U.S. Environmental Protection Agency

Modeling the Clear Skies Act

STAPPA/ALAPCO
July 30, 2003

Topics

- Overview of analysis and results
  - Years and strategies modeled
  - $PM_{2.5}$ and ozone model results
- Updates and improvements from previous Clear Skies modeling (CSI 2002)
- Details on $PM_{2.5}$ reductions and remaining $PM_{2.5}$ components

What Was Modeled for CSA 2003?

- The REMSAD model was used for $PM_{2.5}$ & Hg
  - REMSAD modeling is for the full year
  - National domain

- CAMx was used for ozone
  - CAMx modeling is for three 1995 episodes, 30 days total
  - Eastern domain only

- Base year 1996/2001
  - 1996 for model performance evaluation
  - 2001 for future year projections

- New 2010 and 2020 base cases

- New 2010 and 2020 CSA control cases

Number of Nonattainment Counties: $PM_{2.5}$ and 8-Hour Ozone

$PM_{2.5}$ Annual Average

East

	Counties	2000 Population
1999-2001	114	42.9M
2010 Base	69	32.7M
2010 CSA Control	27	19.0M
2020 Base	43	24.8M
2020 CSA Control	8	12.3M

West

	Counties	2000 Population
1999-2001	15	22.0M
2010 Base	11	20.9M
2010 CSA Control	11	20.9M
2020 Base	10	20.9M
2020 CSA Control	10	20.9M

8-Hour Average Ozone

East

	Counties	2000 Population
1999-2001	268	86.6M
2010 Base	47	25.5M
2010 CSA Control	44	24.5M
2020 Base	23	21.7M
2020 CSA Control	20	15.6M

West

	Counties	2000 Population
1999-2001	22	24.2M
2010 Base	12	19.9M
2010 CSA Control	12	19.9M
2020 Base	7	17.8M
2020 CSA Control	7	17.8M

Modeling Improvements Compared to CSI 2002

- Updated ambient design values ($PM_{2.5}$ and ozone)
- Speciated modeled attainment test ($PM_{2.5}$ only)
- New current year inventory (2001) ($PM_{2.5}$ and ozone)
- New future year inventory files ($PM_{2.5}$ and ozone)
- Newest version of REMSAD ($PM_{2.5}$ only)

New Ambient Design Values

- Using updated design values for the 1999-2001 period (PM2.5 and ozone)
  - CSI 2002 used PM2.5 data from 1999-2000 and ozone data from 1997-1999
  - The new PM2.5 design values are generally lower
- Ambient data from complete sites only (3 years of complete data)

Base Year Design Values

- 1999-2001 were used because they are the most current official values
  - The emissions inventory period is 2001
- Draft 8-hour ozone guidance says to use the higher of the most current DV period or the period straddling the emissions inventory year
  - 1999-2001 was the most current year **and** closest to "straddling" the inventory year
- Draft PM2.5 guidance says to use the highest of the 3 DV periods that coincide with the emissions inventory year
  - This would be 1999-2001, 2000-2002, and 2001-2003
  - Only data available was 1999-2001
- The ozone and PM modeling guidance need to be re-evaluated and coordinated before being finalized

What is the modeled attainment test (MAT)?

- Uses model results in a "relative" sense
- Ambient data is combined with model output to estimate future year concentrations (design values)
  - Relative Reduction Factor = model predicted (%) change in pollutant(s) from base year to future year
  - Base year DV * Relative Reduction Factor = Future year DV
- MAT for PM2.5 uses all of the PM2.5 component species (speciated MAT)

Speciated Modeled Attainment Test

- CSI 2002 used an “unspeciated” modeled attainment test (for PM2.5)
- CSA 2003 is using the “speciated” modeled attainment test (SMAT)
  - Modeled % reduction for **each** of the PM 2.5 species is applied to the ambient measurements (by quarter)
- SMAT shows larger percent $PM_{2.5}$ reduction from current base to future year
  - More influence from the largest ambient components (sulfate and organic carbon)
  - Less influence from smaller components (crustal, elemental carbon, and in some areas nitrate)
- Fewer nonattainment counties in the future compared to unspeciated modeled attainment test

Example Calculation for Quarter 2 in Atlanta (2020)

"Unspeciated" Modeled Attainment Test

	Ambient Data April-June (ug/m3)	Modeled RRF	2020 DV (ug/m3)
PM2.5	17.67	0.970	**17.14**

Speciated Modeled Attainment Test

	Ambient Data April-June (ug/m3)	Modeled RRF	2020 DV (ug/m3)
Sulfate	7.31	0.88	6.43
Nitrate	1.02	0.92	0.94
EC	0.89	0.63	0.56
OC	6.05	0.94	5.69
Crustal	1.30	1.29	1.68
Unatributed	1.10	1.00	1.10
PM2.5	17.67	----	**16.40**

-Model severely overpredicts the crustal component which is increasing in the future (29% in this example)

-One of the main causes of higher future year design values in the "unspeciated" example

Base Year Emissions

- There is an inconsistency between the 1999-2001 ambient data and the 1996 base year for modeling (1996 emissions and meteorology)
  - There are some significant emissions reductions that occurred between 1996 and 2001
  - Using the 1996 base emissions, the speciated modeled attainment test "takes credit" for the emissions reductions in this time period (1996-2001)
    - Leads to unrealistically low future year design values
  - Therefore, we decided to move to a 2001 inventory to fix the mismatch between the emissions and the ambient data
- We created a 2001 "proxy" inventory based on ratios between the 1996 and 2001 National Emissions Inventory (NEI) and interpolations between the 1996 and 2010 modeling inventories
  - Still using 1996 meteorology

2001 Proxy Inventory

- Nonroad and mobile emissions based on ratio of 2001 and 1996 data calculated from NONROAD 2002 and MOBILE6
  - Applied by grid cell
  - Modeling inventory is still MOBILE5b “adjusted” for MOBILE6 from HDE rule modeling
- EGU emissions based on State level ratio from 2001 and 1996 CEM data
- Non-EGU and area sources interpolated between 1996 and 2010 modeling inventories

New Future Year Emissions Files

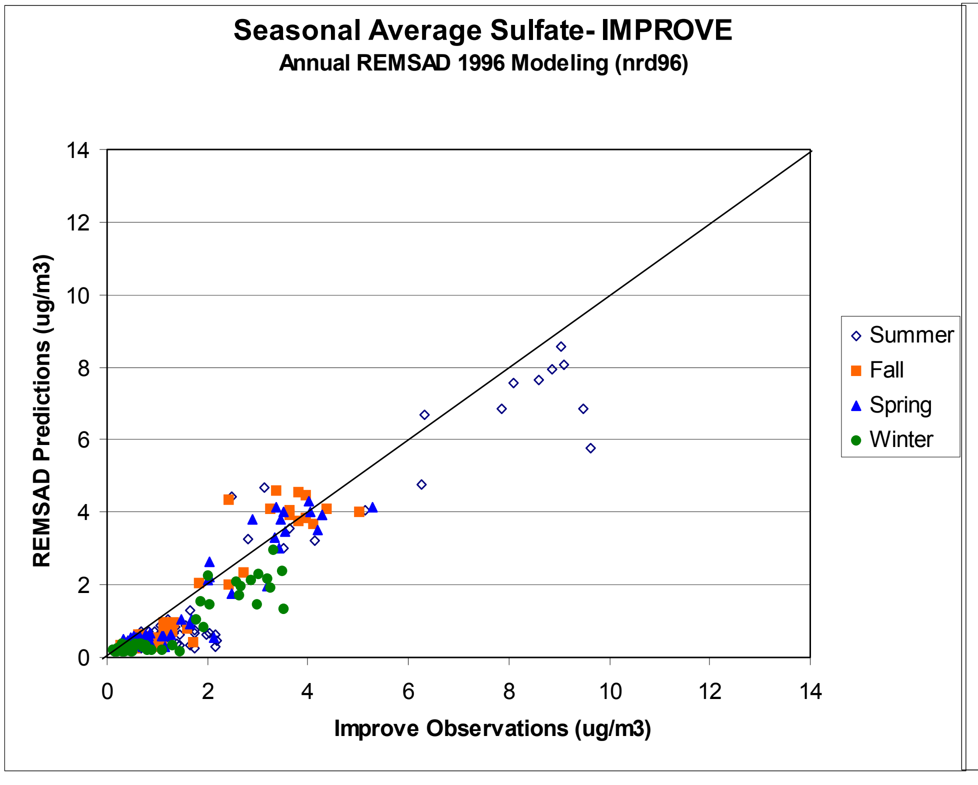
- EGU
  - New 2010 and 2020 EGU data from the Integrated Planning Model (IPM)
    - New IPM includes state NOx (NC and GA) and SO2 (NC) control programs in the base case
    - Old IPM (from 2002) included local control programs in MA, NH, TX, MO, and WI
- Nonroad
  - 2010 and 2020 proposed Nonroad rule control strategy emissions
- Mobile
  - No changes from 2002 CSI modeling
- Non-EGU and area
  - No changes from 2002 CSI

New Version of REMSAD

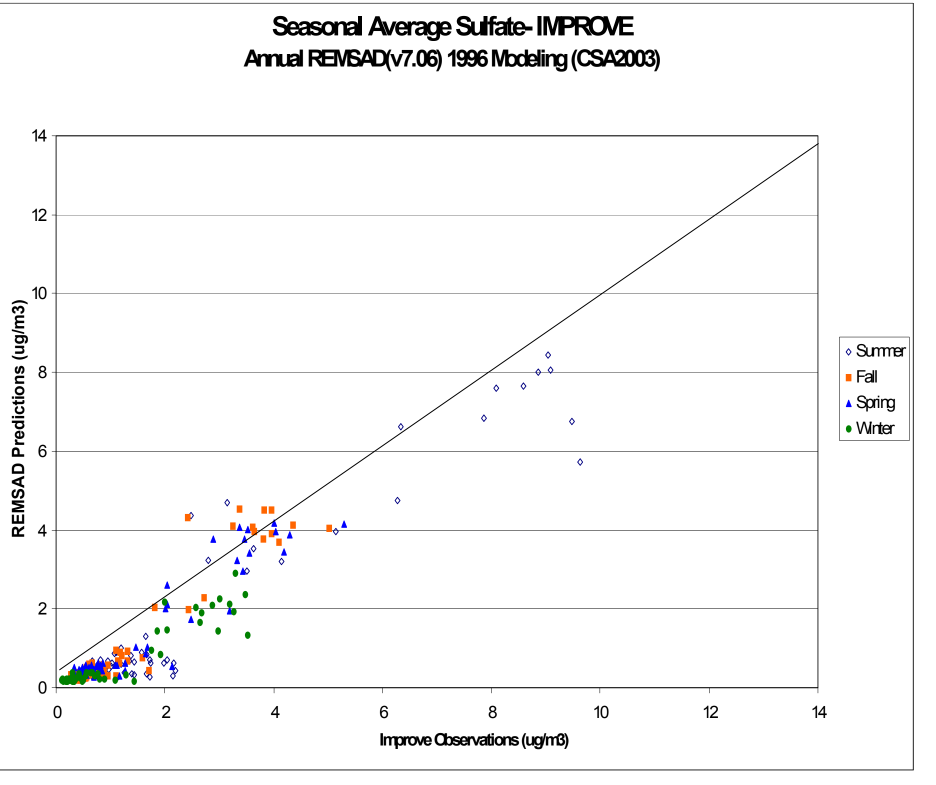
- Updates and corrections to the dry deposition code and the secondary organic aerosol (SOA) code
  - Represents bug fixes and improved understanding of the science
    - Dry deposition
      - Surface resistance for ammonia
    - SOA
      - Reference temperature for gas/particle partitioning
- Annual average nitrate increases by 25-50%
  - Better performance in the Upper Midwest
  - Worse performance in the South and East
- Annual average SOA increases by 1.5-5X
  - Much improved organic carbon performance (especially in the summer)

Seasonal Average Sulfate Performance

REMSAD v7.01

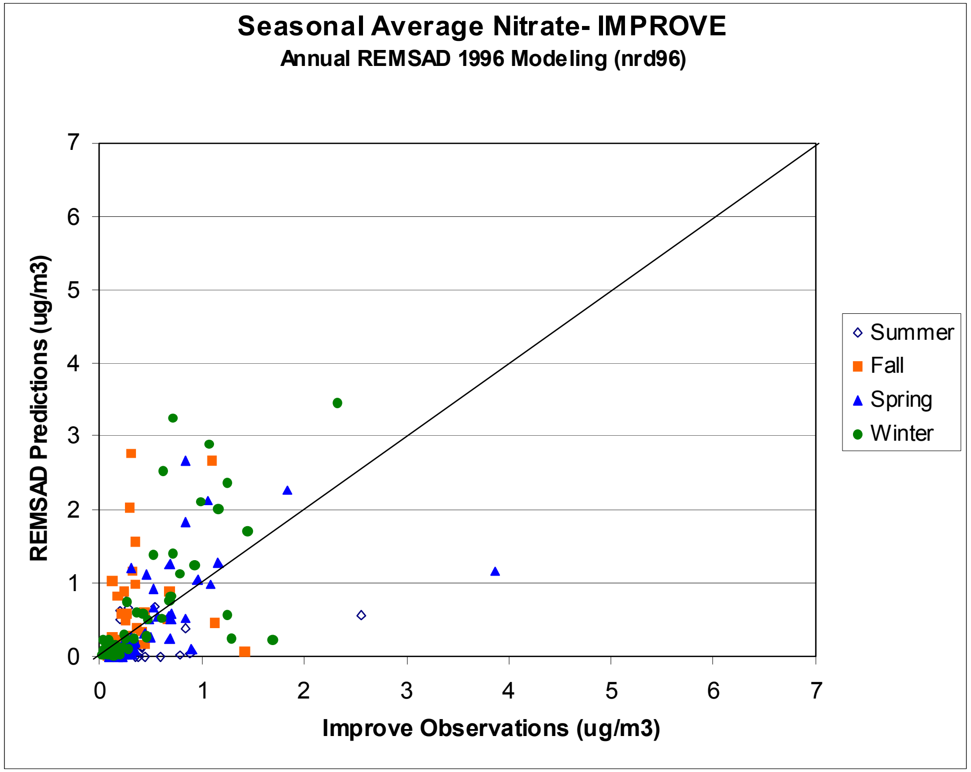


REMSAD v7.06 (CSA)

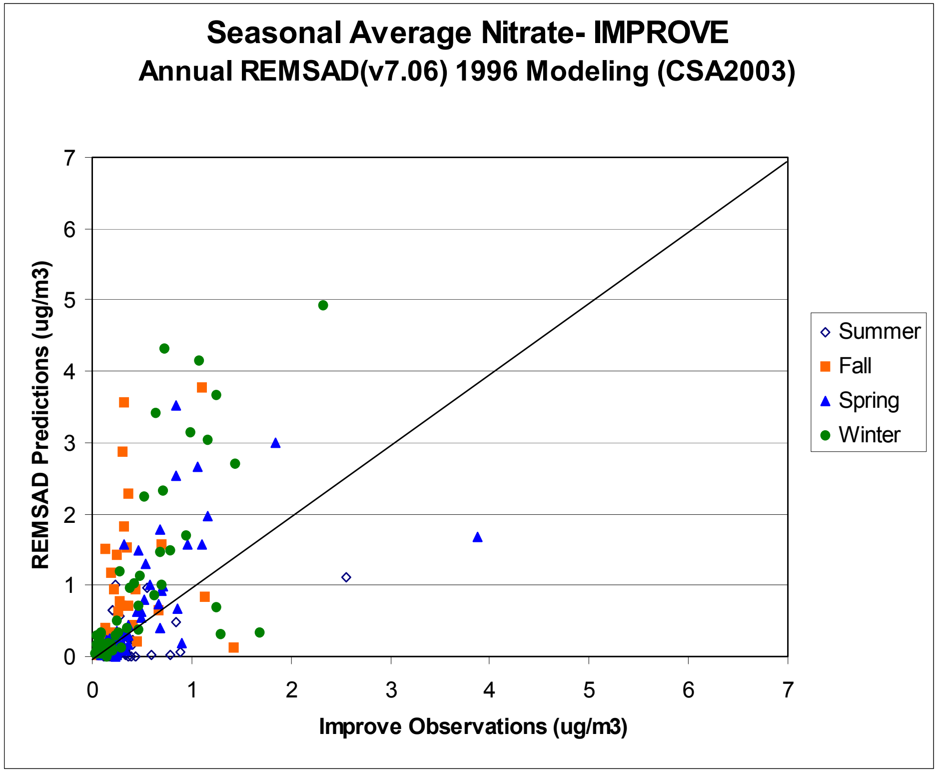


Seasonal Average Particulate Nitrate Performance

REMSAD v7.01

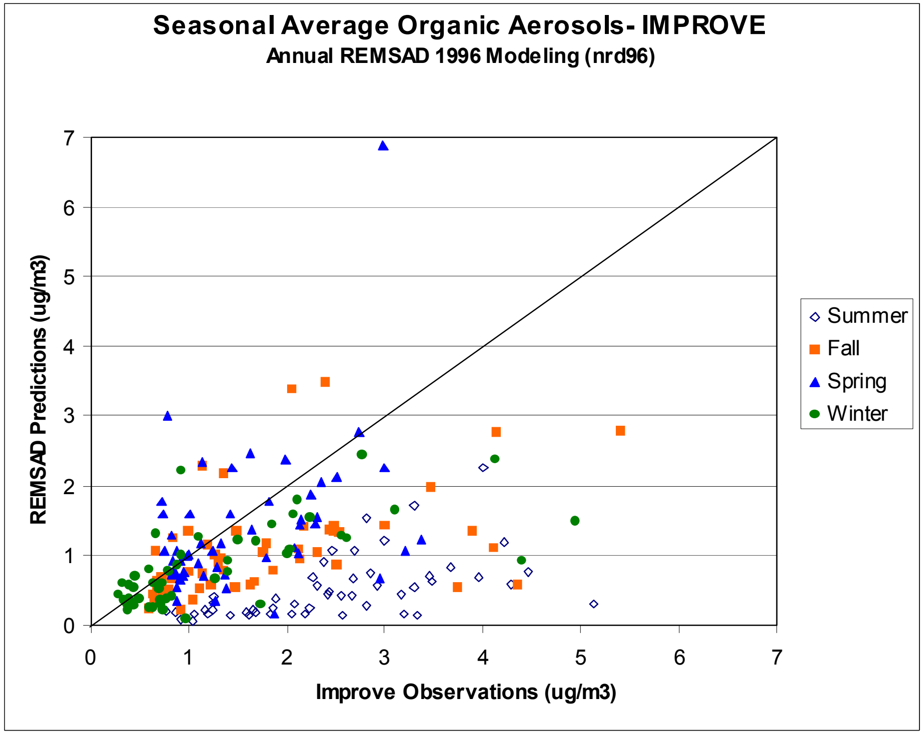


REMSAD v7.06 (CSA)

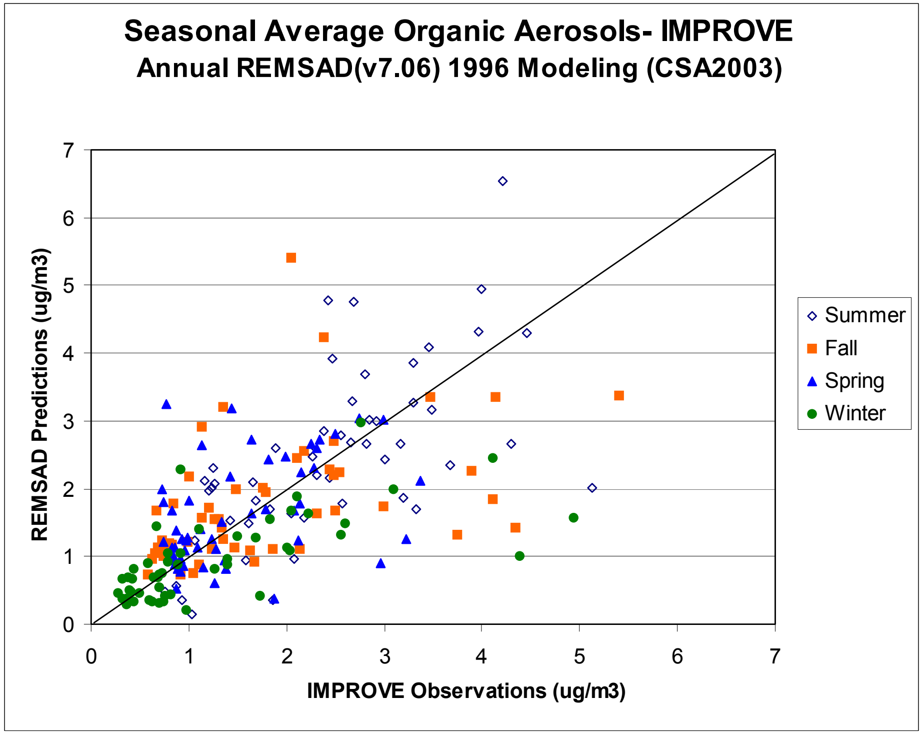


Seasonal Average Organic Aerosols Performance

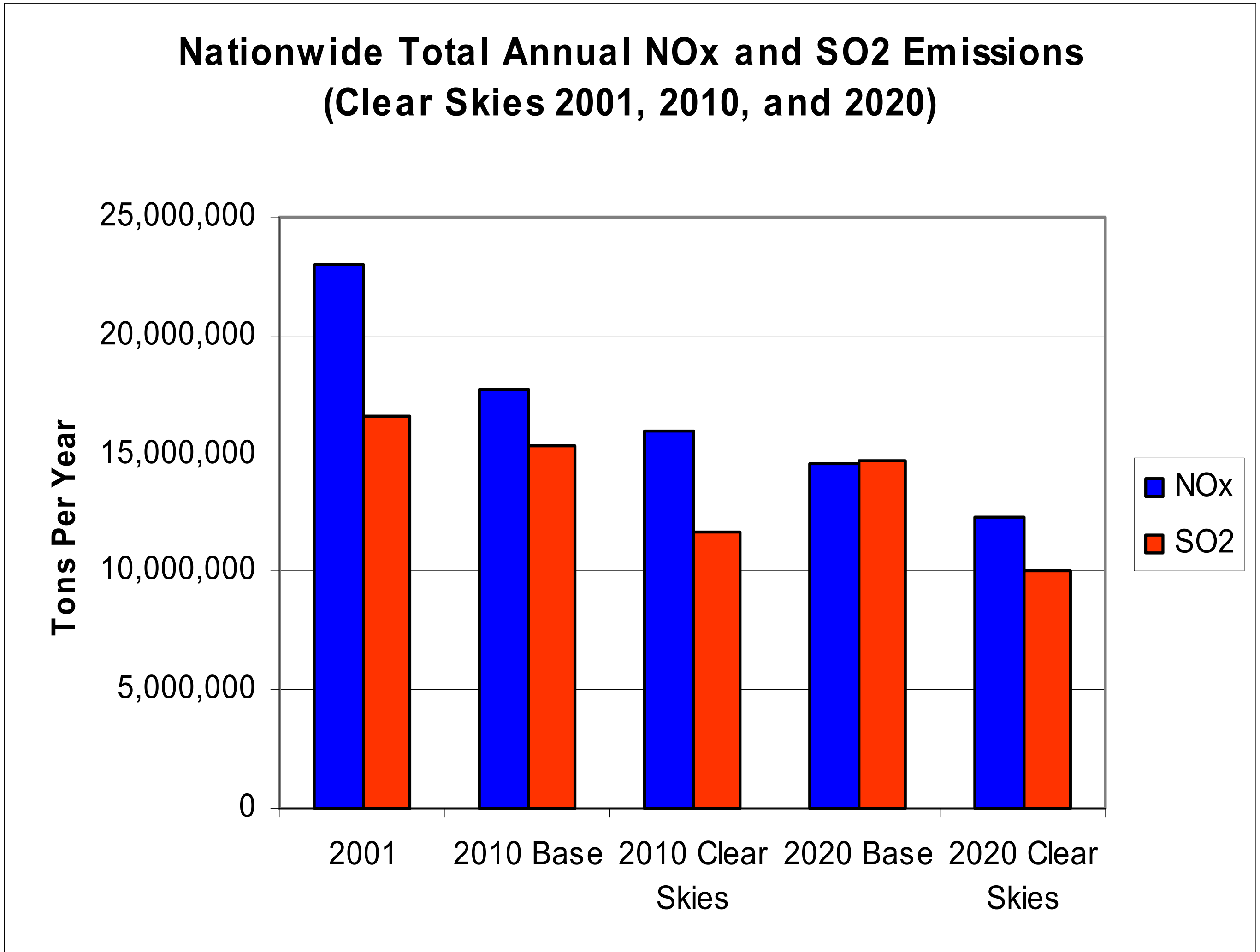
REMSAD v7.01



REMSAD v7.06 (CSA)

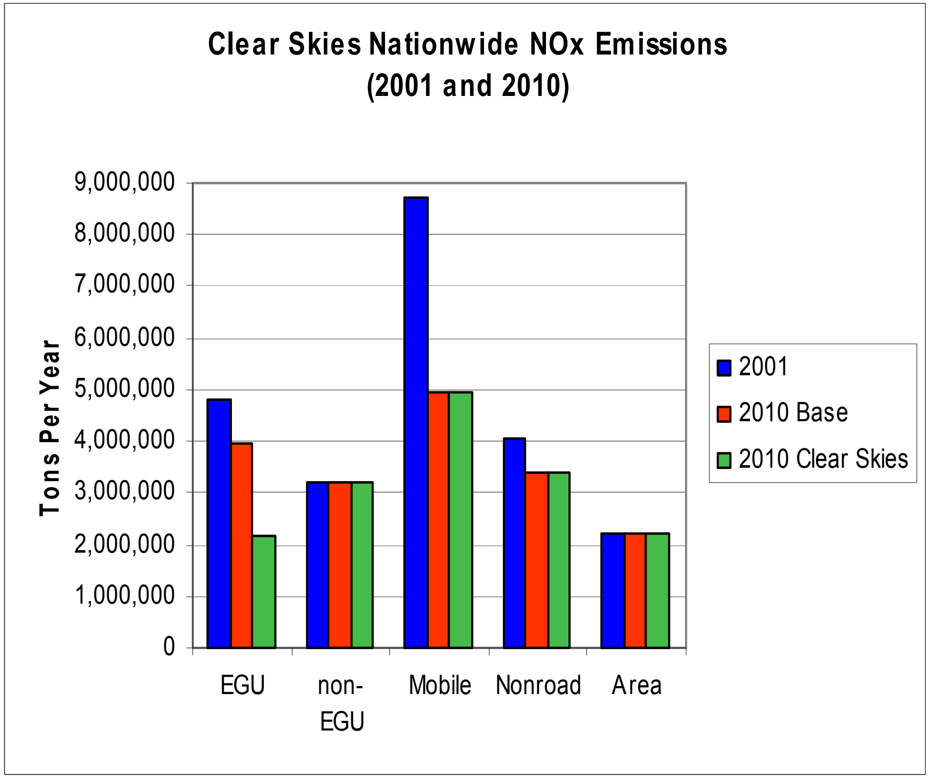


Total NOx and SO2 Emissions

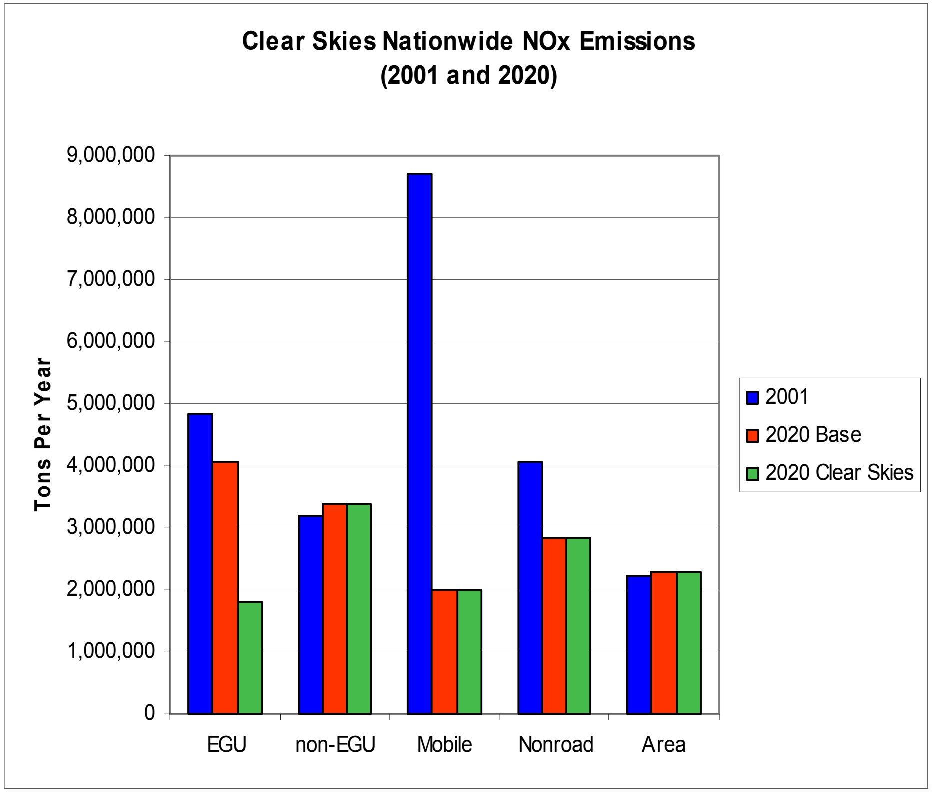


NOx Emissions- 2010 and 2020

2010

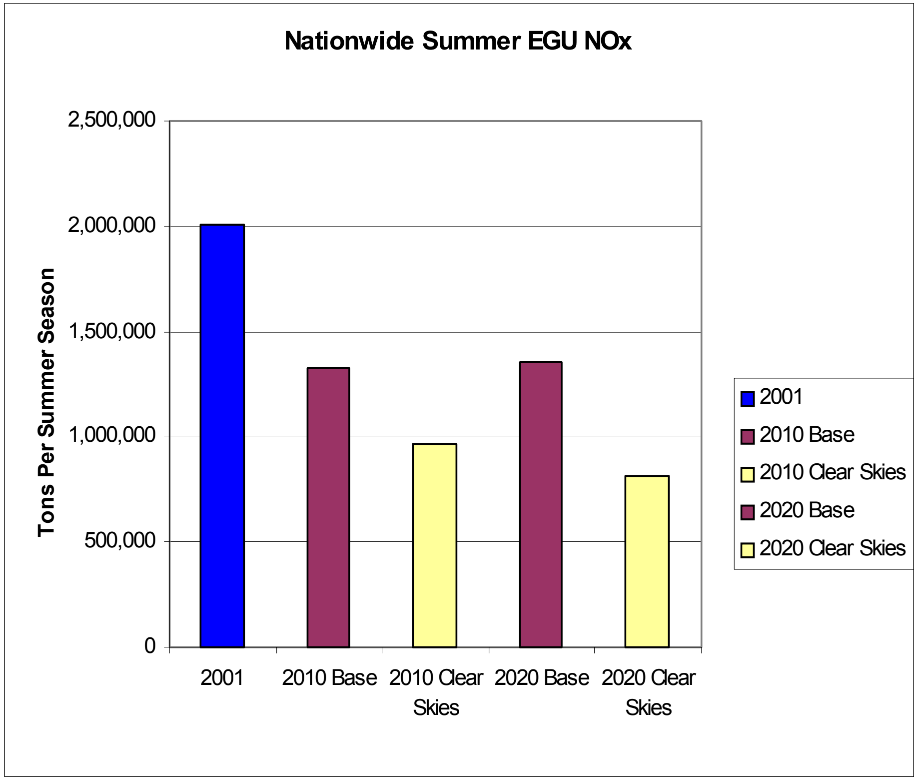


2020

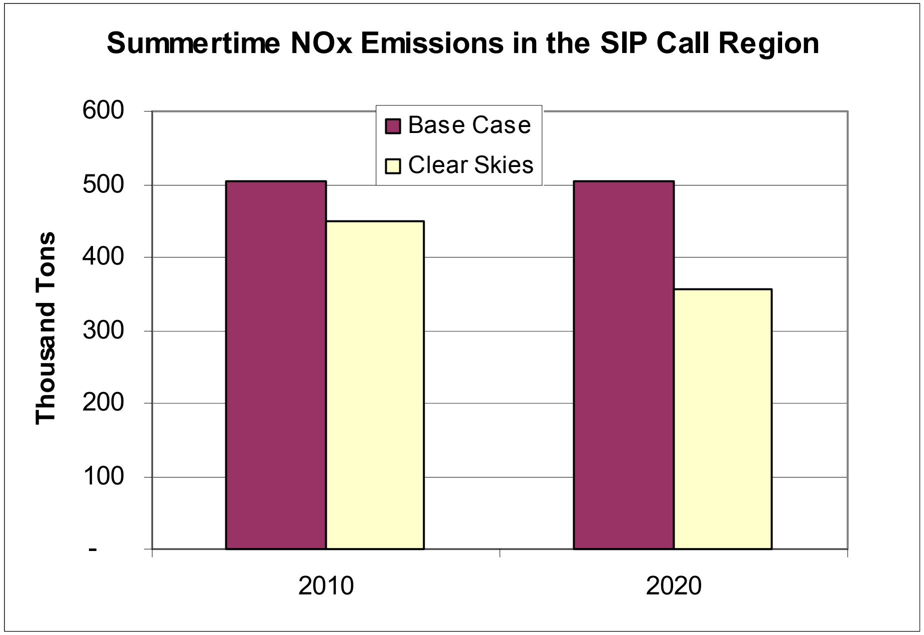


Summer EGU NOx Emissions

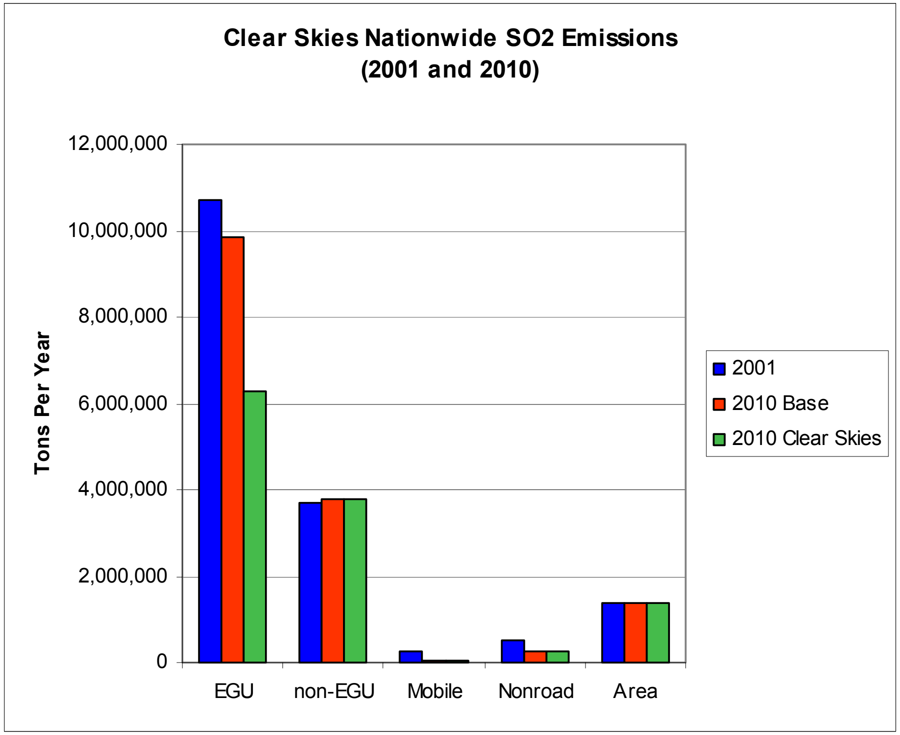
Nationwide

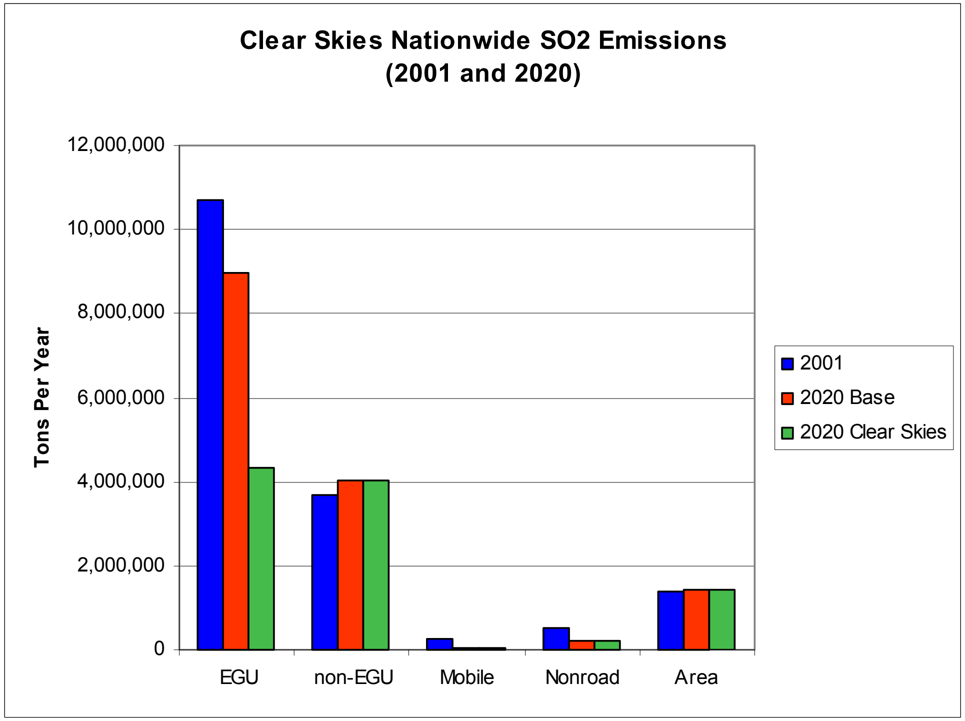


SIP Call Region

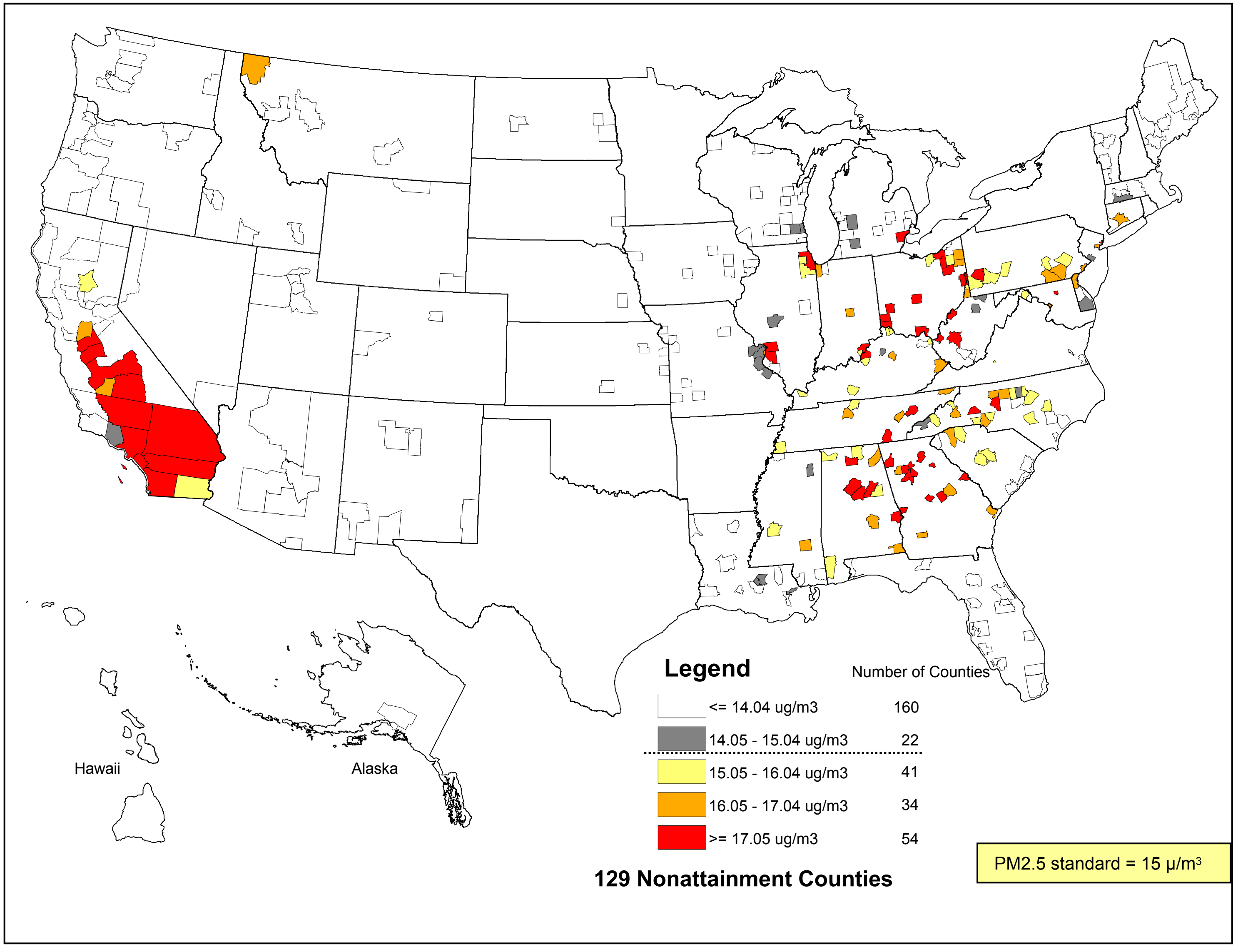


SO2 Emissions- 2010 and 2020





Current Attainment with the Fine Particle ($PM_{2.5}$) Standard (1999-2001)

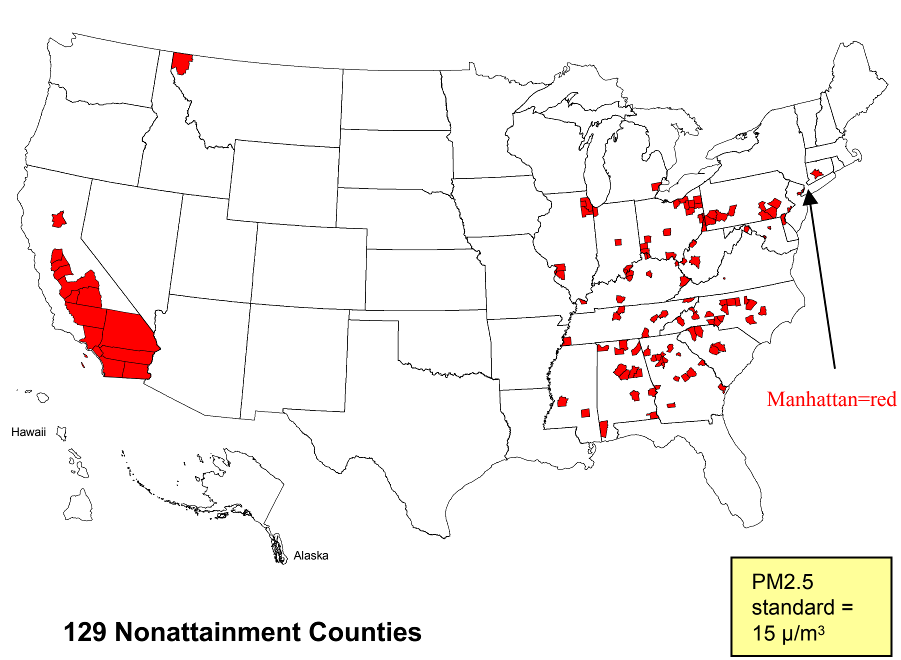


- **There are 129 counties nationwide (114 counties in the East) that are likely to exceed the annual fine particle standard of 15 μ/m³.**
- **65 million people (43 million people in the East) live in counties that would not meet this standard.**

Note: Based on 1999-2001 monitoring data of counties with monitors that have three years of complete data.

Clear Skies with Other Air Programs Would Substantially Improve Fine Particle Attainment over the Next Two Decades

Counties Exceeding the Annual Fine Particle Standard in 2001

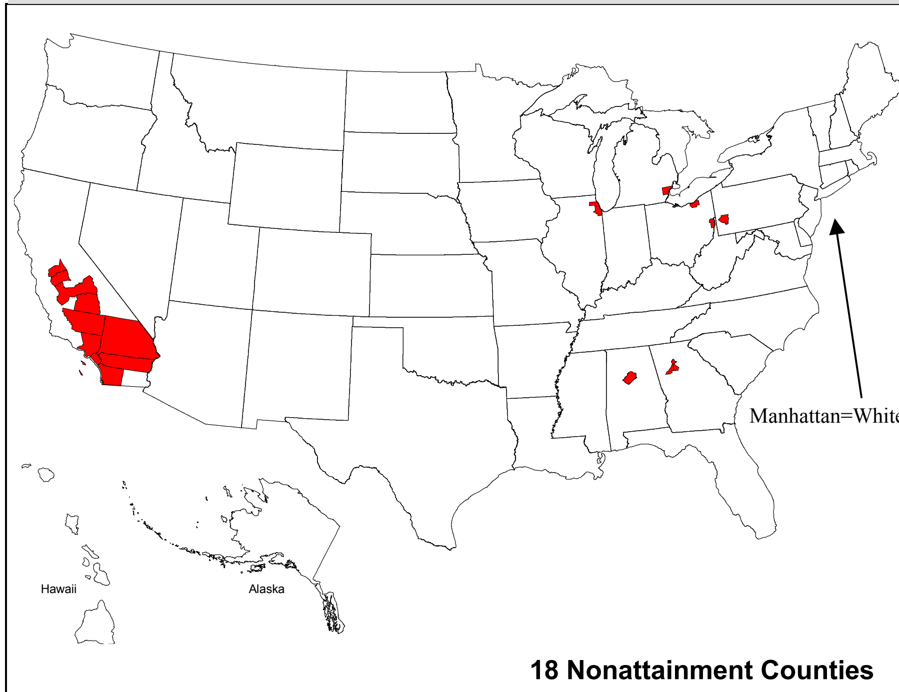


- There are 129 counties nationwide (114 counties in the East) that are currently estimated to exceed the annual fine particle standard of 15 μ/m^3.
  - 65 million people (43 million people in the East) currently live in counties that would not meet the standard.

Most counties would be brought into attainment with the $PM_{2.5}$ standard by 2020:

- **Clear Skies and existing programs will bring 111 counties (home to approximately 32 million people) into attainment with the fine particle standard (compared to current conditions).**

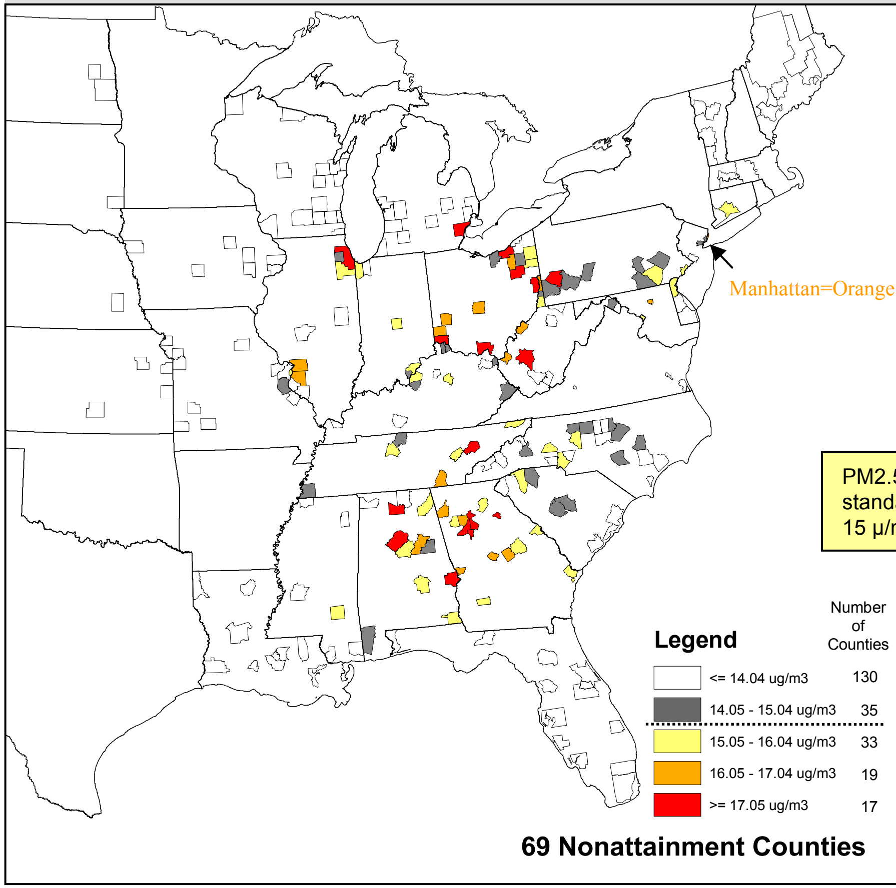
Remaining Counties Likely to Exceed the Annual Fine Particle Standard with Clear Skies in 2020



Notes: Based on 1999-2001 data of counties with monitors that have three years of complete data. Additional federal and state programs must bring all counties into attainment by 2016 at the latest. The methodology used to predict nonattainment status in the West is different than that used for the East.

Clear Skies Achieves Early Benefits by Bringing More Areas into Attainment with the $PM_{2.5}$ Standard in 2010

Remaining Counties Likely to Exceed the Annual Fine Particle Standard under the Base Case in 2010



$PM_{2.5}$ attainment status in 2010 base case:

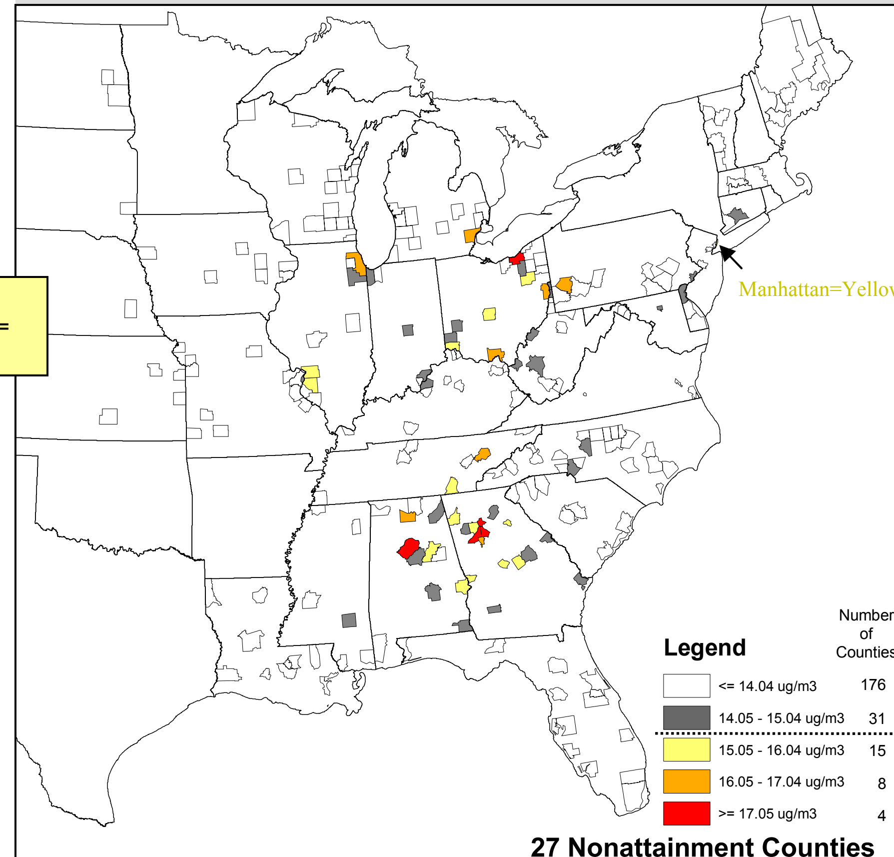
- Existing programs will bring 45 eastern counties (home to approximately 10 million people) into attainment with the fine particle standard (compared to current conditions).

PM2.5 standard = 15 μ/m³

$PM_{2.5}$ attainment status in 2010 Clear Skies case:

- Clear Skies would bring 42 additional eastern counties (home to approximately 14 million people) into attainment with the fine particle standard (as compared to the Base Case).

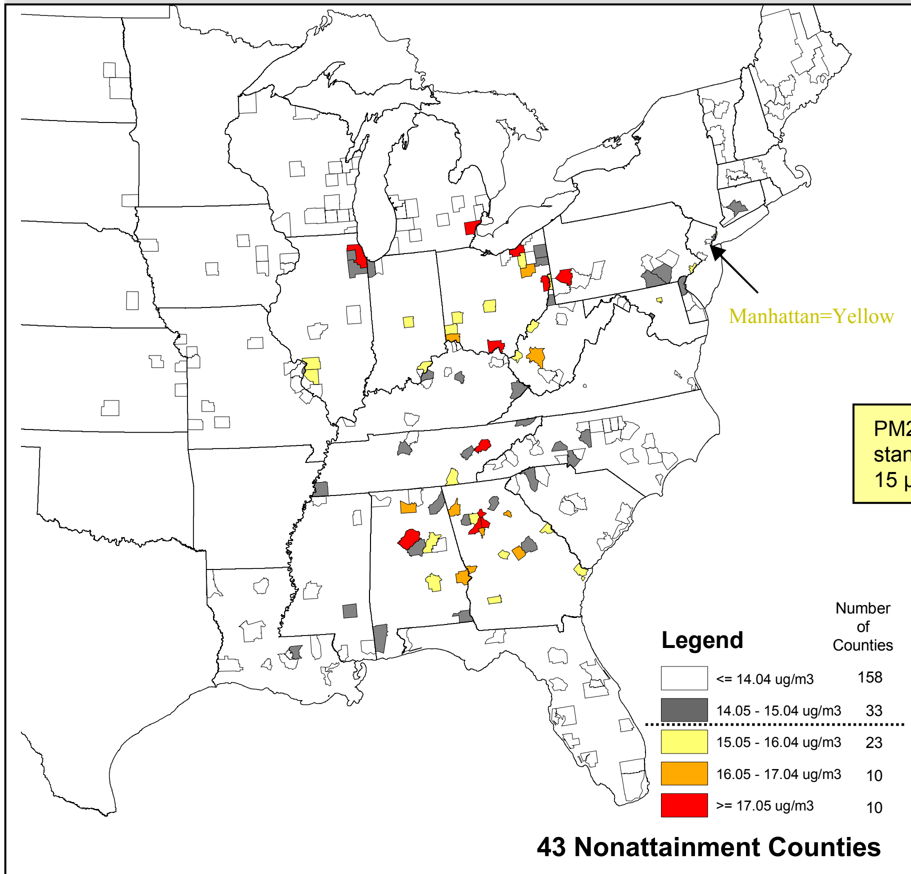
Remaining Counties Likely to Exceed the Annual Fine Particle Standard with Clear Skies in 2010



Notes: Based on 1999-2001 data of counties with monitors that have three years of complete data. Additional federal and state programs must bring all counties into attainment by 2016 at the latest. Clear Skies is not expected to bring additional counties into attainment for 2020 in the West. Therefore, the western region is not presented here.

Clear Skies Would Bring More Areas into Attainment with the $PM_{2.5}$ Standard in 2020

Remaining Counties Likely to Exceed the Annual Fine Particle Standard under the Base Case in 2020



$PM_{2.5}$ attainment status in 2020 base case:

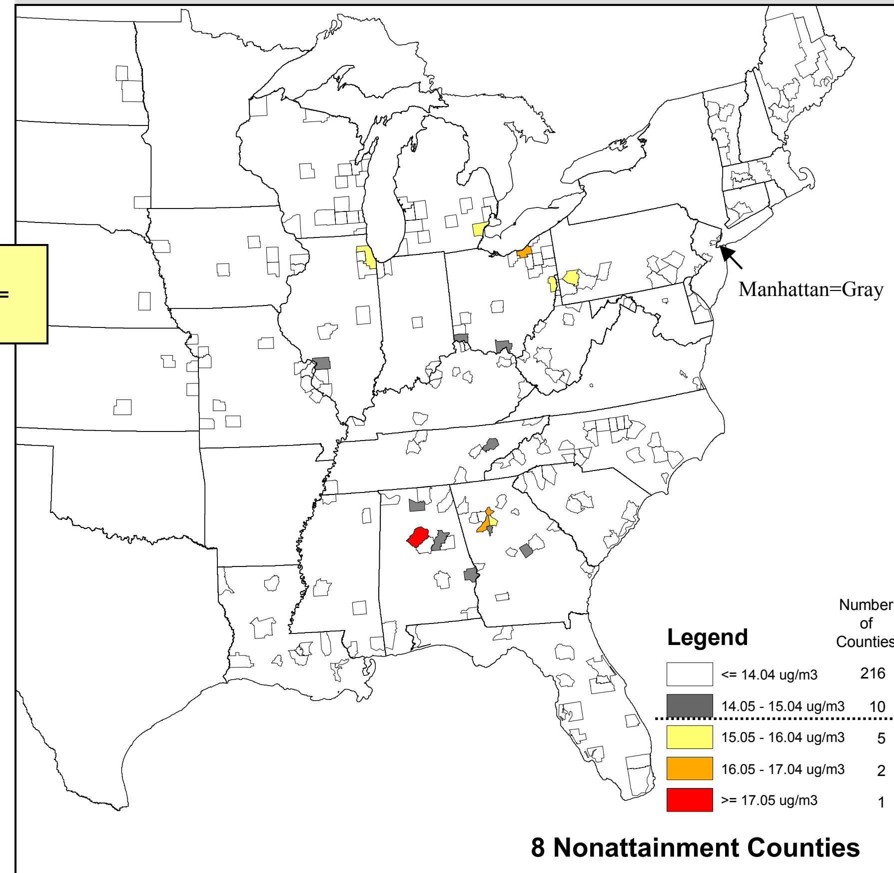
- **Existing programs will bring 71 eastern counties (home to approximately 18 million people) into attainment with the fine particle standard (compared to current conditions).**

PM2.5 standard = 15 µ/m³

$PM_{2.5}$ attainment status in 2020 Clear Skies Case:

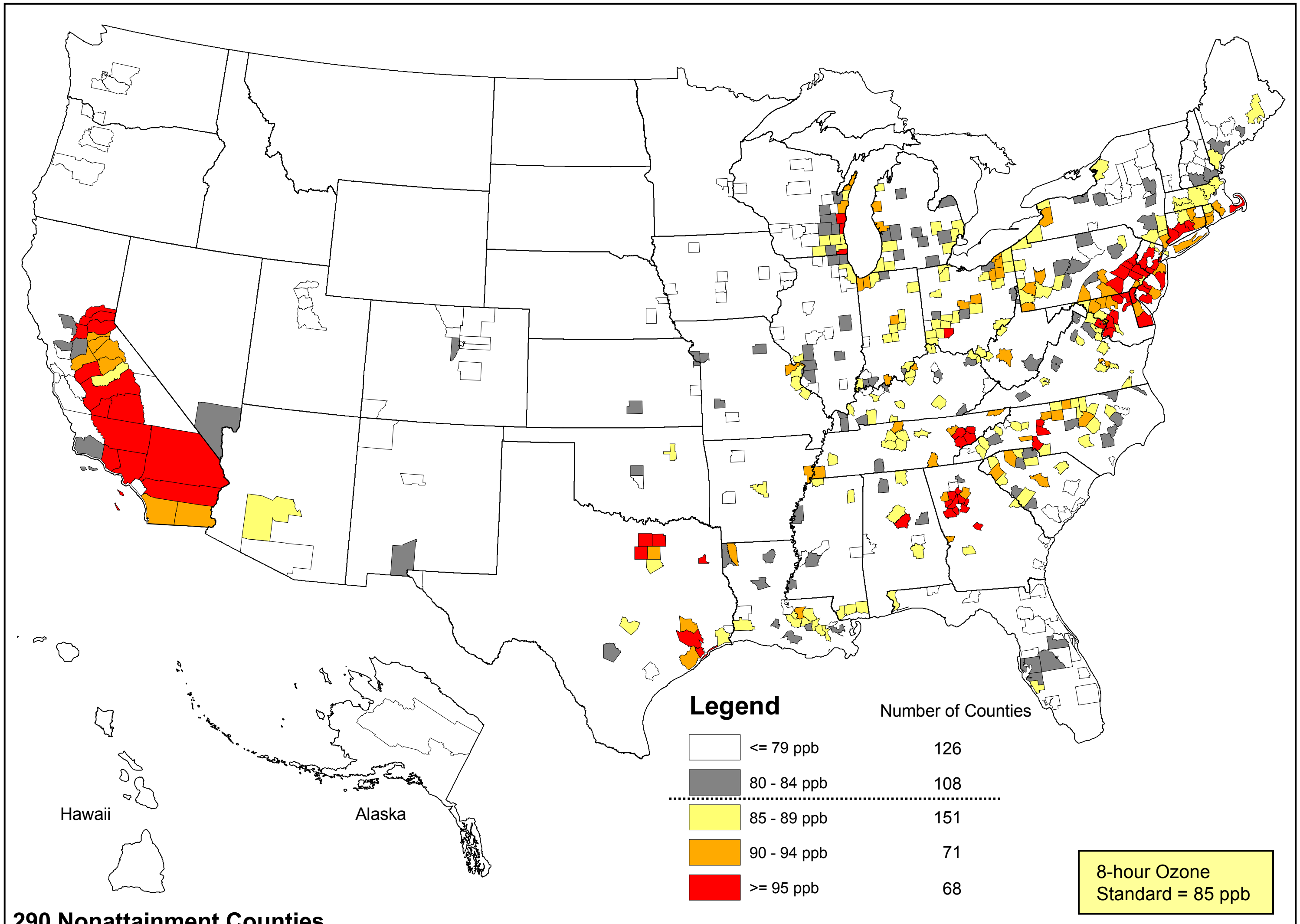
- **Clear Skies would bring 35 additional eastern counties (home to approximately 12 million people) into attainment with the fine particle standard (as compared to the Base Case).**

Remaining Counties Likely to Exceed the Annual Fine Particle Standard with Clear Skies in 2020



Notes: Based on 1999-2001 data of counties with monitors that have three years of complete data. Additional federal and state programs must bring all counties into attainment by 2016 at the latest. Clear Skies is not expected to bring additional counties into attainment for 2020 in the West. Therefore, the western region is not presented here.

Current Attainment in the US with the 8-hour Ozone Standard (1999-2001)

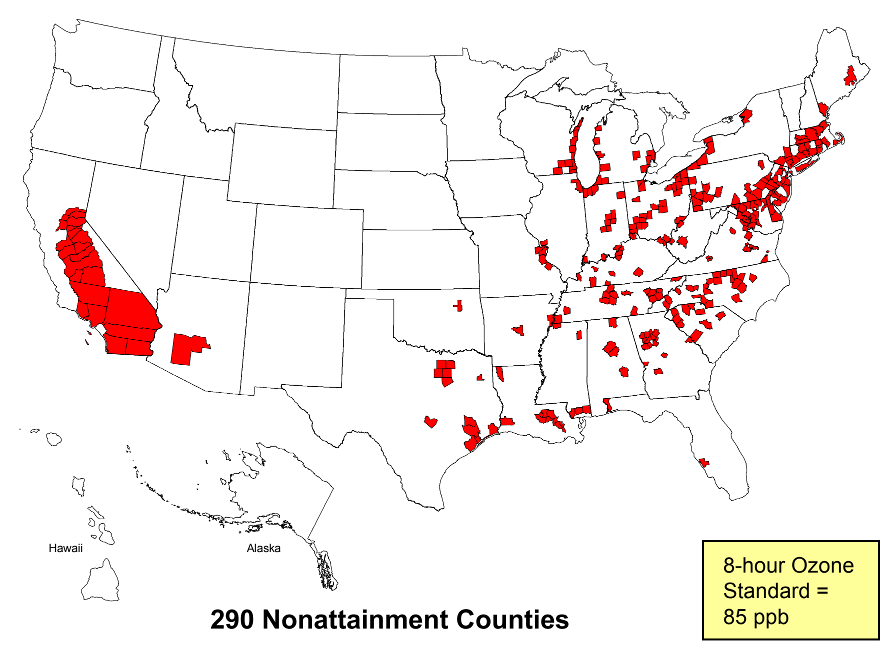


- **There are 290 counties nationwide (268 counties in the East) estimated to exceed the 8-hour ozone standard.**
- **111 million people (87 million people in the East) live in counties that would not meet this standard.**

Note: Based on 1999-2001 monitoring data of counties with monitors that have three years of complete data.

Clear Skies with Other Air Programs Would Substantially Improve Ozone Attainment over the Next Two Decades

Counties Exceeding the 8-hour Ozone Standard in 2001

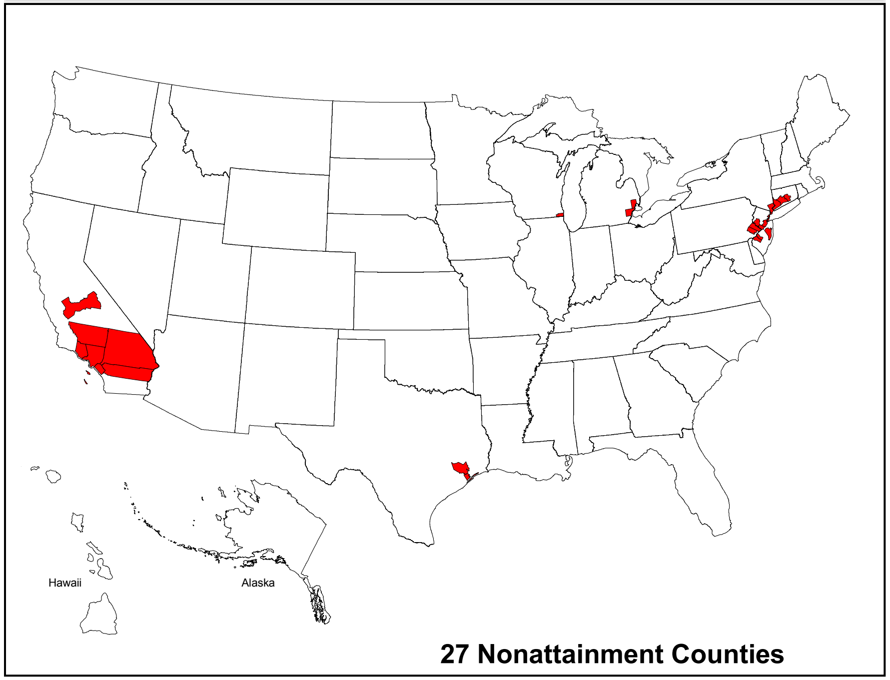


- **There are 290 counties nationwide (268 counties in the East) currently estimated to exceed the 8-hour ozone standard.**
  - **111 million people (87 million people in the East) currently live in counties with projected ozone concentrations greater than the 8-hour ozone standard of 85 ppb.**

Most counties would be brought into attainment with the ozone standard by 2020 :

- **Clear Skies and existing programs (primarily the NOx SIP Call and vehicle rules, including the proposed non-road rule) will bring 263 counties (home to approximately 77 million people) into attainment with the 8-hour ozone standard (compared to current conditions).**

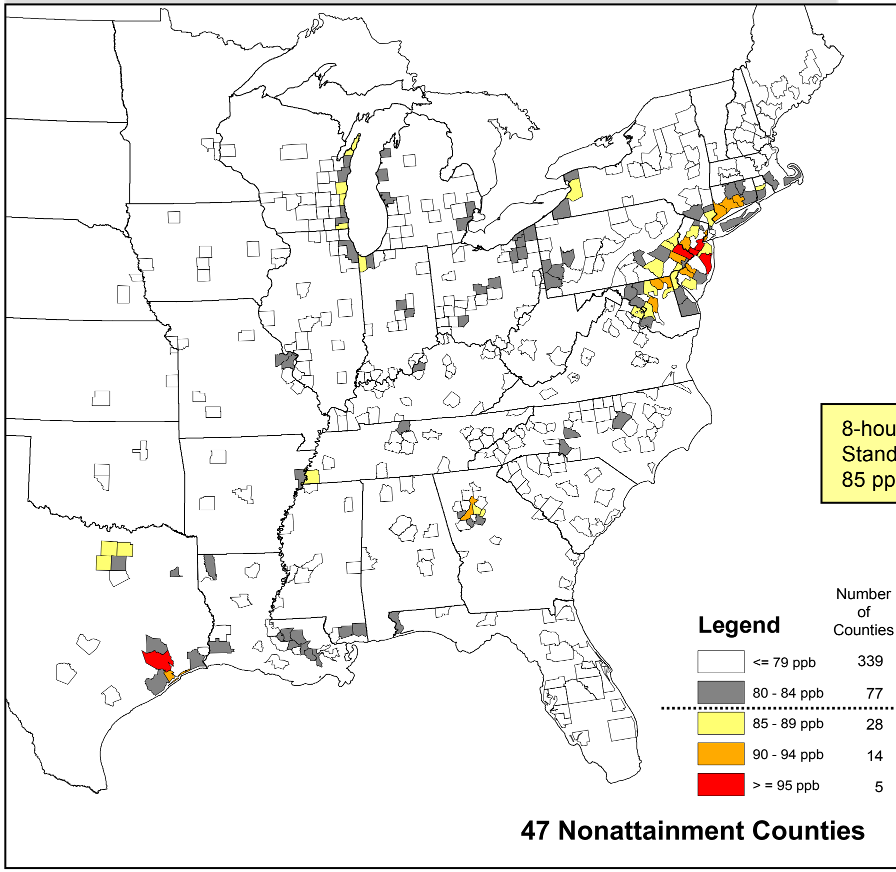
Remaining Counties Likely to Exceed the 8-hour Ozone Standard with Clear Skies in 2020



Notes: Based on 1999-2001 data of counties with monitors that have three years of complete data. Additional federal and state programs must bring all counties into attainment between 2007 and 2021. The methodology used to predict nonattainment status in the West is different than that used for the East.

Clear Skies Achieves Early Benefits by Bringing More Areas into Attainment with the 8-hour Ozone Standard in 2010

Remaining Counties Likely to Exceed the 8-hour Ozone Standard under Base Case in 2010



Ozone attainment status in 2010 base case:

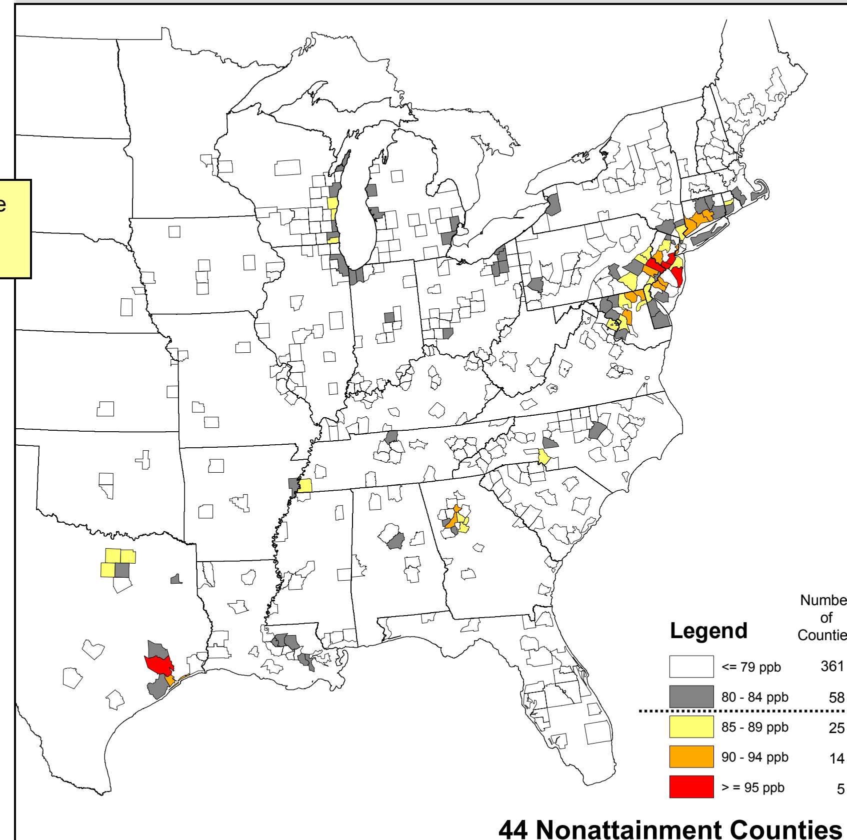
- Existing programs (primarily the NOx SIP Call and vehicle rules) will bring 221 additional eastern counties (home to approximately 61 million people) into attainment with the 8-hour ozone standard (compared to current conditions).

8-hour Ozone Standard = 85 ppb

Ozone attainment status in 2010 Clear Skies case:

- The NOx SIP Call will bring many Eastern counties into attainment with the 8-hour ozone standard.
- With Clear Skies, as compared to the Base Case, the number of counties out of attainment with the 8-hour ozone standard decreases from 47 to 44 (approximately 1 million more people living in counties in attainment).

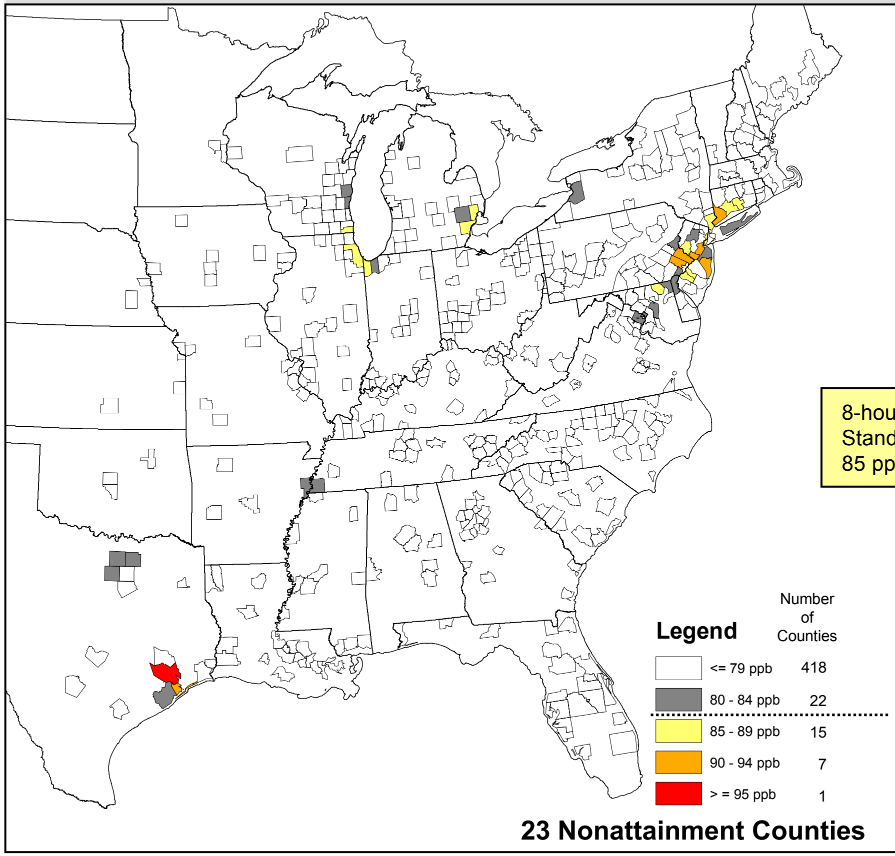
Remaining Counties Likely to Exceed the 8-hour Ozone Standard with Clear Skies in 2010



Notes: Based on 1999-2001 data of counties with monitors that have three years of complete data. Additional federal and state programs must bring all counties into attainment between 2007 and 2021. Clear Skies is not expected to bring additional counties into attainment for 2010 in the West. Therefore, the western region is not presented here.

Clear Skies Would Bring More Areas into Attainment with the 8-hour Ozone Standard in 2020

Remaining Counties Likely to Exceed the 8-hour Ozone Standard under Base Case in 2020



8-hour Ozone Standard = 85 ppb

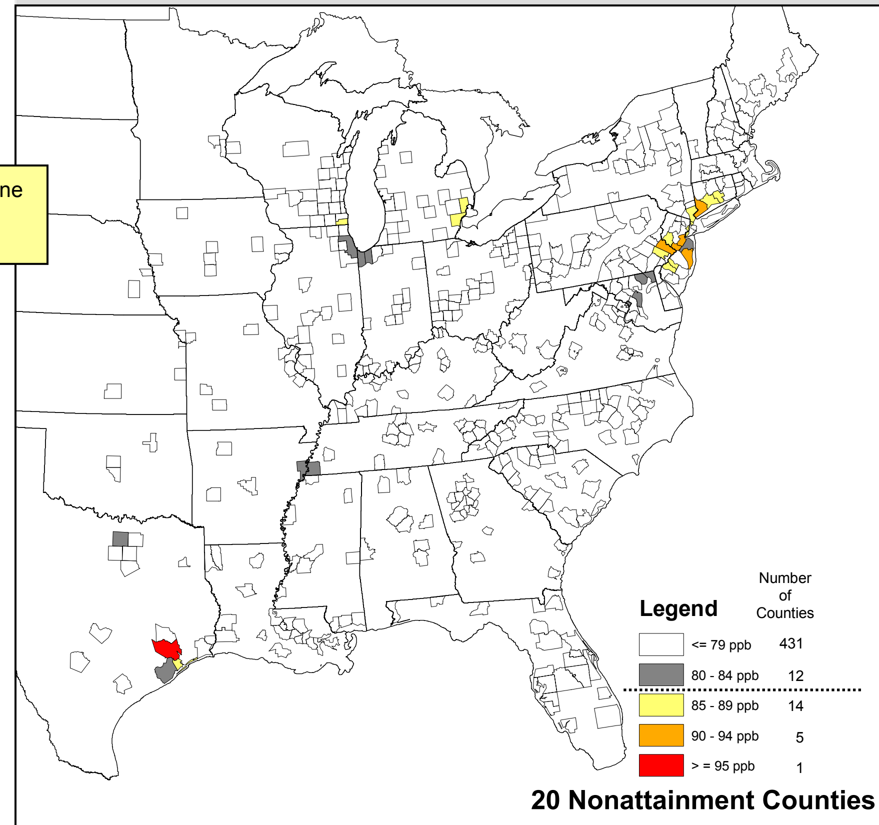
Ozone attainment status in 2020 base case:

- Existing programs (primarily the NOx SIP Call and vehicle rules, including the proposed non-road rule) will bring 245 eastern counties (home to approximately 65 million people) into attainment with the 8-hour ozone standard (compared to current conditions).

Ozone attainment status in 2020 Clear Skies case:

- The NOx SIP Call will bring many Eastern counties into attainment with the 8-hour ozone standard.
- Clear Skies would bring 3 additional counties (home to approximately 6 million people) into attainment with the 8-hour ozone standard (as compared to the Base Case).

Remaining Counties Likely to Exceed the 8-hour Ozone Standard with Clear Skies in 2020



Notes: Based on 1999-2001 data of counties with monitors that have three years of complete data. Additional federal and state programs must bring all counties into attainment between 2007 and 2021. Clear Skies is not expected to bring additional counties into attainment for 2020 in the West. Therefore, the western region is not presented here.

Current Design Values and Future Attainment

-Spreadsheet available with current and future predicted attainment status for 8-hour ozone and PM2.5

-Predictions from the highest monitor in each county

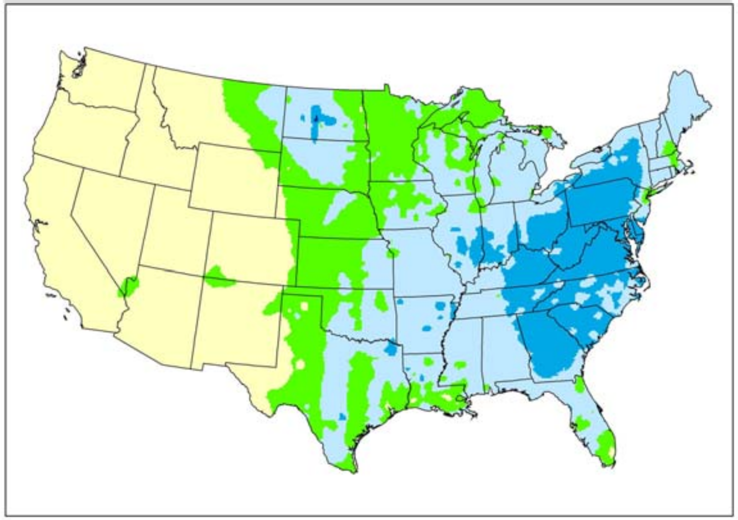
-All projections based on 1999-2001 ambient design values

Example for selected 8-hour ozone counties

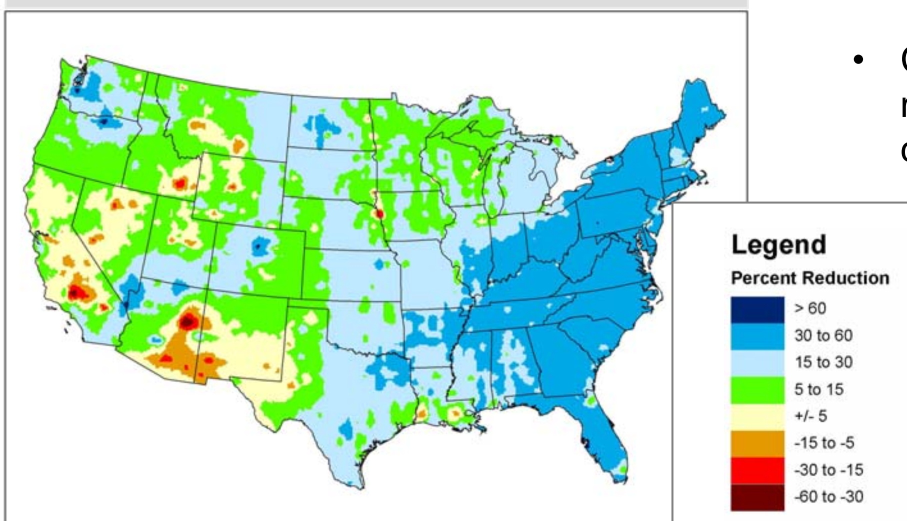
State	County	MSA/CMSA Name	2000 Population	Ozone 1999-2001 Ambient Design Value	Ozone Base case 2010	Ozone Clear Skies 2010	Ozone Base case 2020	Ozone Clear Skies 2020
Illinois	Cook County	Chicago-Gary-Kenosha, IL-IN-WI CMSA	5,376,741	88	not attaining	attaining	not attaining	attaining
Illinois	Jersey County	St. Louis, MO-IL MSA	21,668	89	attaining	attaining	attaining	attaining
Indiana	Lake County	Chicago-Gary-Kenosha, IL-IN-WI CMSA	484,564	90	not attaining	attaining	not attaining	attaining
Indiana	Posey County	Evansville-Henderson, IN-KY MSA	27,061	86	attaining	attaining	attaining	attaining
Indiana	Allen County	Fort Wayne, IN MSA	331,849	87	attaining	attaining	attaining	attaining
Indiana	Hamilton County	Indianapolis, IN MSA	182,740	91	attaining	attaining	attaining	attaining
Indiana	Clark County	Louisville, KY-IN MSA	96,472	86	attaining	attaining	attaining	attaining
Indiana	Perry County		18,899	90	attaining	attaining	attaining	attaining
Indiana	La Porte County		110,106	85	attaining	attaining	attaining	attaining
Michigan	Berrien County	Benton Harbor, MI MSA	162,453	87	attaining	attaining	attaining	attaining
Michigan	Wayne County	Detroit-Ann Arbor-Flint, MI CMSA	2,061,162	88	attaining	attaining	not attaining	not attaining
Michigan	Muskegon County	Grand Rapids-Muskegon-Holland, MI MSA	170,200	92	attaining	attaining	attaining	attaining
Michigan	Allegan County	Grand Rapids-Muskegon-Holland, MI MSA	105,665	87	attaining	attaining	attaining	attaining
Michigan	Mason County		28,274	91	attaining	attaining	attaining	attaining
Michigan	Benzie County		15,998	89	attaining	attaining	attaining	attaining
Michigan	Cass County		51,104	87	attaining	attaining	attaining	attaining
Missouri	St. Charles County	St. Louis, MO-IL MSA	283,883	90	attaining	attaining	attaining	attaining

Sulfur Deposition Improvements in 2020 with Clear Skies

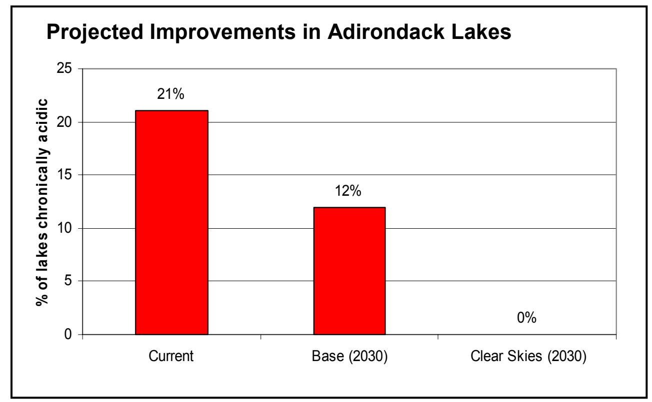
Projected Changes in Sulfur Deposition with Clear Skies compared to the Base Case in 2020



Projected Changes in Sulfur Deposition with Clear Skies and Base Case in 2020 compared to 2001



- Clear Skies would reduce sulfur deposition up to 60% beyond Base Case in some of the most acid-sensitive regions of the country, including the Appalachian Mountains, southern Blue Ridge, and southeastern U.S.
- Together with existing programs, Clear Skies would reduce sulfur deposition 30-60% across the most of the Eastern U.S. and several sensitive areas of the West.

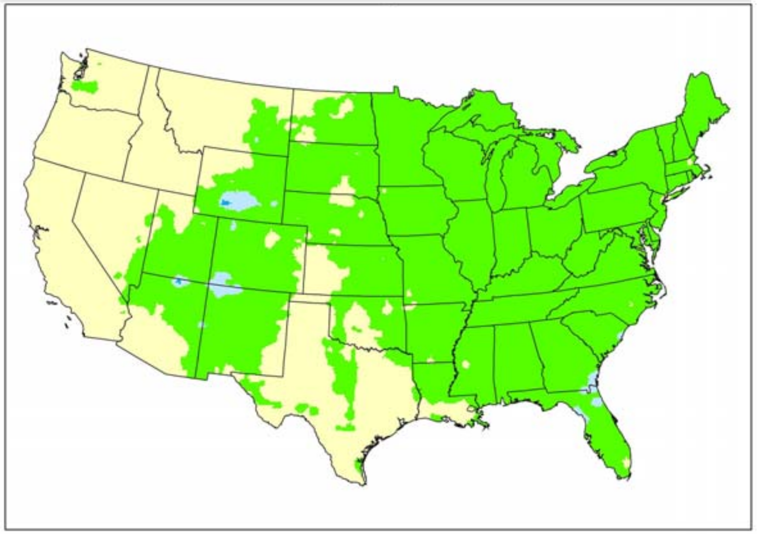


- Clear Skies would eliminate chronic acidity in Adirondack region lakes by 2030, and only 1% of lakes would remain chronically acidic in the Northeast region.
- Clear Skies would benefit acid-sensitive ecosystems in the Southeast, by slowing the deterioration of stream health expected under the Base Case.

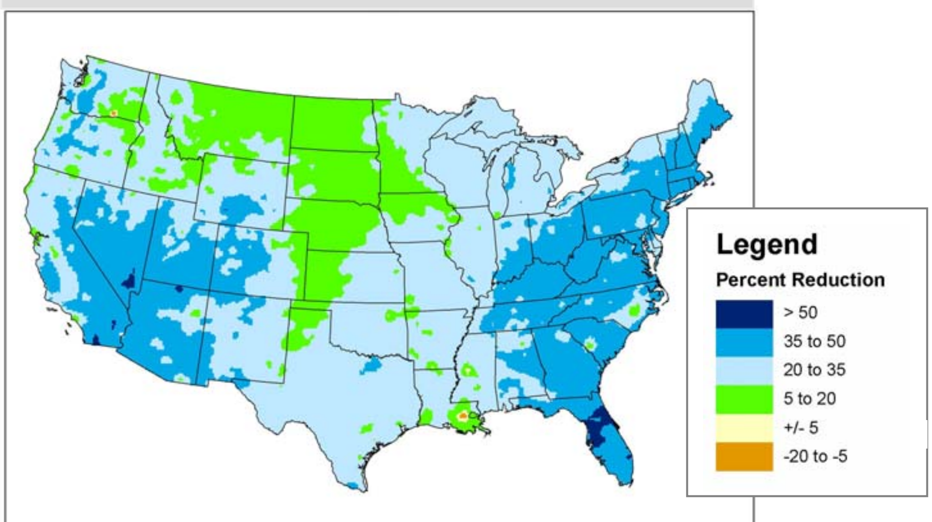
Note: Sulfur deposition in the West is generally low. The large percentage increases correspond to relatively small changes in actual deposition from expected increases in emissions primarily from sources not affected by Clear Skies (e.g., metals processing, petroleum refining, chemical and fertilizer manufacturing). A few power plants are expected to increase emissions slightly under existing programs.

Nitrogen Deposition Improvements with Clear Skies in 2020

Projected Changes in Nitrogen Deposition with Clear Skies compared to the Base Case in 2020



Projected Changes in Nitrogen Deposition with Clear Skies and Base Case in 2020 compared to 2001

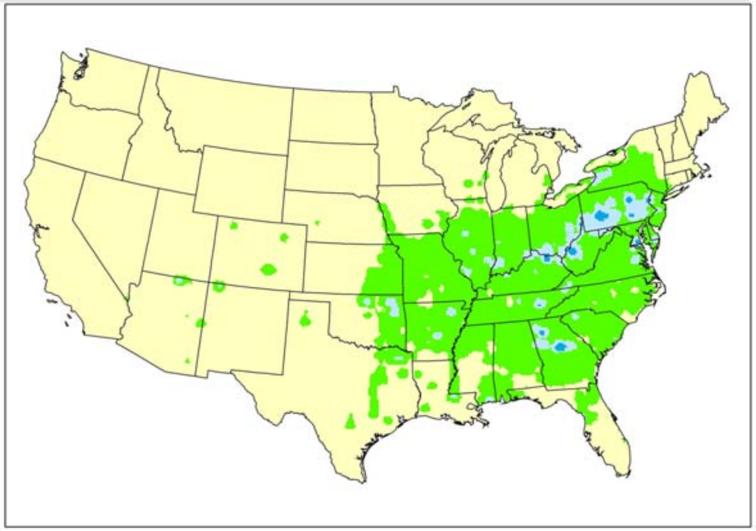


- Clear Skies would reduce nitrogen deposition up to 20% beyond the Base Case across much of the country.
- Clear Skies along with existing programs would reduce nitrogen deposition across much of the country by 20 to 50 percent.

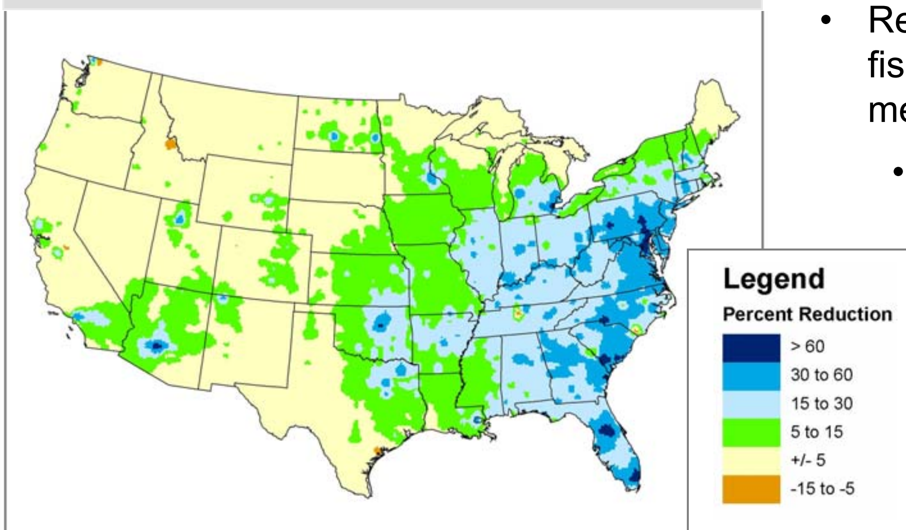
Note: The increases in nitrogen deposition at locations in Louisiana and Washington state occur under the Base Case and with Clear Skies and are the result of increases in emissions from manufacturing and refining sources.

Mercury Deposition Improvements in 2020 with Clear Skies

Projected Changes in Mercury Deposition with Clear Skies compared to Base Case in 2020



Projected Changes in Mercury Deposition with Clear Skies and Base Case in 2020 compared to 2001



- Eating contaminated fish is the primary route of harmful exposure to mercury. Developing fetuses are most at risk for neurological harm due to mercury.
- Considering Clear Skies without the safety valve, Clear Skies could potentially reduce mercury deposition 5-15%* beyond the Base Case across much of the East.
  - In some areas mercury deposition would be reduced up to 60%.
- Together with existing programs, Clear Skies would contribute to a 15-60%* reduction in mercury deposition from current levels throughout the East and Midwest.
- Reductions are expected to occur in many places where fish advisories are in effect due to elevated levels of mercury.
  - Ecosystems in Florida, including fish tissue concentrations, have already been shown to respond quickly to changes in mercury loads.

* These results are based on modeling the Clear Skies mercury cap without triggering the safety valve.
Note: The increases in mercury deposition in the bottom map occur under the Base Case and with Clear Skies and are the result of increases in emissions from sources other than power plants that are not affected by Clear Skies.

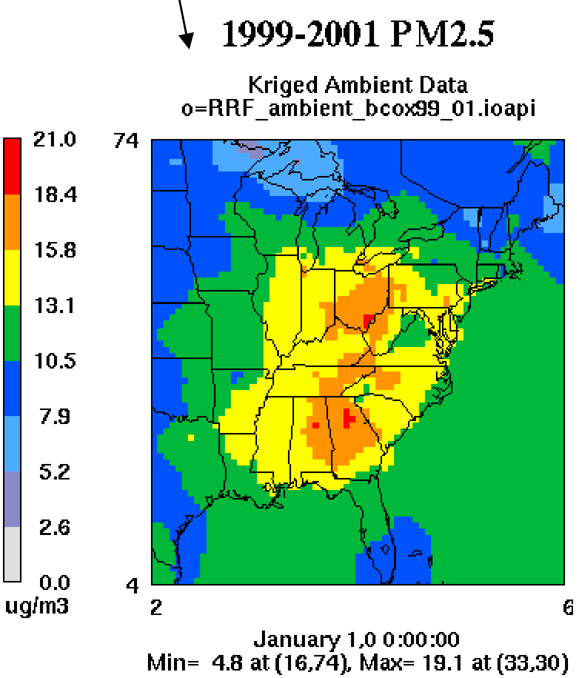
Gridded $PM_{2.5}$ and Species Maps

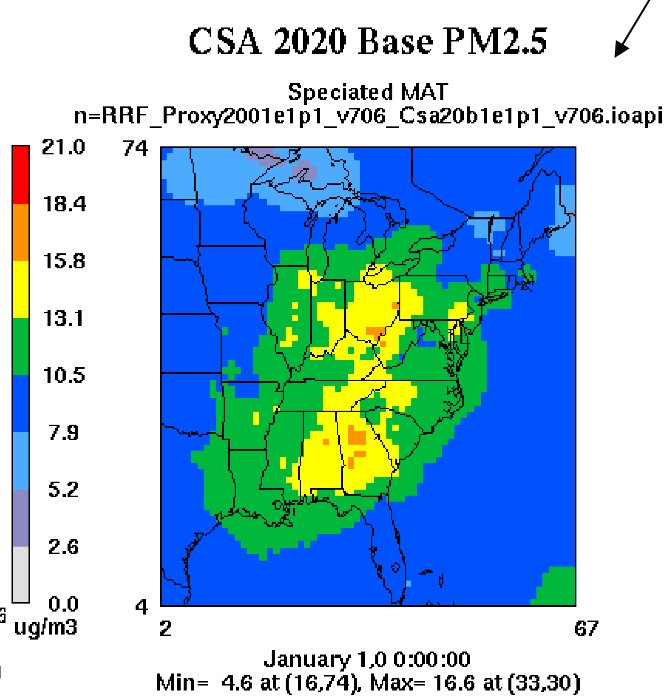
Maps were created from gridded interpolated ambient data as part of the speciated MAT.
Useful for giving an overall spatial picture of base and future year $PM_{2.5}$ and components

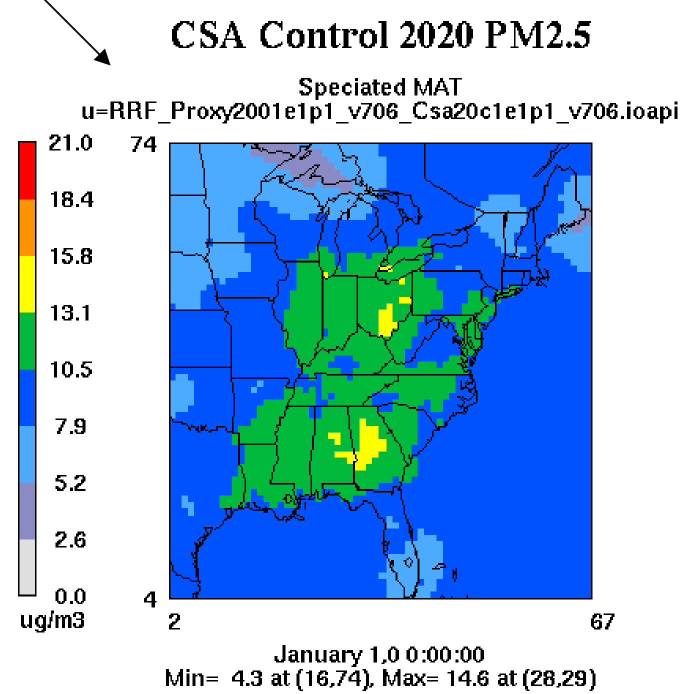
- -Spatial fields are currently only available for the East
- -$PM_{2.5}$ peak values are underestimated due to smoothing of gradients associated with interpolation of the ambient data to 36km grid cells

Interpolated ambient $PM_{2.5}$ data

Future year estimates based on model predicted % change applied to the base year ambient data



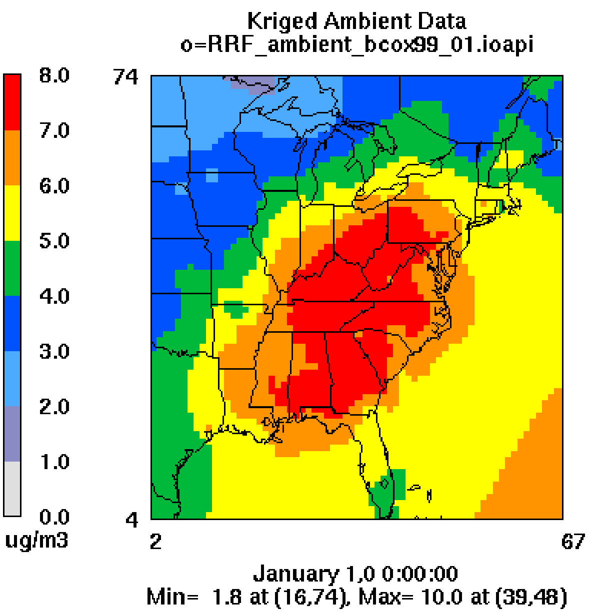




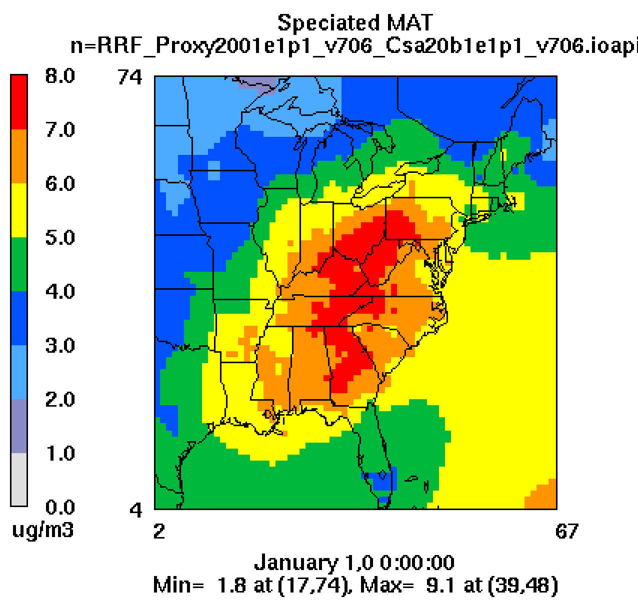
Gridded Ammonium Sulfate:
Annual Average

Individual $PM_{2.5}$ species were derived in a similar matter as $PM_{2.5}$. The ambient data was interpolated from all available speciation data (IMPROVE and STN) as part of the speciated modeled attainment test (SMAT).

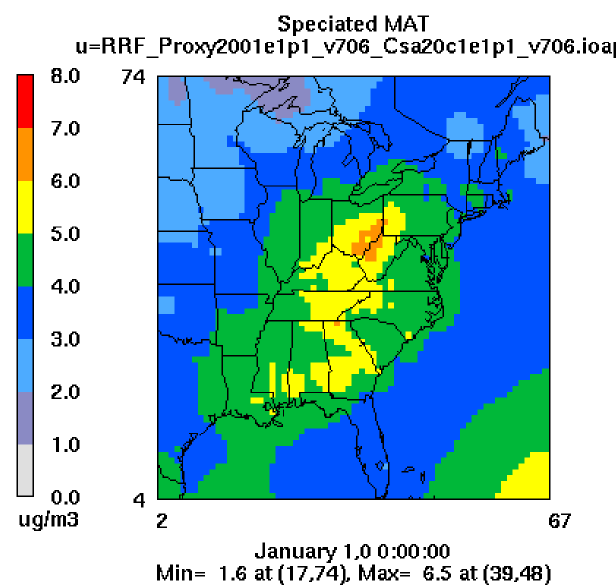
1999-2001 Amm. Sulfate



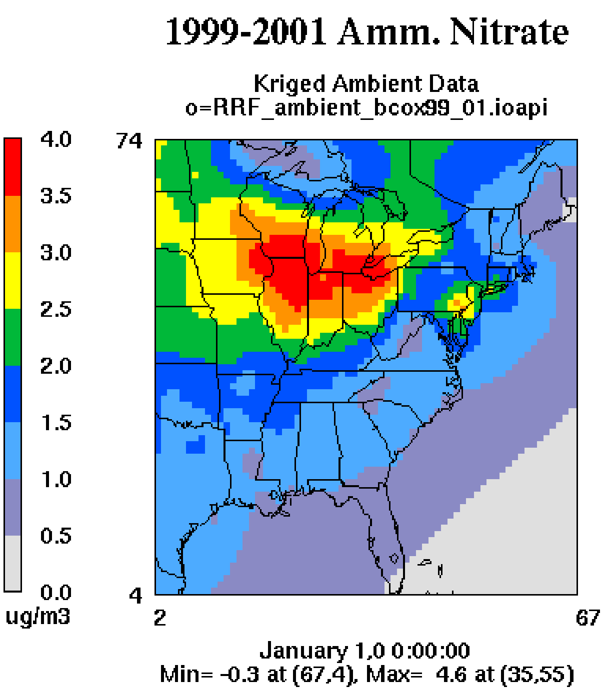
CSA 2020 Base Amm. Sulfate

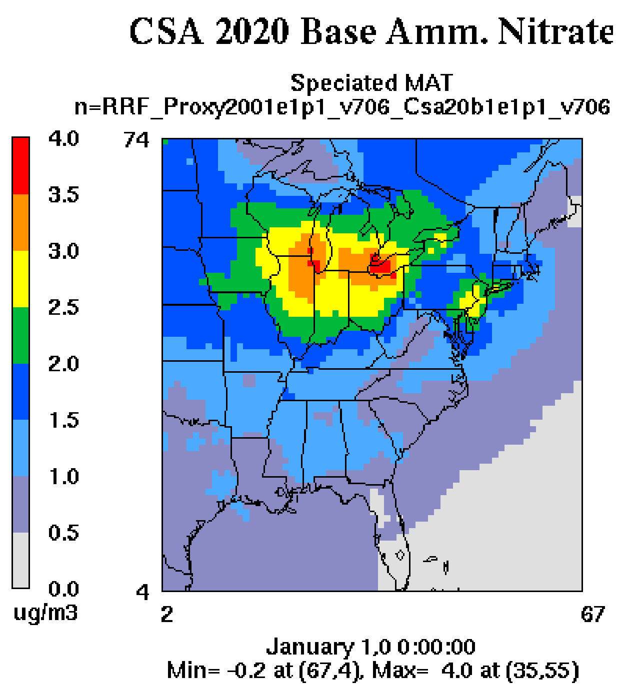


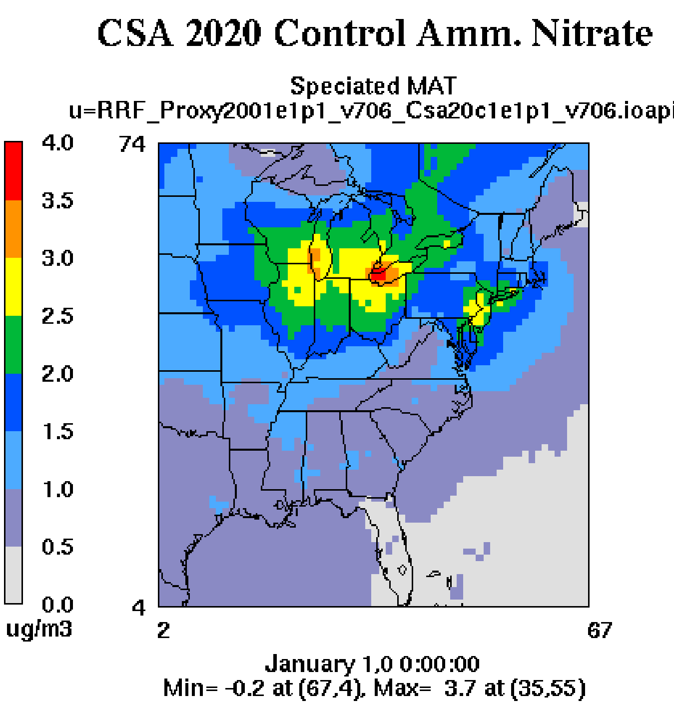
CSA 2020 Control Amm. Sulfate



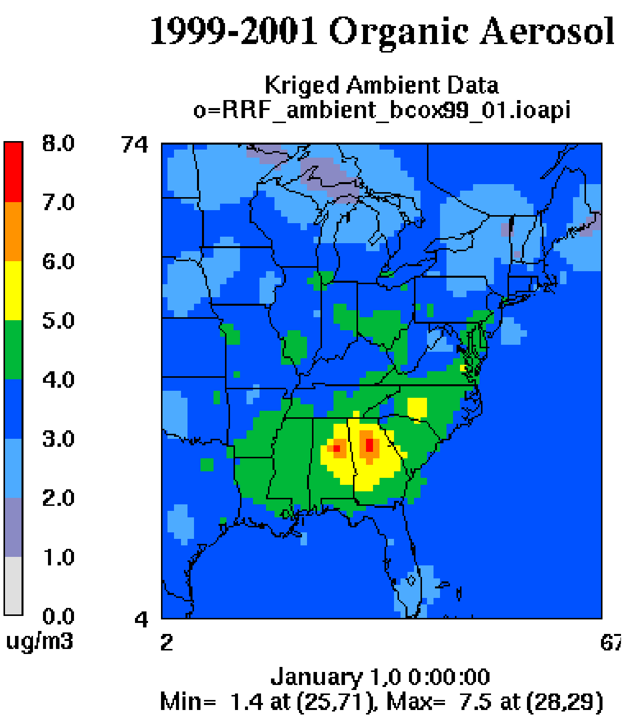
Gridded Ammonium Nitrate:
Annual Average

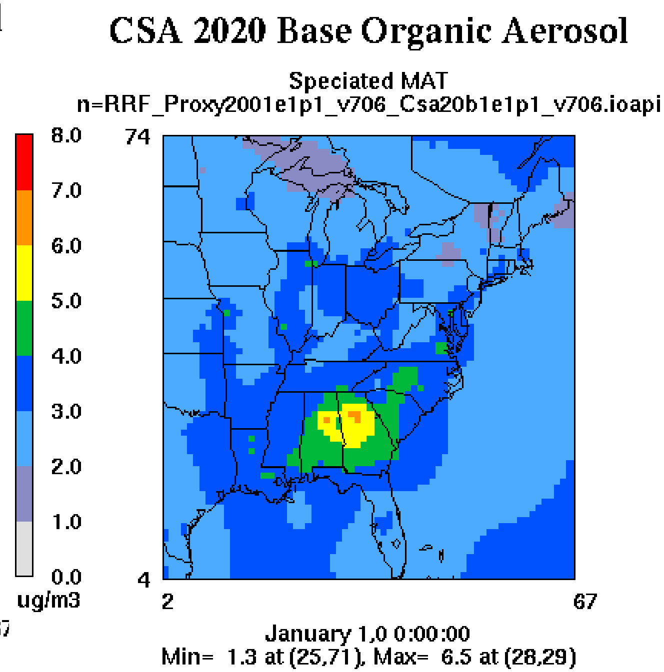


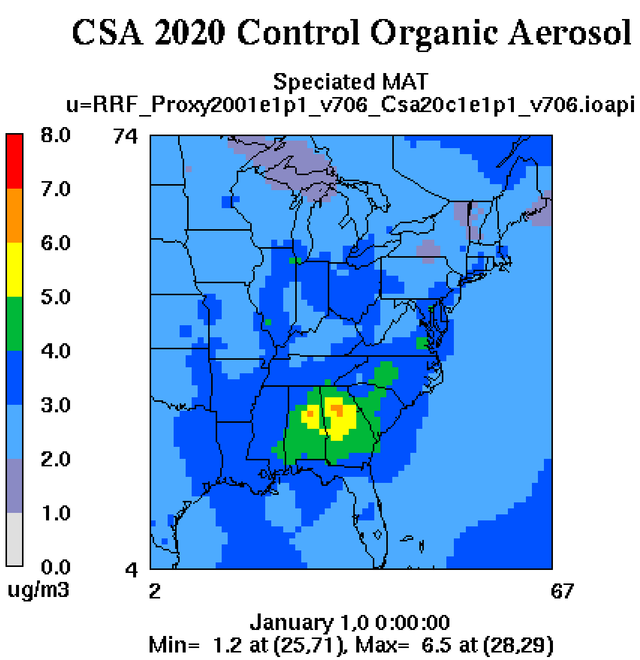




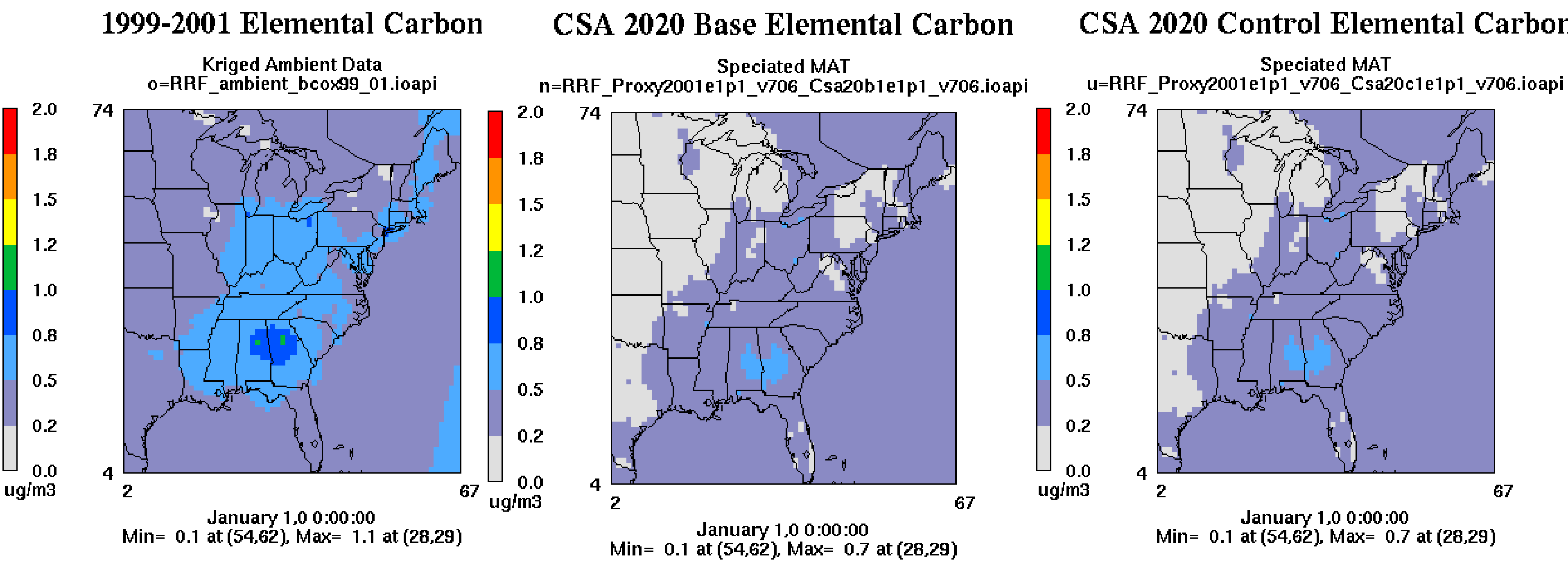
Gridded Organic Aerosol: Annual Average



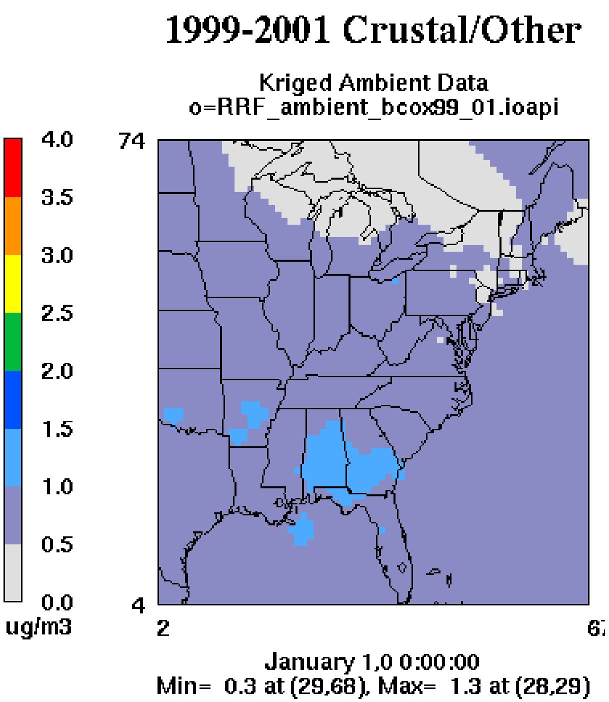


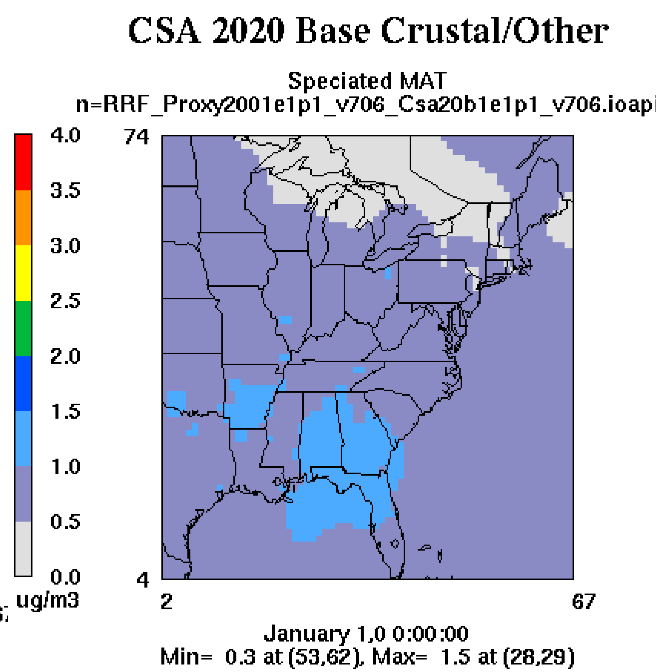


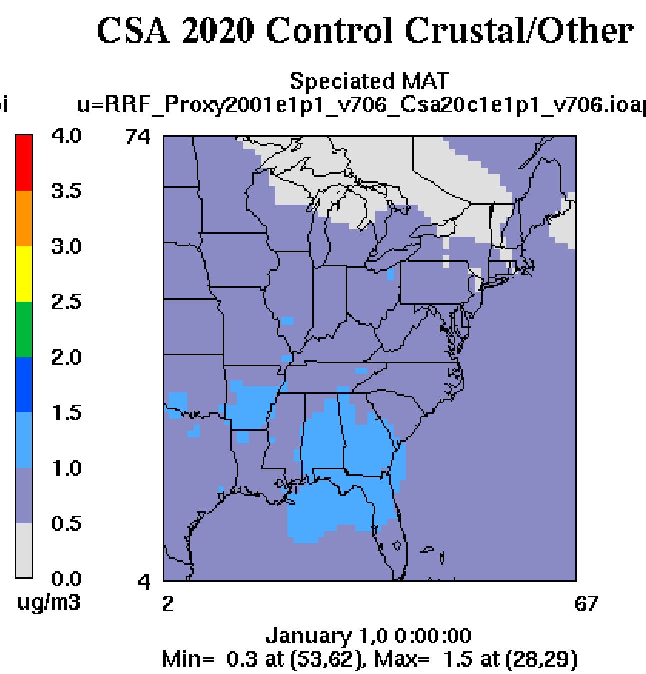
Gridded Elemental Carbon:
Annual Average



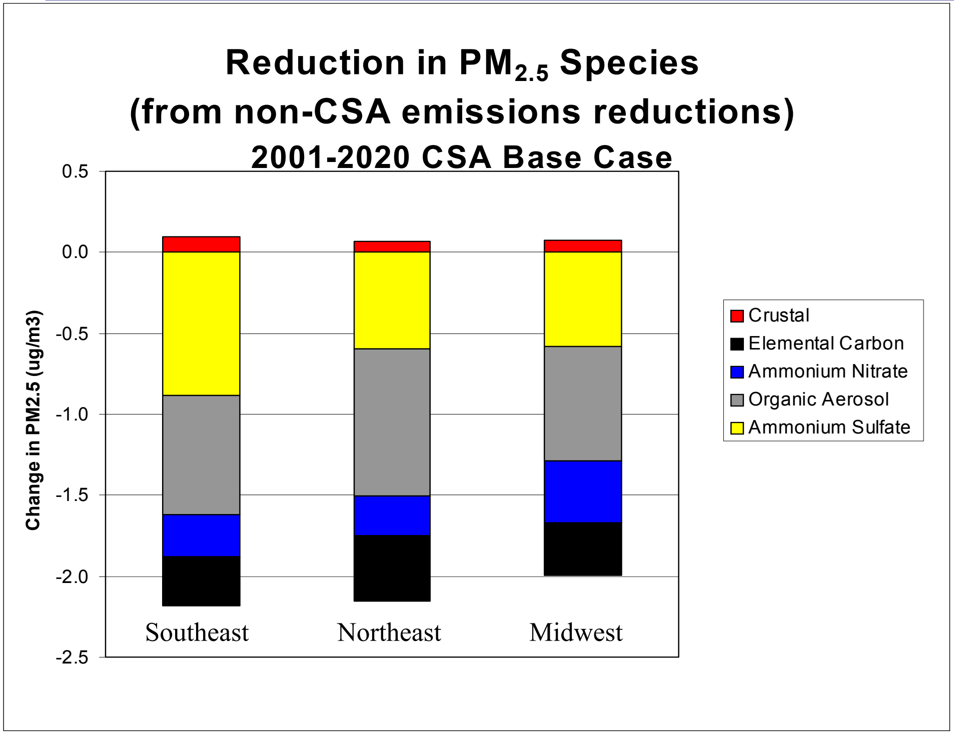
Gridded Crustal/Other $PM_{2.5}$: Annual Average







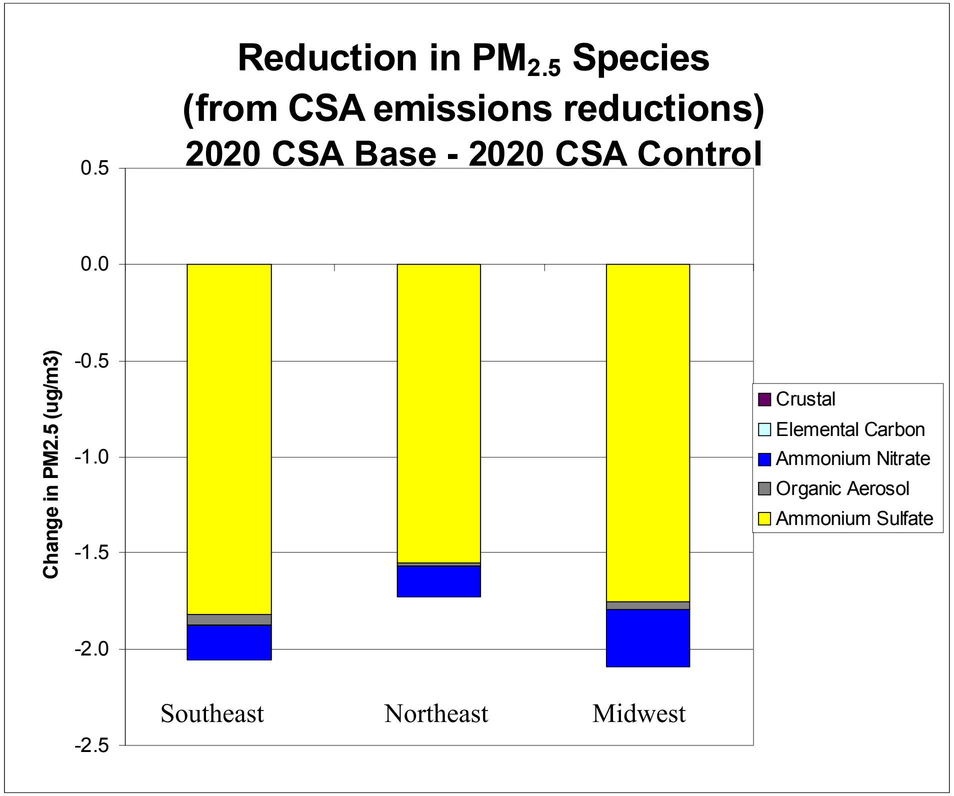
Which $PM_{2.5}$ Species are Being Reduced?



There is ~2 μg/m³ reduction from 2001 to the 2020 base

The reduction is split among all species (except crustal)

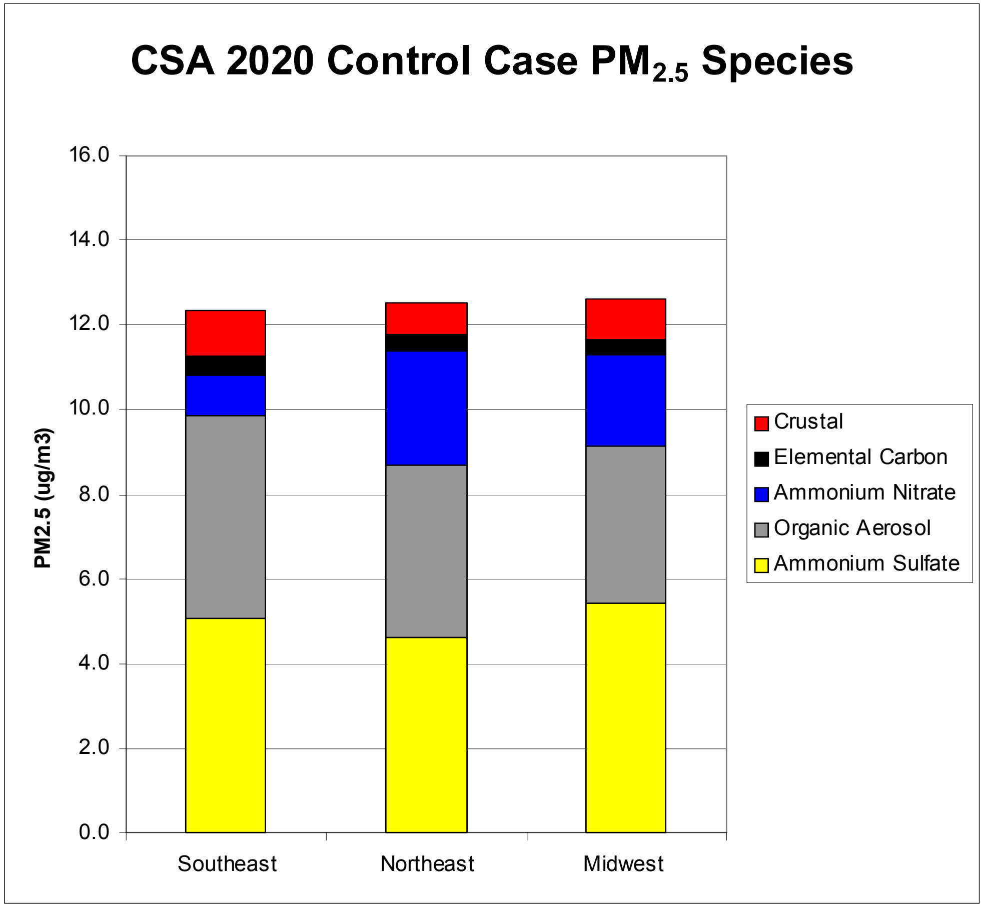
Sulfate and organics account for the largest reductions



There is ~2 μg/m³ reduction from the 2020 base to the 2020 control case

The reduction is mostly from sulfate, with a 0.2-0.3 μg/m³ reduction in nitrate

$PM_{2.5}$ Component Species in the Base Year Nonattainment Counties (114 counties) - What is left in 2020 after Clear Skies?



- High remaining sulfate and organics in all regions
  - Lower sulfate in Northeast
  - Higher organics in South
- Low nitrate in South
- Small amounts of EC and crustal

CSA Documentation

- Current
  - Information on Clear Skies Website
    http://www.epa.gov/clearskies/
    - Summary presentations
    - Health benefits and costs
    - IPM modeling
  - State-by-State emissions summaries
  - Attainment status spreadsheet
- Coming Soon
  - Air quality modeling Technical Support Document
    - Model performance evaluation
    - Documentation of methodologies
  - Emissions Documentation
    - Further details on development of 2001 “proxy” inventory