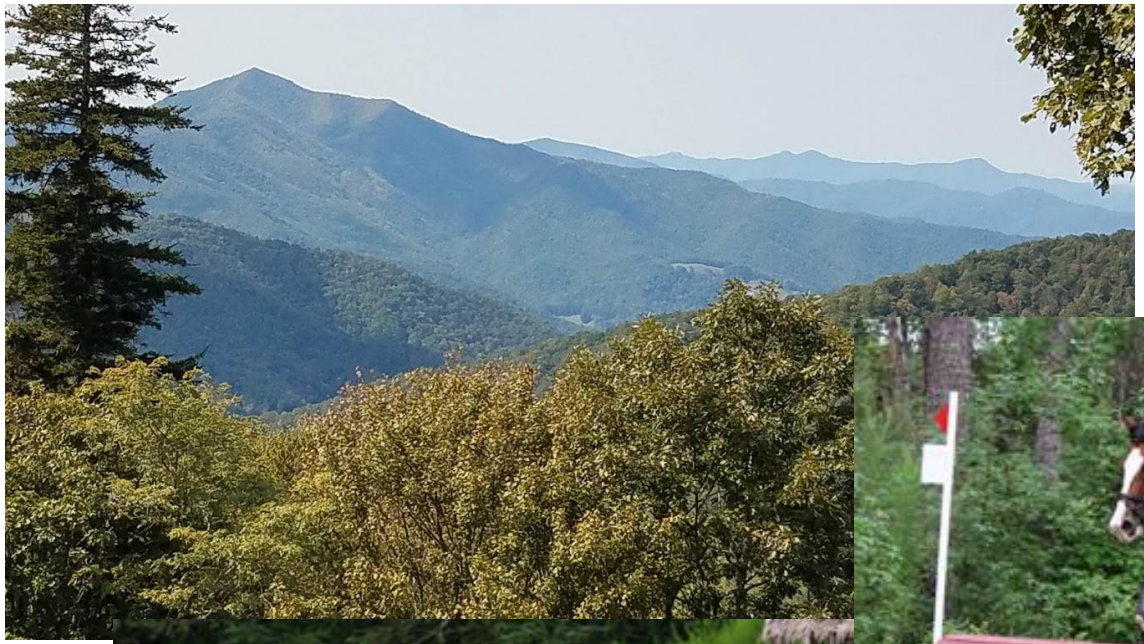
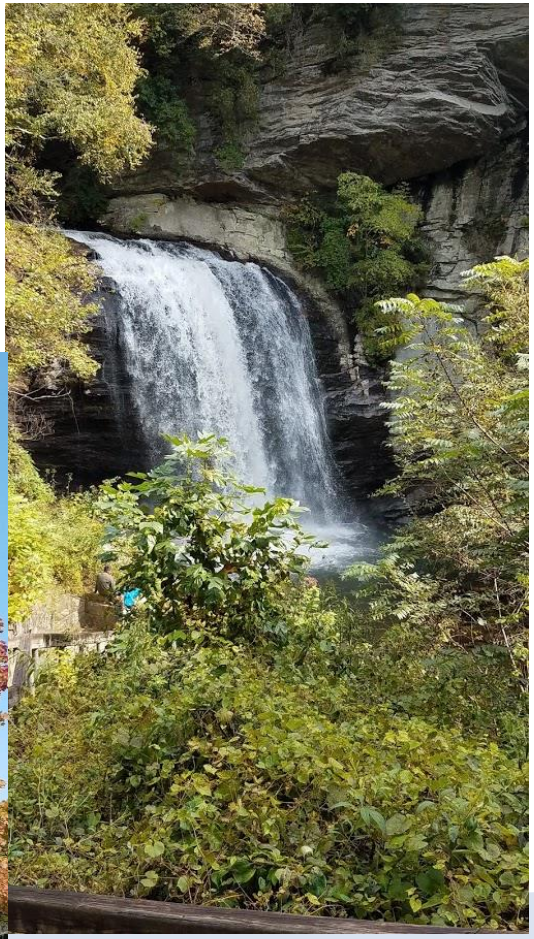
Grassland fires are prevalent in the center of the U.S. (2M acres)

Prescribed fires are dominant in the east and south.

Agricultural Fire $PM_{2.5}$ Emissions and Change from 2016

Agricultural fire emissions occur on lands designated for agriculture and are smaller in magnitude than the wildland and prescribed fires.





Thank You