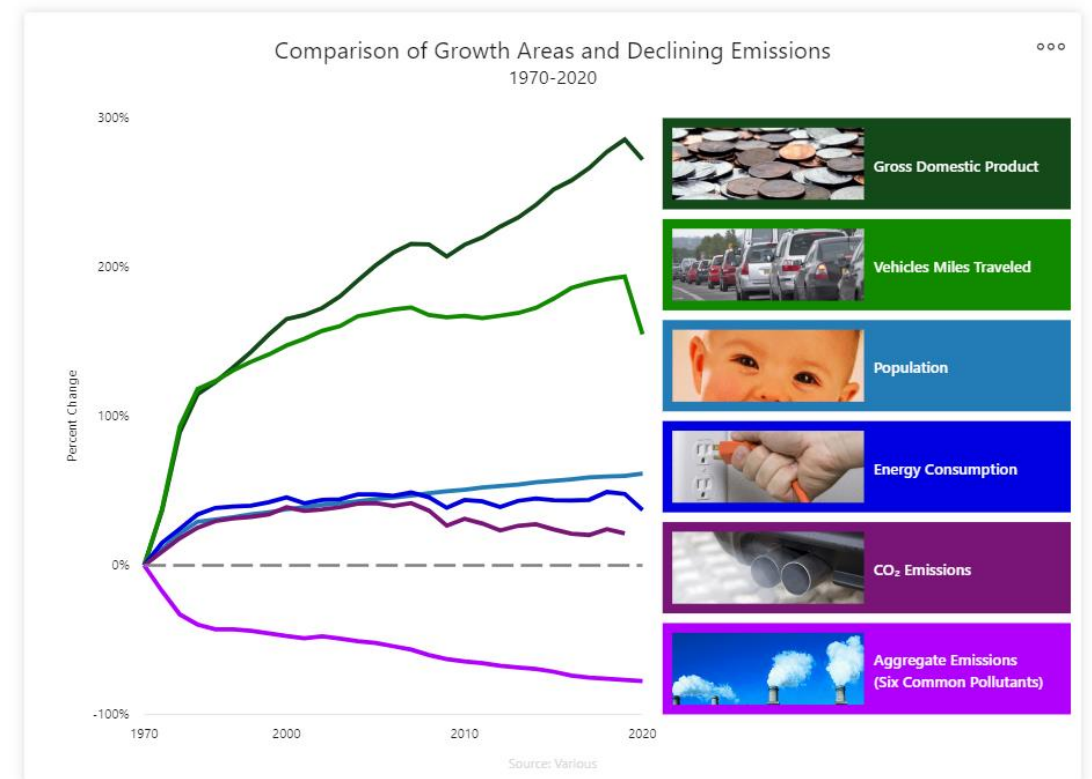
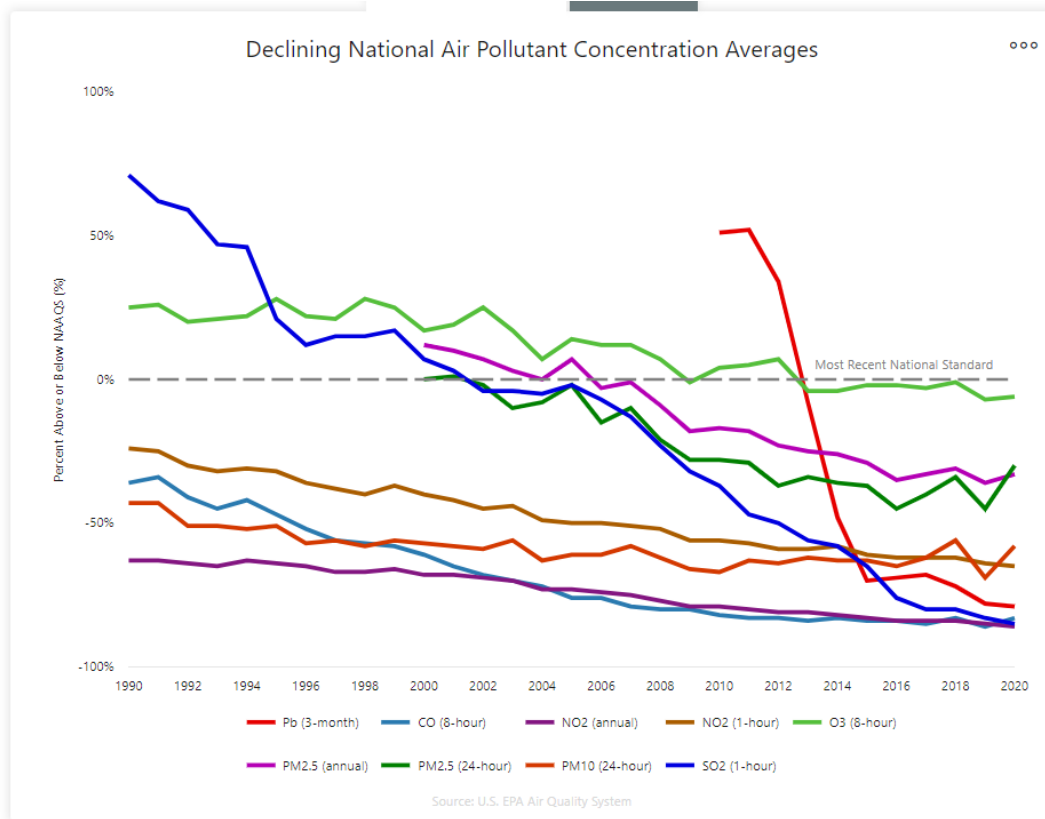


Methods Changes/Improvements to EPA's Criteria Air Pollutant Emission Trends

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Emissions Inventory Conference, Seattle, WA, Sept 28, 2023



Presentation topics

- Past (recent) status of CAP trends
- Background on EQUATES project
 - EPA's Air Quality Time Series Project = "EQUATES"
- Where will data come from for all years 1970-2022?
- Merging old data with new EQUATES data
- New features that will accompany our transition to using EQUATES to replace old trends data for 2002-2019
- Some examples of CAP national trend lines, "before" and "now"
- Looking ahead on trends related work

Previous Air Emissions Trends Status

- CHIEF Trends website provided national and state-specific CAP and CAP precursor trends from 1970 to 2021: <https://www.epa.gov/air-emissions-inventories/air-pollutant-emissions-trends-data>

Before moving to the updated methods:

- Annual estimates, includes all states and sectors except for offshore and biogenic emissions
- Using Tier 1 sectors
 - Wildfire emissions reported separately at the national level
 - Miscellaneous category contains many sectors including dust and ag sources
- NEI values used during NEI years and interpolation/extrapolation and holding values constant used in interim years
 - Some data in interim years are year-specific data
- Methods changes over time sometimes mask true emission trends discounting actual changes that likely occurred

How did we
report CAP
Trends on CHIEF
by Tier 1 level of
categorization?

https://www.epa.gov/sites/default/files/2015-07/documents/trends_procedures_old.pdf

Source Category

FUEL COMB. ELEC. UTIL.

FUEL COMB. INDUSTRIAL

FUEL COMB. OTHER

CHEMICAL & ALLIED PRODUCT MFG

METALS PROCESSING

PETROLEUM & RELATED INDUSTRIES

OTHER INDUSTRIAL PROCESSES

SOLVENT UTILIZATION

STORAGE & TRANSPORT

WASTE DISPOSAL & RECYCLING

HIGHWAY VEHICLES

OFF-HIGHWAY

MISCELLANEOUS

Total

Wildfires

Total without wildfires

Miscellaneous without wildfires

Stationary fuel combustion

Industrial and other processes

Transportation

Miscellaneous

Total

Previous Air Trends Website...

Air Pollutant Emissions Trends Data

Current emission trends data and the documentation of estimation methods are available via the links below. The latest version of the 1970 - 2021 data show the trends for Tier 1 categories which distinguish pollutant emission contributions among major source types. The trends shown are for criteria air pollutants (CAPs) and precursors covered by the National Ambient Air Quality Standards (NAAQS), excluding lead. Lead emissions sharply declined after it was eliminated from gasoline and have remained low. As inventory methods are improved over time, for some emission sources and improved estimation method may be applied 'backwards' to previous year trend estimates.

[National Tier 1 CAPS Trends \(xlsx\)](#) Criteria pollutants National Tier 1 for 1970 - 2021.

[State Tier 1 CAPS Trends \(xlsx\)](#) Criteria pollutants State Tier 1 for 1990 - 2021.

[Trends Procedural Documentation](#) - Any changes in the data or methodologies used to estimate the emissions for a specific time period will continue to be noted in future updates.

Source Category	1970	1975	1980	1985	1990	1991	1992	1993
Carbon Monoxide (CO)								
National Emissions Totals (thousands of tons)								
FUEL COMB. ELEC. UTIL.	237	276	322	291	363	349	350	363
FUEL COMB. INDUSTRIAL	770	763	750	670	879	920	955	1,043
FUEL COMB. OTHER	3,625	3,441	6,230	7,525	4,269	4,587	4,849	4,181
CHEMICAL & ALLIED PRODUCT MFG	3,397	2,204	2,151	1,845	1,183	1,127	1,112	1,093
METALS PROCESSING	3,644	2,496	2,246	2,223	2,640	2,571	2,496	2,536
PETROLEUM & RELATED INDUSTRIES	2,179	2,211	1,723	462	333	345	371	371
OTHER INDUSTRIAL PROCESSES	620	630	830	694	537	548	544	594
SOLVENT UTILIZATION	NA	NA	NA	2	5	5	5	5
STORAGE & TRANSPORT	NA	NA	NA	49	76	28	17	51
WASTE DISPOSAL & RECYCLING	7,059	3,230	2,300	1,941	1,079	1,116	1,138	1,248
HIGHWAY VEHICLES	163,231	153,555	143,827	134,187	110,255	104,980	99,705	94,431
OFF-HIGHWAY	11,371	14,329	16,685	19,029	21,447	21,934	22,419	22,904
MISCELLANEOUS	7,909	5,263	8,344	7,927	11,122	8,618	6,934	7,082
Total	204,042	188,398	185,408	176,845	154,188	147,128	140,895	135,902
Wildfires	6,766	4,433	7,622	7,289	10,583	10,583	6,389	6,537
Total without wildfires	197,276	183,965	177,786	169,556	143,605	136,545	134,506	129,365
Miscellaneous without wildfires								

Past Questions About EPA Emission Trends

- Trends data are used often by many stakeholders, EPA, and other agencies. Questions we get include
 - How much do methods play a role in the time series?
 - What constitutes the “miscellaneous” category for the various pollutants?
 - Can you provide trends information that is sub-state? Sub-Tier 1 category?
 - Can you include black carbon in the trends database?
 - Can you isolate some sectors that aren’t done now, such as RWC/O&G?
 - How exactly are interim years handled (non-NEI years)
 - What about HAPs?
 - Can you develop trends at the county level?

EQUATES project

- Focused on development of a set of modeled meteorology, emissions, air quality and pollutant deposition spanning the years 2002 through 2017; our main interest here is the emissions part: establishing consistent emission estimates for CAPs and CAP precursors from 2002-2019, using sectors that are model-platform centric
 - Use emission methods in 2017 NEI and back-cast to 2002 preserving the methods (as much as possible)
 - 2018 and 2019 were estimated using OAQPS emissions modeling platforms with some minor modifications to some sectors to make the estimation methods more consistent with the 2002-2017 data
 - Gave us a wonderful opportunity to update and make more robust our emission trends methods for the more recent years
 - For each source category apply one of four approaches:
 - New methods for creating consistent emissions for all years
 - Scale 2016 or 2017 emissions with scaling factors based on activity data and/or control information
 - Use existing modeling platform data
 - Leave flat at 2017 NEI levels
- Data were developed and aggregated to modeling sectors starting with SCC level estimates (which will enable mapping to other sector aggregations such as Tier 1, and EIS sectors)
- Data were developed at the state level and aggregated to the national level
- For more information on EQUATES, see: <https://www.epa.gov/cmaq/equates> & published manuscript “2002–2017 anthropogenic emissions data for air quality modeling over the United States,” @ <https://www.sciencedirect.com/science/article/pii/S2352340923001403?via%3Dihub>

More specifics on where new Trends data come from

- EQUATES “v1.1” for all years 2002-2019 except for the 2016v3 regulatory platform estimates is used for 2016.
 - Differences between EQUATES results in 2016 and the modeling platform data are minimal
- For 2020, the final 2020 NEI is used.
- For 2021, 2020 NEI is used except for updated fires, EGUs, onroad, and nonroad.
- For 2022, 2020 NEI is used except for updated EGUs, onroad and nonroad.
- 2021 and 2022 onroad CONUS were interpolated between 2019ge and 2023gf.
- 2021 and 2022 onroad non-CONUS were interpolated between 2018gc and 2023fh and nonroad was interpolated between 2020NEI and 2023gf.

Merging EQUATES-based data with previously-available emission trends data

- Data for years earlier than 2002 remains as-is across all pollutants (including not having the embellishments and updates for 2002-2022)
- 2002-2019 data comes from EQUATES analysis, for all except the year 2016 which will rely on a modeling platform dataset that represents version 3 of that inventory
- This (new) dataset has been posted on CHIEF for both the national and state trends and looks identical to the current format
 - Trends data continues to be reported at Tier 1 level
 - Ancillary data are available as discussed on next slide to help understand sectors that fall under the broad Tier 1 categories from 2002 on forward
- New documentation is provided.

Current Air Trends web page: <https://www.epa.gov/air-emissions-inventories/air-pollutant-emissions-trends-data>

Air Pollutant Emissions Trends Data

Current emission trends data (including “readme” files included in the spreadsheets) and the documentation of estimation methods are available via the links below. The latest version of the 1970 - 2022 data show the trends for Tier 1 categories which distinguish pollutant emission contributions among major source types. Improvements to the methods used to estimate emissions for the years 2002-2019 are included in these data. These updated procedures will minimize the effects of method changes on emissions over this time frame. In addition, 2020 is represented by the 2020 NEI data, and 2021 and 2022 are based on the 2020 NEI with some year specific embellishments for point sources, fires, and mobile sources. Another addition to the suite of trends products includes EIS sector specific national and state trends for the time frame 2002-2022, and the addition of black carbon and organic carbon as pollutants to all the files. The trends shown are for criteria air pollutants (CAPs) and precursors covered by the National Ambient Air Quality Standards (NAAQS), excluding lead. Lead emissions sharply declined after it was eliminated from gasoline and have remained low.

[National Tier 1 CAPS Trends \(xlsx\)](#). Criteria pollutants National Tier 1 for 1970 - 2022.

[State Tier 1 CAPS Trends \(xlsx\)](#). Criteria pollutants State Tier 1 for 1990 - 2022.

[National and State EIS Sector CAPS Trends \(xlsx\)](#) (5.12 MB, April 2023) Criteria pollutants National State EIS Sector for 2002 - 2022.

[National and State Tier 2 CAPS Trends by Tier 1 and EIS Sector \(xlsx\)](#) (6.7 MB) National and State Tier 1 CAPS Trends by Tier 1 and EIS Sector for 2002 - 2022.

[Trends Procedural Documentation](#) - Any changes in the data or methodologies used to estimate the emissions for a specific time period will continue to be noted in future updates.

New features

- Black carbon and organic carbon are new pollutants that will be available for the 2002-2022, for the very first time
 - We get a lot of requests for BC trends
- In addition to the Tier 1 sector classifications available previously on CHIEF, we have made a more descriptive accounting of sectors available. This relies on using the current 60 EIS sectors and enables users to see which subsectors under the Tier 1 categorization are causing the noted trends. For example,
 - Agricultural sources are included in “miscellaneous,” under Tier 1, but are now available separately with the new EIS-based emissions
 - Dust, O&G, RWC emissions, for example, are also available separately instead of hidden inside Tier 1 categories
- These new updates result in 2002-2019 trends that have less method change-related effects year to year
- Backfilled PM emission estimates for Wildfires back to 1990

Agriculture - Crops & Livestock Dust
Agriculture - Fertilizer Application
Agriculture - Livestock Waste
Bulk Gasoline Terminals
Commercial Cooking
Dust - Construction Dust
Dust - Paved Road Dust
Dust - Unpaved Road Dust
Fires - Agricultural Field Burning
Fires - Prescribed Fires
Fires - Wildfires
Fuel Comb - Comm/Institutional - Biomass
Fuel Comb - Comm/Institutional - Coal
Fuel Comb - Comm/Institutional - Natural Gas
Fuel Comb - Comm/Institutional - Oil
Fuel Comb - Comm/Institutional - Other
Fuel Comb - Electric Generation - Biomass
Fuel Comb - Electric Generation - Coal
Fuel Comb - Electric Generation - Natural Gas
Fuel Comb - Electric Generation - Oil
Fuel Comb - Electric Generation - Other
Fuel Comb - Industrial Boilers, ICs - Biomass
Fuel Comb - Industrial Boilers, ICs - Coal
Fuel Comb - Industrial Boilers, ICs - Natural Gas
Fuel Comb - Industrial Boilers, ICs - Oil
Fuel Comb - Industrial Boilers, ICs - Other
Fuel Comb - Residential - Natural Gas
Fuel Comb - Residential - Oil
Fuel Comb - Residential - Other
Fuel Comb - Residential - Wood
Gas Stations
Industrial Processes - Cement Manuf
Industrial Processes - Chemical Manuf
Industrial Processes - Ferrous Metals
Industrial Processes - Mining
Industrial Processes - NEC
Industrial Processes - Non-ferrous Metals
Industrial Processes - Oil & Gas Production
Industrial Processes - Petroleum Refineries
Industrial Processes - Pulp & Paper
Industrial Processes - Storage and Transfer

Miscellaneous Non-Industrial NEC
Mobile - Aircraft
Mobile - Commercial Marine Vessels
Mobile - Locomotives
Mobile - Non-Road Equipment - Diesel
Mobile - Non-Road Equipment - Gasoline
Mobile - Non-Road Equipment - Other
Mobile - On-Road Diesel Heavy Duty Vehicles
Mobile - On-Road Diesel Light Duty Vehicles
Mobile - On-Road non-Diesel Heavy Duty Vehicles
Mobile - On-Road non-Diesel Light Duty Vehicles
Solvent - Consumer & Commercial Solvent Use

Sector
Solvent - Degreasing
Solvent - Dry Cleaning
Solvent - Graphic Arts
Solvent - Industrial Surface Coating & Solvent Use
Solvent - Non-Industrial Surface Coating
Waste Disposal

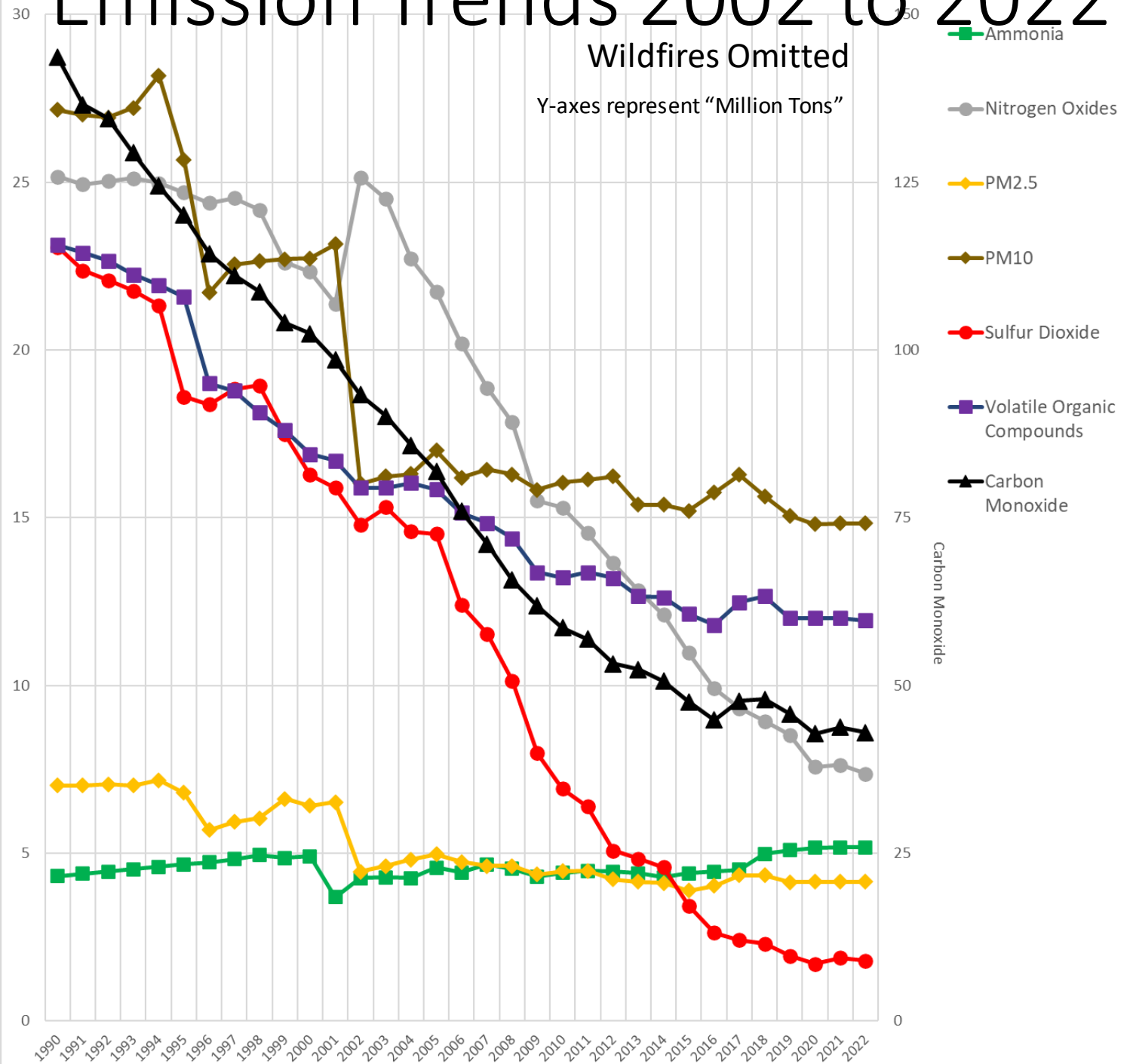
← 60 EIS Sectors

Key 2020 NEI updates

- Introduction of agricultural silage (VOC) to NEI
- Revised PM emissions factors and updated activity data methodology for Residential Wood Combustion (PM) leads to increases in emissions
- Updated activity data and inputs increasing agricultural fertilizer application and livestock waste (NH₃)
 - Ag Fertilizer more than doubles nationally
 - Livestock waste slight national increase but larger state-to-state variability in 2020
- Improved default assumptions for nonpoint ICI = state variability in 2020 (NOX, SO₂, CO, PM)
- New Solvents methodology, much less VOC from Graphic Arts
- Continued improvement in oil/gas –variability in VOC and NOX
- Onroad mobile activity changes due to COVID-19 (NOX, VOC)

Emission Trends 2002 to 2022

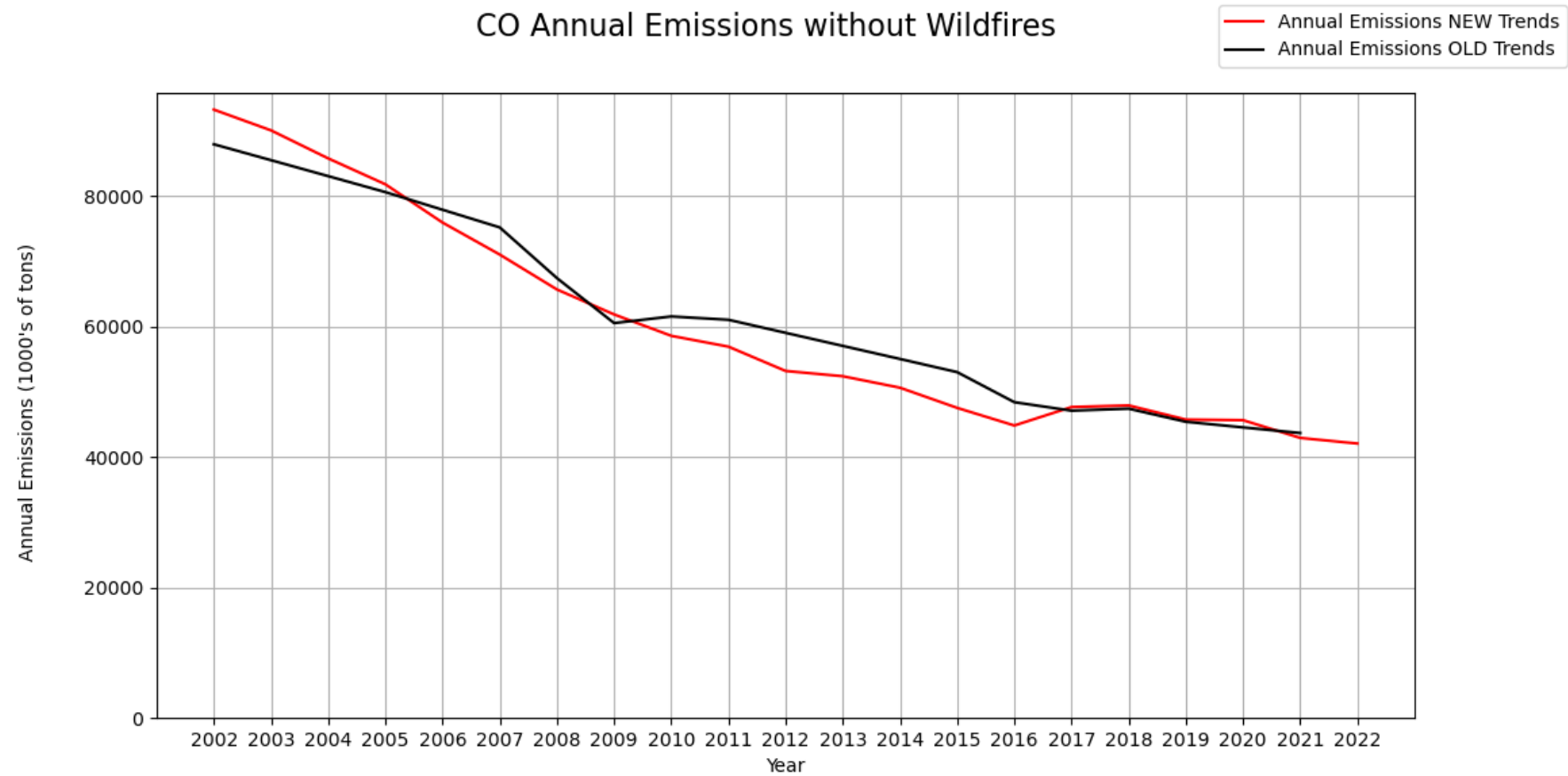
Wildfires Omitted
Y-axes represent "Million Tons"



Overall new CAP trends from 1990 on:
Items to note:

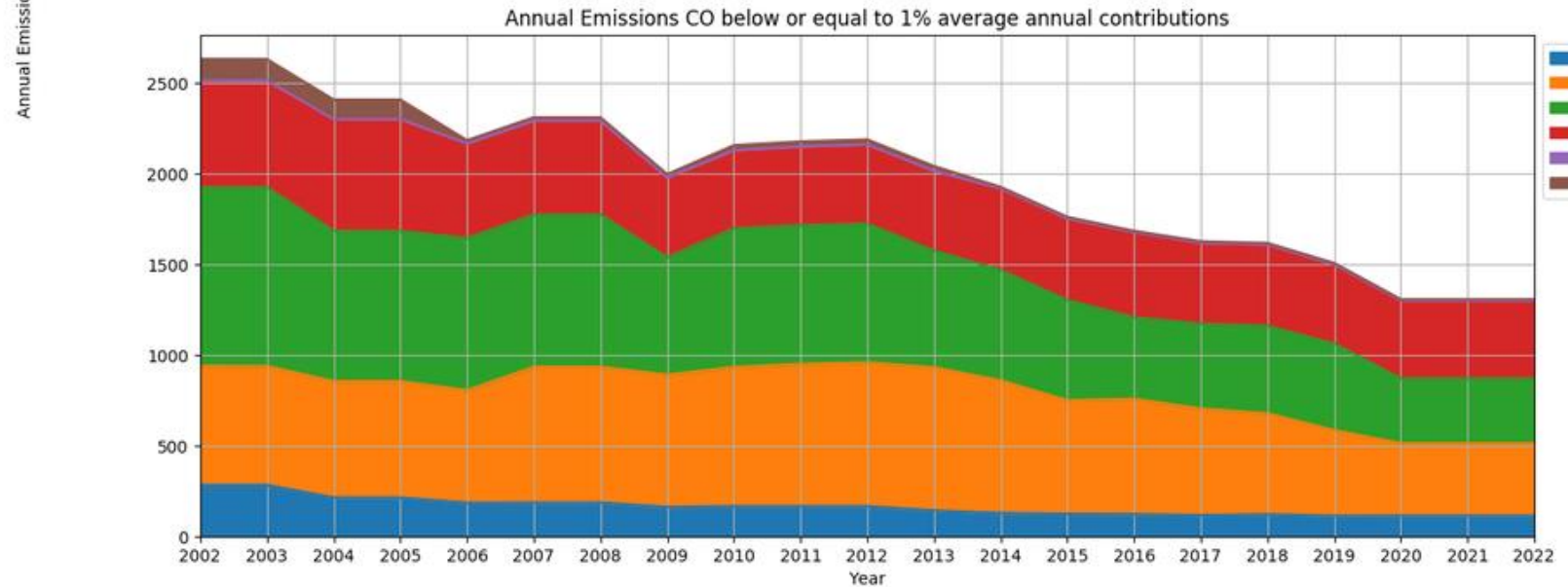
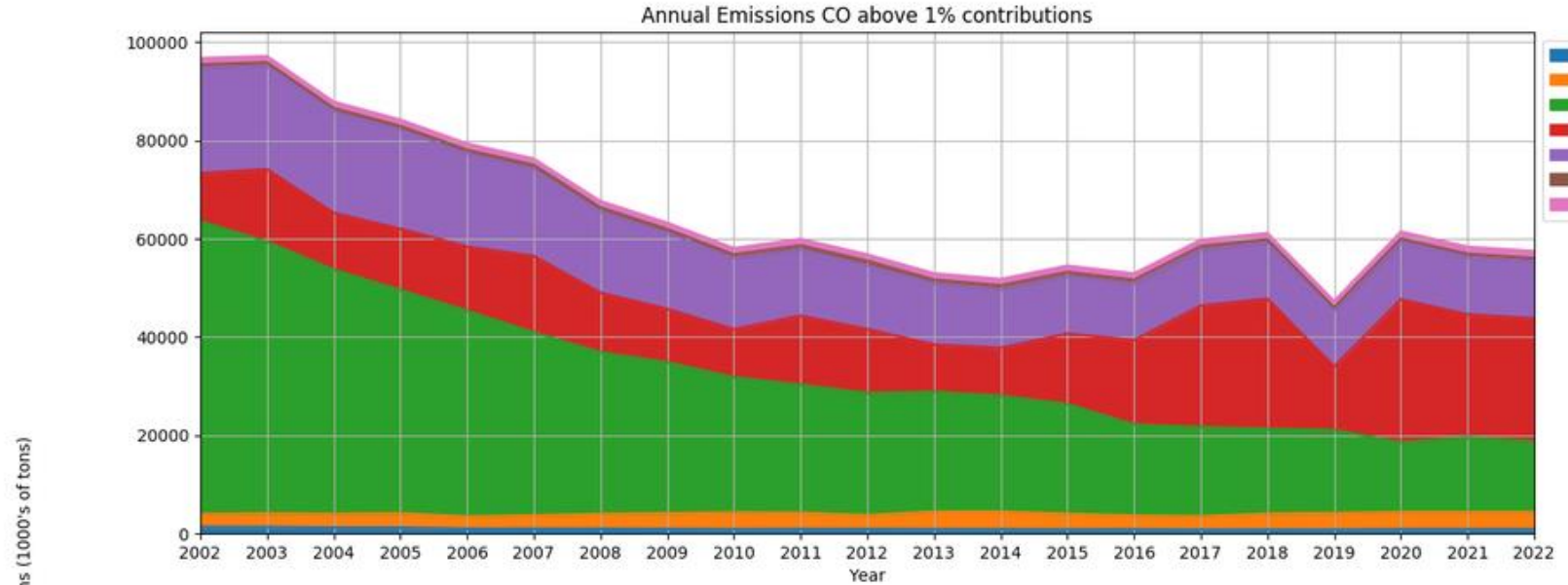
- PM2.5 shows static trends over time since 2002, POC shows similar trends
- NH3 shows an increasing trend in recent years up to 2020
- VOC flattening trends in recent years
- Carbon Monoxide shows a decreasing trend in recent years
- Large point source SO2 reductions leading to other sectors playing a role (O&G contributes about 10%) in 2020
- From 2002-2019, these trends reflect EQUATES data, which minimizes time series effects due to method changes

Old and new trends: CO

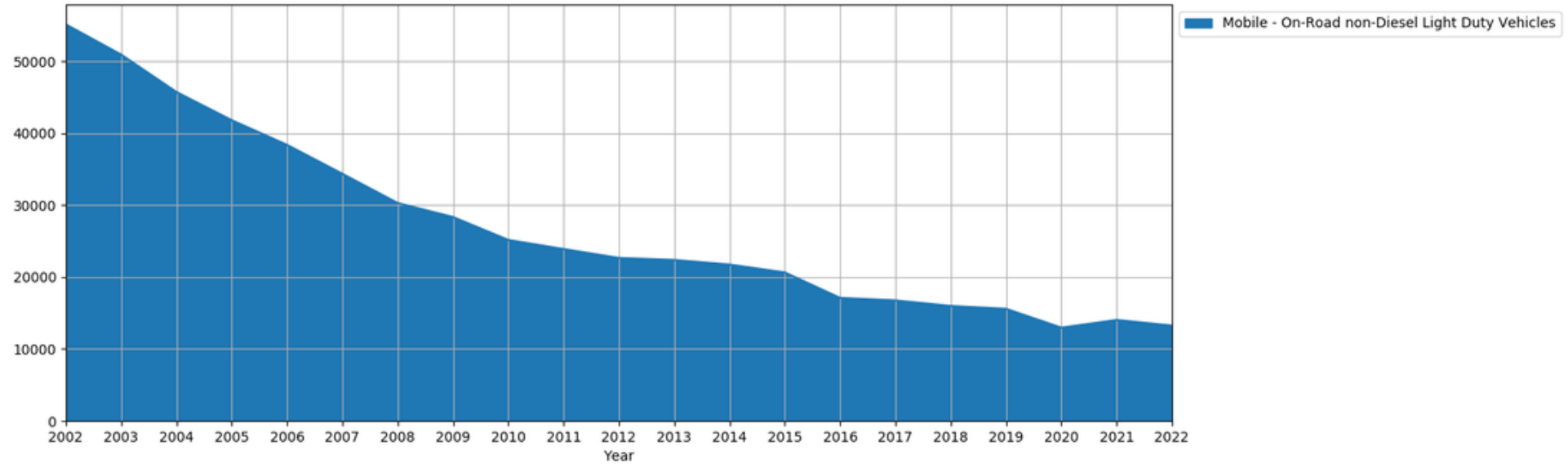


Annual Emissions CO

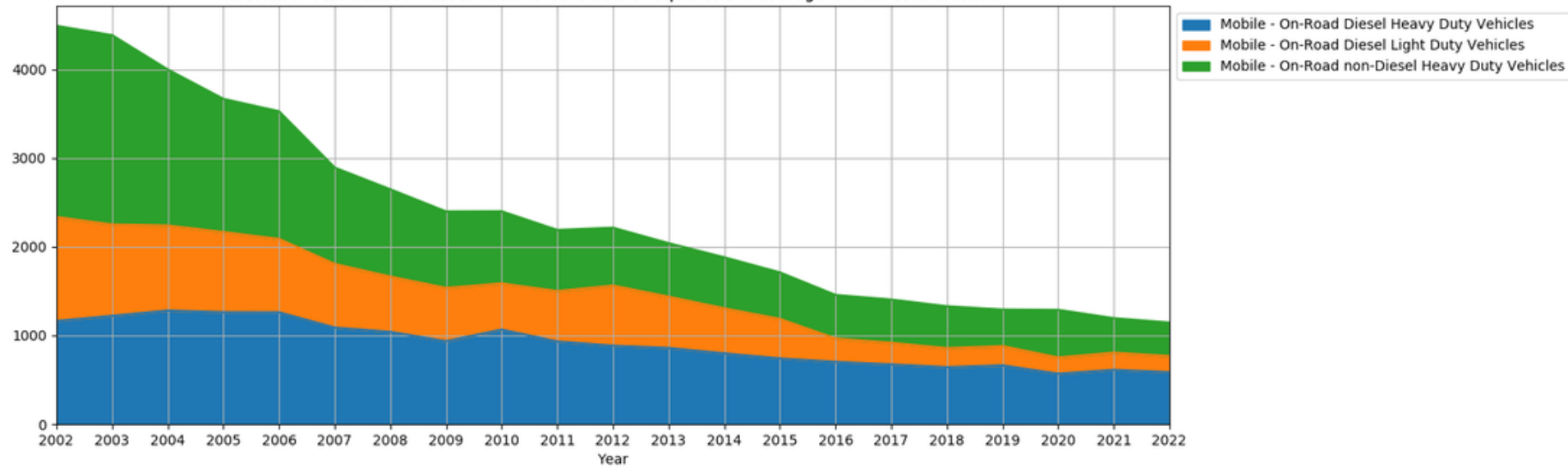
This was all that could be investigated with the previous trends information...looking at Tier 1 sectors only



HIGHWAY VEHICLES Annual Emissions CO above 5% contributions

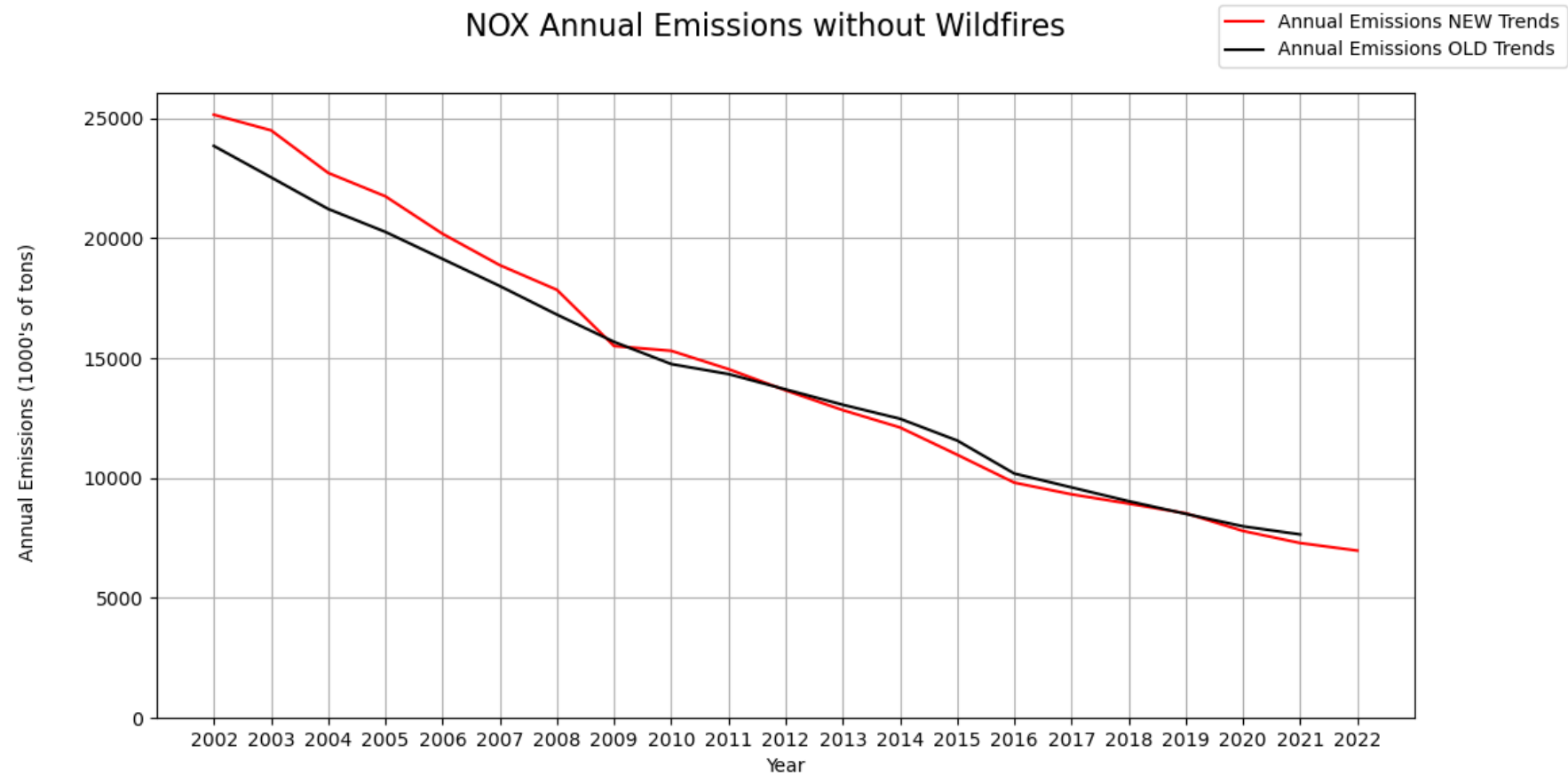


HIGHWAY VEHICLES Annual Emissions CO below or equal to 5% average annual contributions

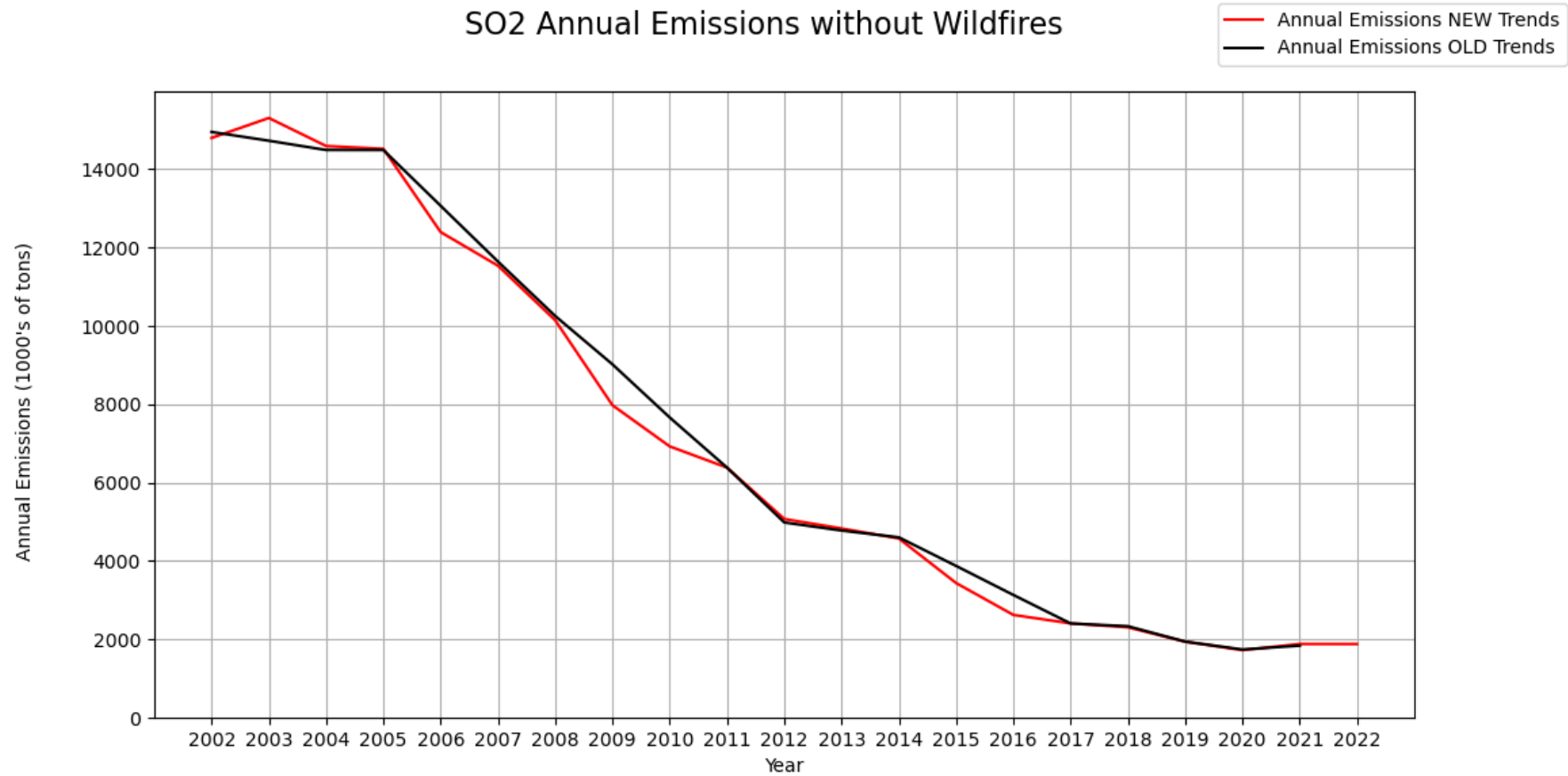


Digging deeper into the Tier 1 classifications using crosswalks developed to the current 60 EIS sectors. This could not be done with the previous data we provided

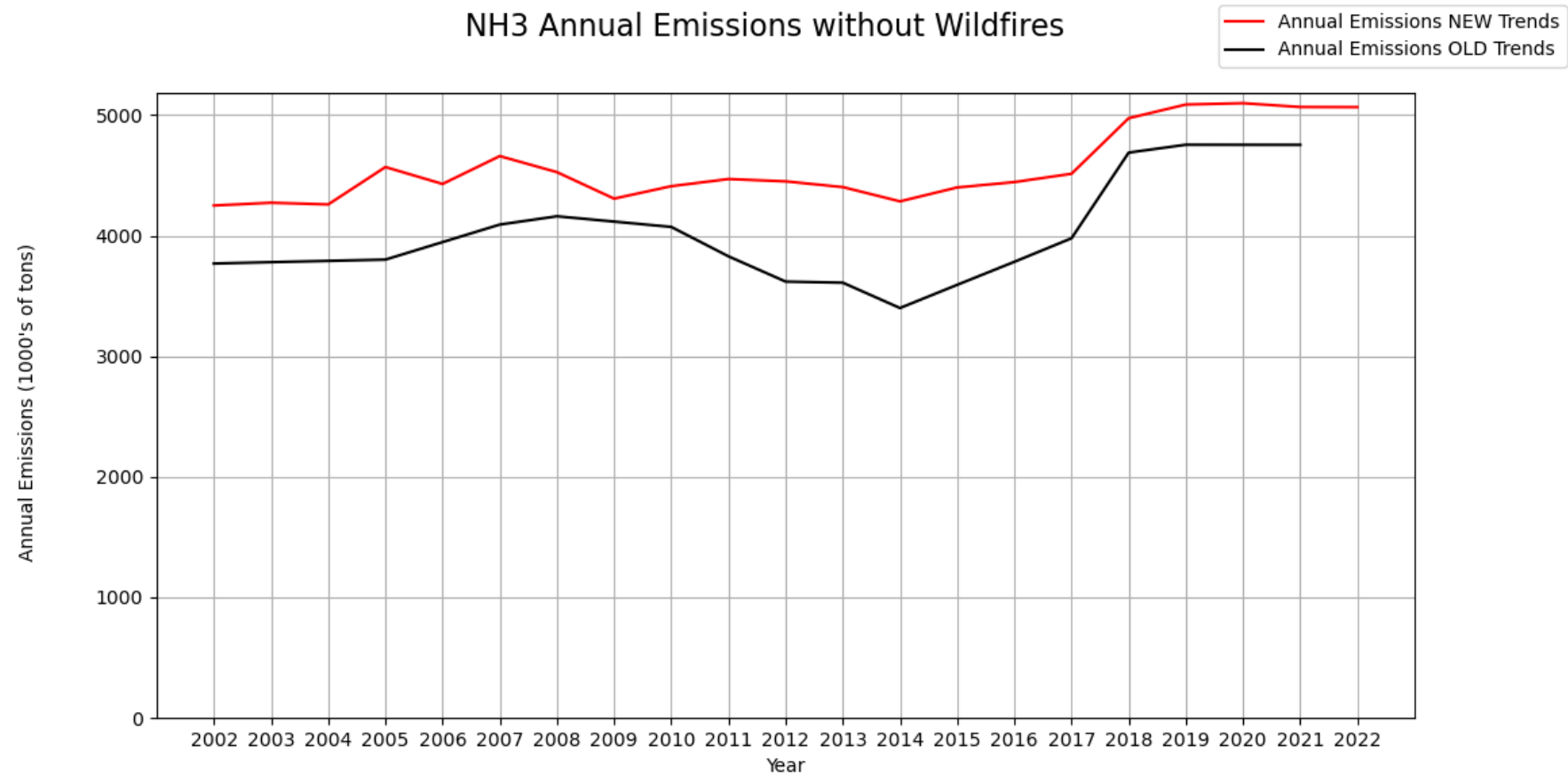
Old and new trends: NOx



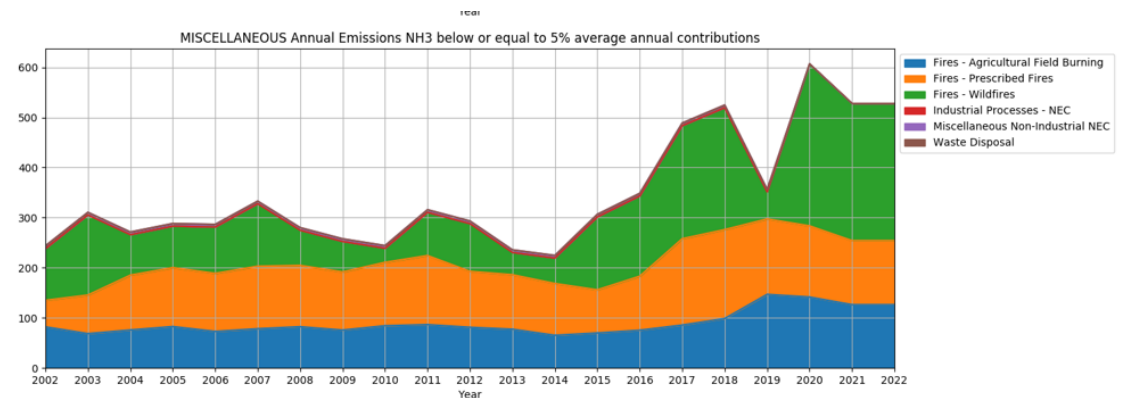
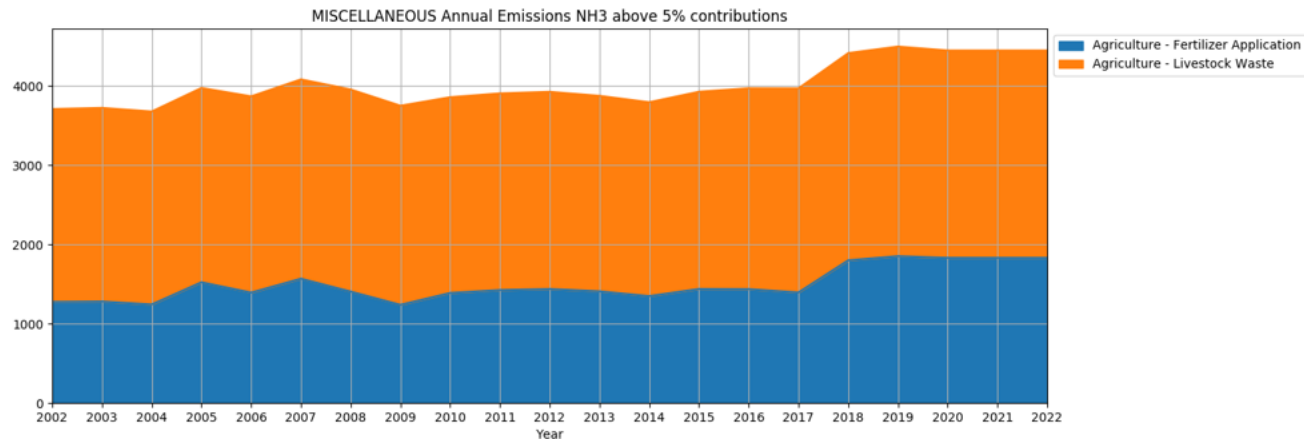
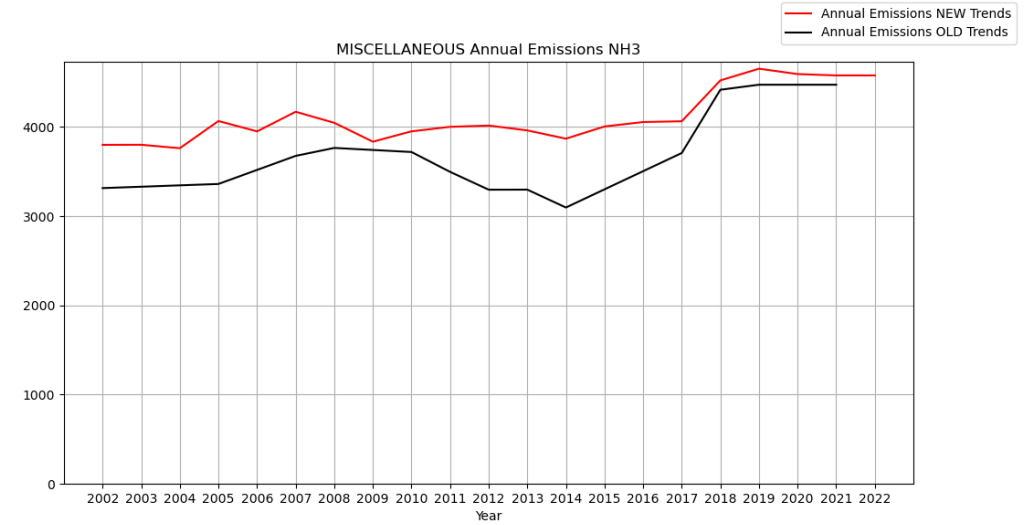
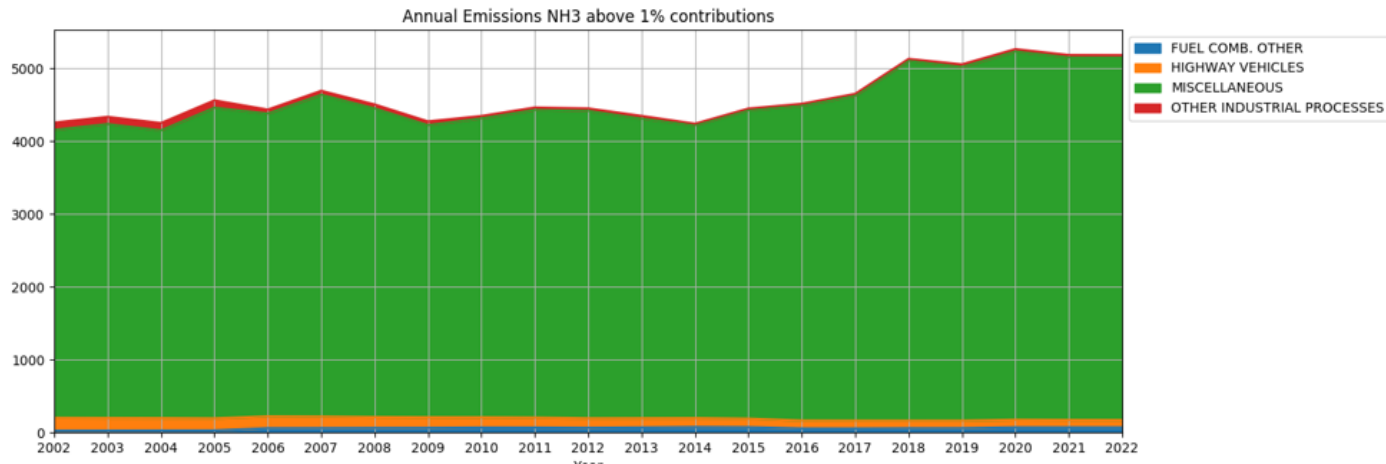
Old and new trends: SO2



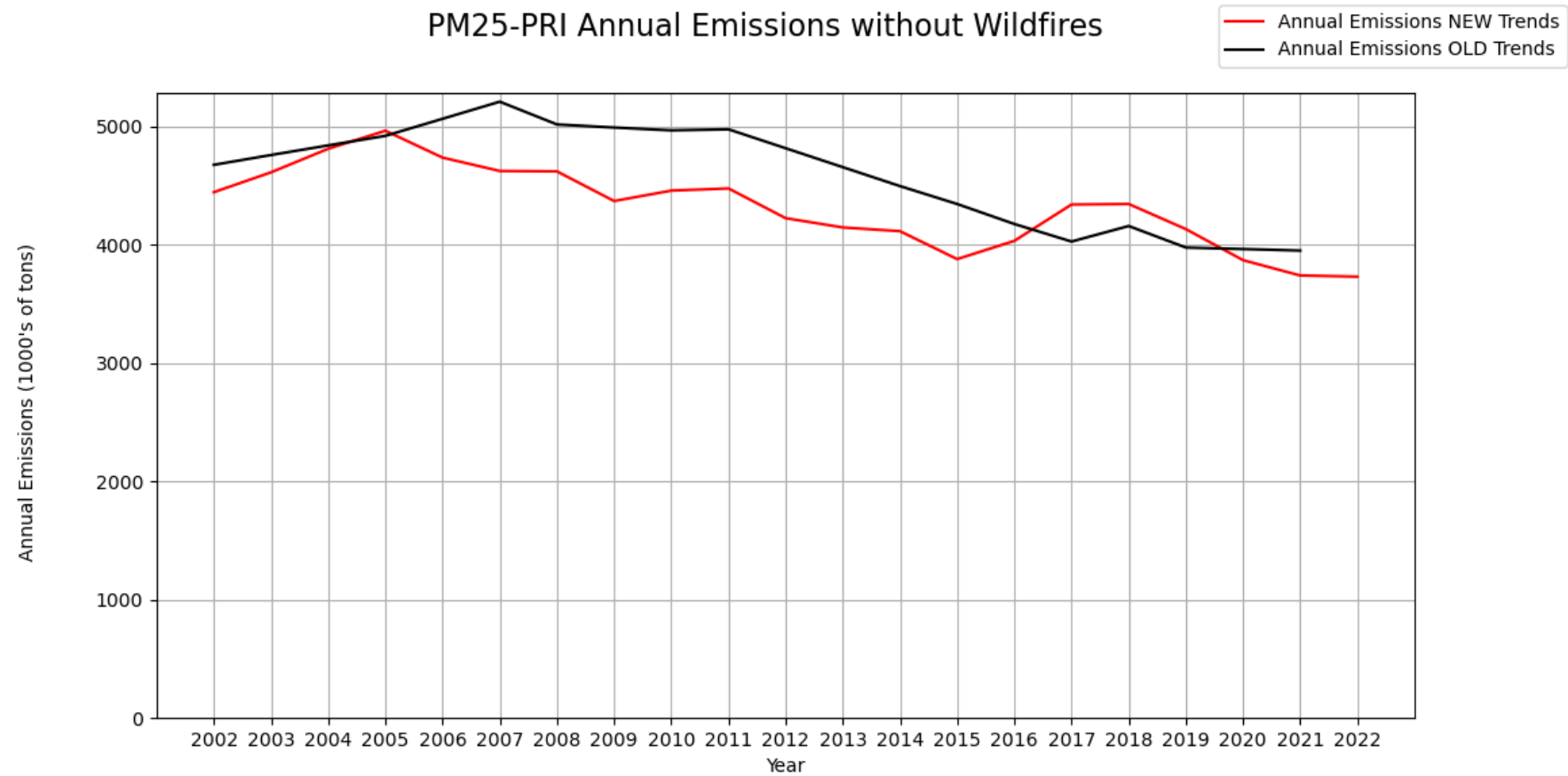
Old and new trends: NH3



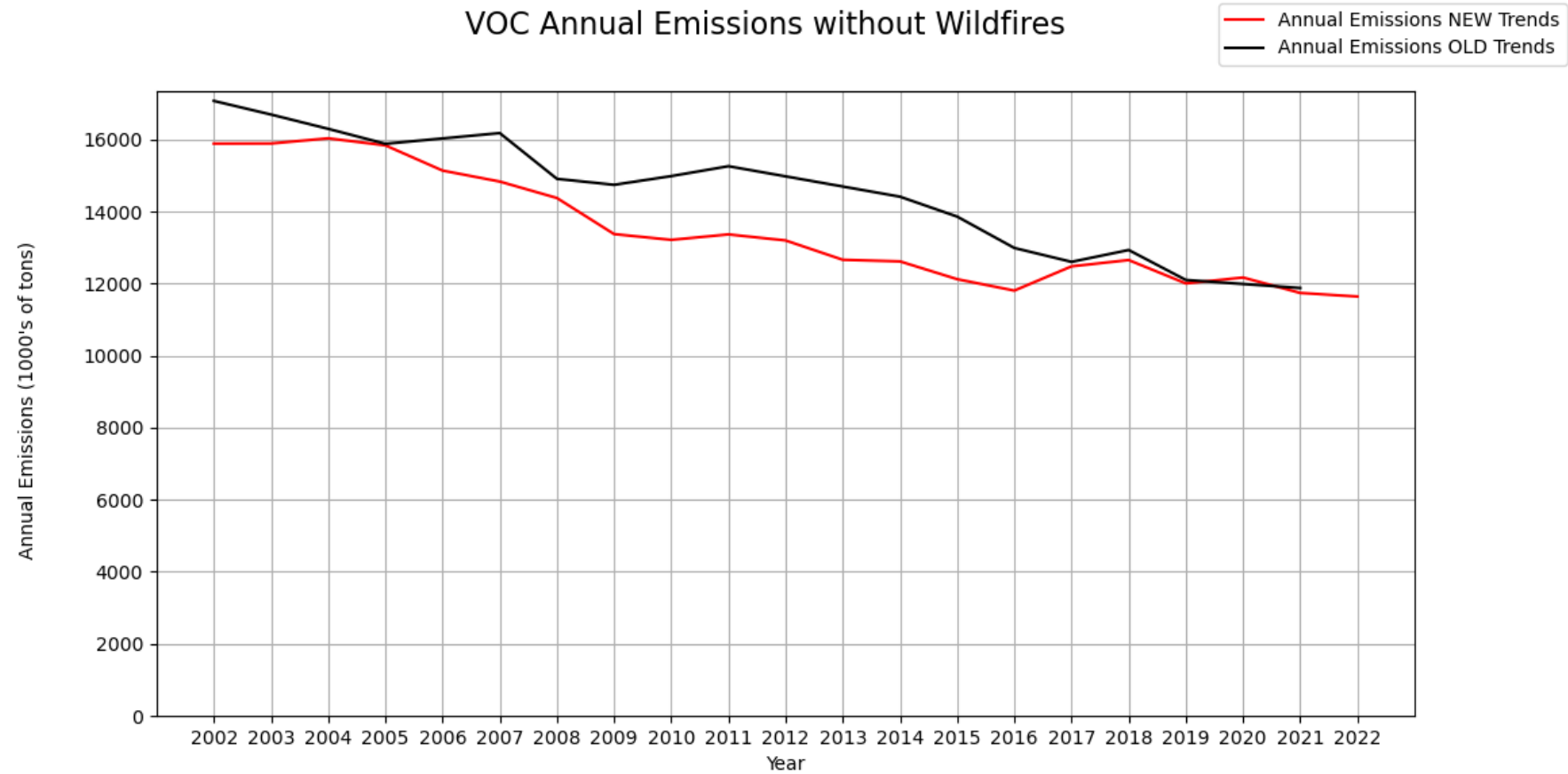
Sectors contributing to NH3 changes



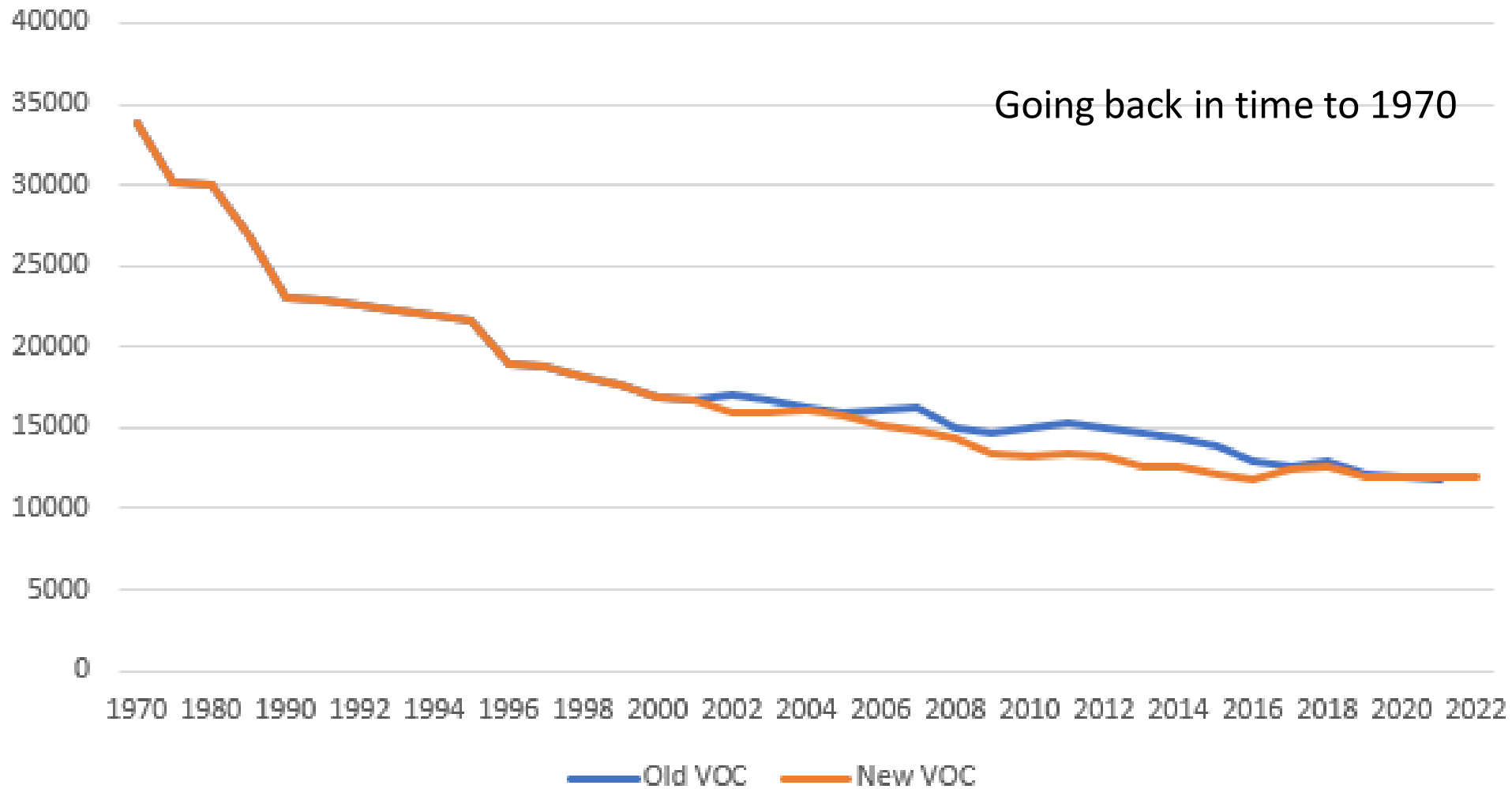
Old and New Trends: PM2.5



Old and new trends: VOC

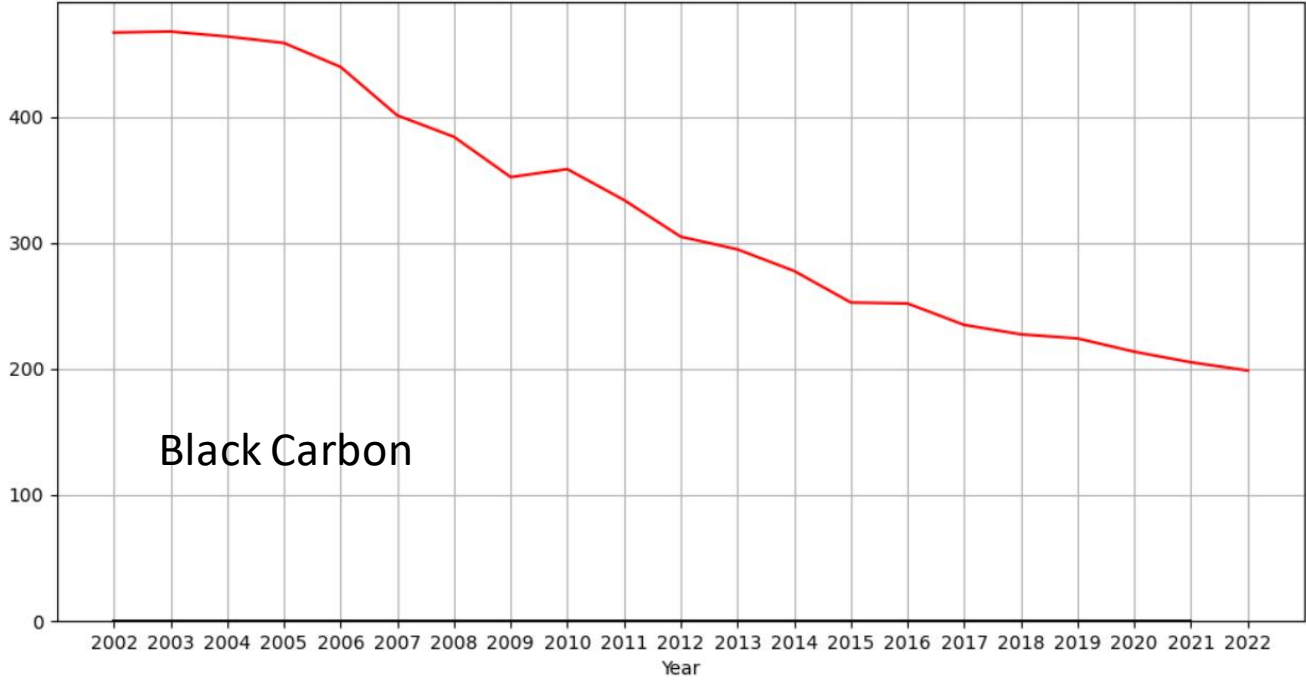


Anthropogenic VOCs, no Wildfires, x1000 tons



PEC Annual Emissions without Wildfires

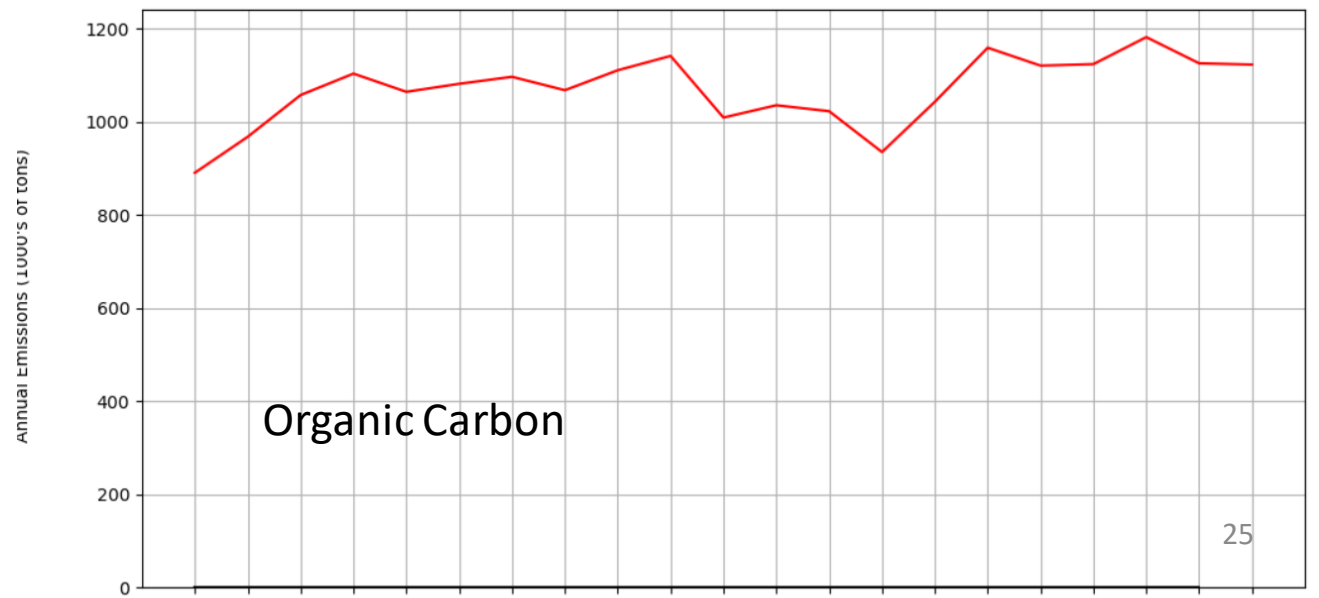
Annual Emissions NEW Trends
Annual Emissions OLD Trends



Black Carbon

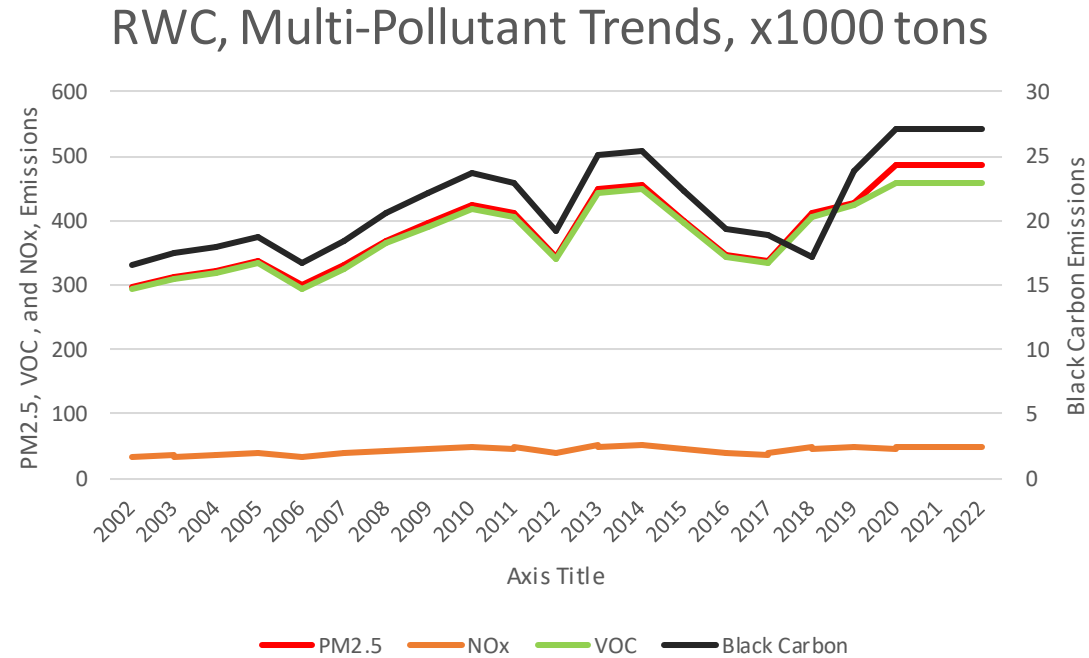
POC Annual Emissions without Wildfires

Annual Emissions NEW Trends
Annual Emissions OLD Trends



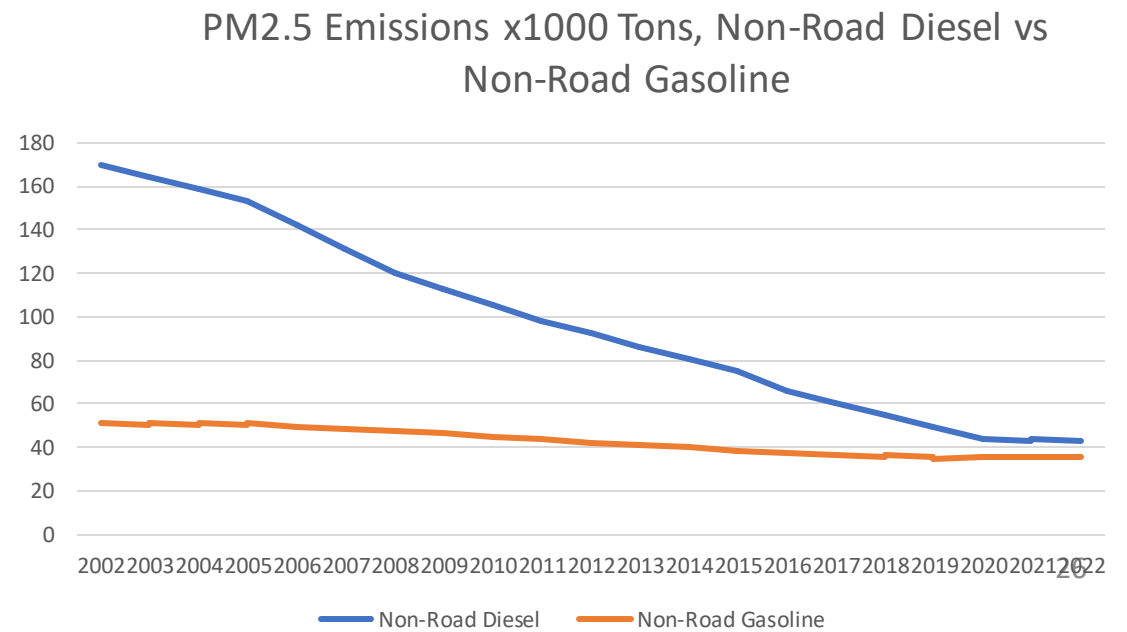
Organic Carbon

Other things you can examine now, with availability of trends data 2020-2022 at EIS sector level



← RWC SECTOR IN ISOLATION

Diesel vs Gasoline PM2.5, non-road sources →



Moving forward...

- See new interactive 2020 NEI report for data summaries, factoids about the NEI, and an ability to look at these trends as detailed in this presentation
 - <https://storymaps.arcgis.com/stories/d7d730f974c6474190b142a49ae8d3bd>
- Develop HAP trends
 - Use EQUATES methods as much as possible
 - Point source HAPs likely better represented by data in the NEI rather than using speciation to get individual HAPs
 - Considering using 2002 as a baseline year to help with transparency

Thank You! rao.venkatesh@epa.gov

Summary of Emission Methods in EQUATES for 2002-2017

Source	Category Name(s)	Brief Method Description
Agriculture	ag	NH3 fertilizer emissions estimated online in CMAQ. All other emissions based on scaling 2017 NEI values based on USDA animal head counts.
Electrical Generating Units	ptegu, cem	Use existing data (from multiple NEIs) for all years but processed using most recent tools/methods.
Fires	ptfire, ptfire_grass, ptagfire	Based on new methods (Pouliot, 2020 CMAS presentation)
Fugitive Dust	afdust	For ag dust, unpaved road dust, and paved road dust, use 2017 NEI data and scaling factors based on activity surrogates. All other sources use 2017 NEI data for all years
Mobile – Airports	airports	Use 2017 NEI data and scaling factors based on FAA Terminal Area Forecast data
Mobile - Commercial Marine Vessels	cmvc1c2, cmvc3	Use 2017 NEI data and scaling factors based on regional fuel consumption as an activity surrogate with additional pollutant-specific adjustments for fuel standards
Mobile – Nonroad	nonroad_gas, nonroad_diesel	Estimated using MOVES2014b supplemented with new data for CA and TX
Mobile – Onroad	onroad_gas, onroad_diesel	Estimated using MOVE3 supplemented with new data for CA
Mobile - Rail	rail	Use 2017 NEI data and scaling factors based on fuel sales data as an activity surrogate with additional adjustment for specific pollutants to account for regulation and sulfur technology
Oil and Gas	pt_oilgas	Use year-specific modeling platform data (based on multiple NEIs)
Oil and Gas	np_oilgas	Oil and Gas Tool
Other Nonpoint Sources -Commercial Cooking	nonpt	Use year-specific modeling platform data (based on multiple NEIs)
Other Nonpoint Sources -Fuel Combustion	nonpt	Commercial and Industrial Biomass use 2017 NEI data and scaling factors based on national -level consumption data. For all other emissions use year-specific modeling platform data (based on multiple NEIs).
Other Nonpoint Sources - Gas Stations	nonpt	Linear interpolation between 2002 and 2017 modeling platform data
Other Nonpoint Sources - Industrial Processes	nonpt	Use year-specific modeling platform data (based on multiple NEIs)
Other Nonpoint Sources - Miscellaneous	nonpt	2017 NEI data for all years
Other Nonpoint Sources - Waste Disposal	nonpt	Use 2017 NEI data for all years, except composting. For composting scale 2017 NEI values based on activity surrogate.
Other Point Sources - Fuel Combustion	ptnonipm	Use year-specific modeling platform data (based on multiple NEIs)
Other Point Sources - Gas Stations	ptnonipm	Linear interpolation between 2002 NEI and 2017 NEI data.
Other Point Sources - Industrial Processes	ptnonipm	Use year-specific modeling platform data (based on multiple NEIs)
Other Point Sources - Miscellaneous	ptnonipm	2017 NEI data for all years
Other Point Sources - Waste Disposal	ptnonipm	Use 2017 NEI data for all years.
Residential Wood Combustion	rwc	Scale 2017 NEI values based on national -level consumption data
Volatile Chemical Products including Solvents	np_solvents	Based on new method (Seltzer et al., 2021)