GEORGIA
DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION

Review of the Secondary NOx/SOx/PM NAAQS

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BACKGROUND

- Section 109(b)(2) of the Clean Air Act defines secondary National Ambient Air Quality Standards (NAAQS) as ones that “the attainment and maintenance of which in the judgment of the Administrator, based on such criteria, is requisite to protect the public welfare from any known or anticipated adverse effects associated with the presence of such air pollutant in the ambient air.”
- The NAAQS is not required to be set at a zero-risk level.
- Welfare effects include “effects on soils, water, crops, vegetation, man-made materials, animals, wildlife, weather, visibility and climate…”

CURRENT SECONDARY STANDARDS

- The current secondary standards were established based on direct effects of the pollutants in ambient air
- SO_2 and NO_2 standards historically focused on protecting against direct phytotoxic effects on vegetation
- $PM_{2.5}$ and PM_{10} standards have historically focused on protecting against visibility, climate, and materials damage effects
  - These effects are covered under the 2020 PM NAAQS

Pollutant	Indicator	Averaging Time	Level	Form
S Oxides	SO_2	3 hours	0.5 ppm	Not to be exceeded more than once per year
PM	$PM_{2.5}$	1 year	15 µg m^{-3}	Annual mean, averaged over 3 years
		24 hours	35 µg m^{-3}	98th percentile, averaged over 3 years
	PM_{10}	24 hours	150 µg m^{-3}	Not to be exceeded more than once per year on average over 3 years
N Oxides	NO_2	1 year	53 ppb	Annual mean

CURRENT SECONDARY REVIEW

- The current review focuses on the adequacy of the current secondary standards for NO_2, SO_2, and PM in providing protection against direct effects on vegetation and deposition-related ecological effects
- Unlike the 2012 review of the secondary standards for oxides of nitrogen and sulfur, the current review encompasses the secondary PM standards* as well as the secondary standards for oxides of nitrogen and sulfur

*Regarding PM, welfare effects associated with visibility impairment, climate effects, and materials effects (i.e., damage and soiling) are being addressed in the separate review of the NAAQS for PM.

RECENT REVIEW STEPS

- EPA develops final Integrated Science Assessment
- EPA develops draft Policy Assessment (with draft REA)
- CASAC reviews draft Policy Assessment (with draft REA)
- EPA develops final Policy Assessment (with final REA)
- EPA proposed secondary standards (04/09/24)
- EPA finalizes secondary standards (12/10/24)

SOx/NOx/PM COMPOSITION

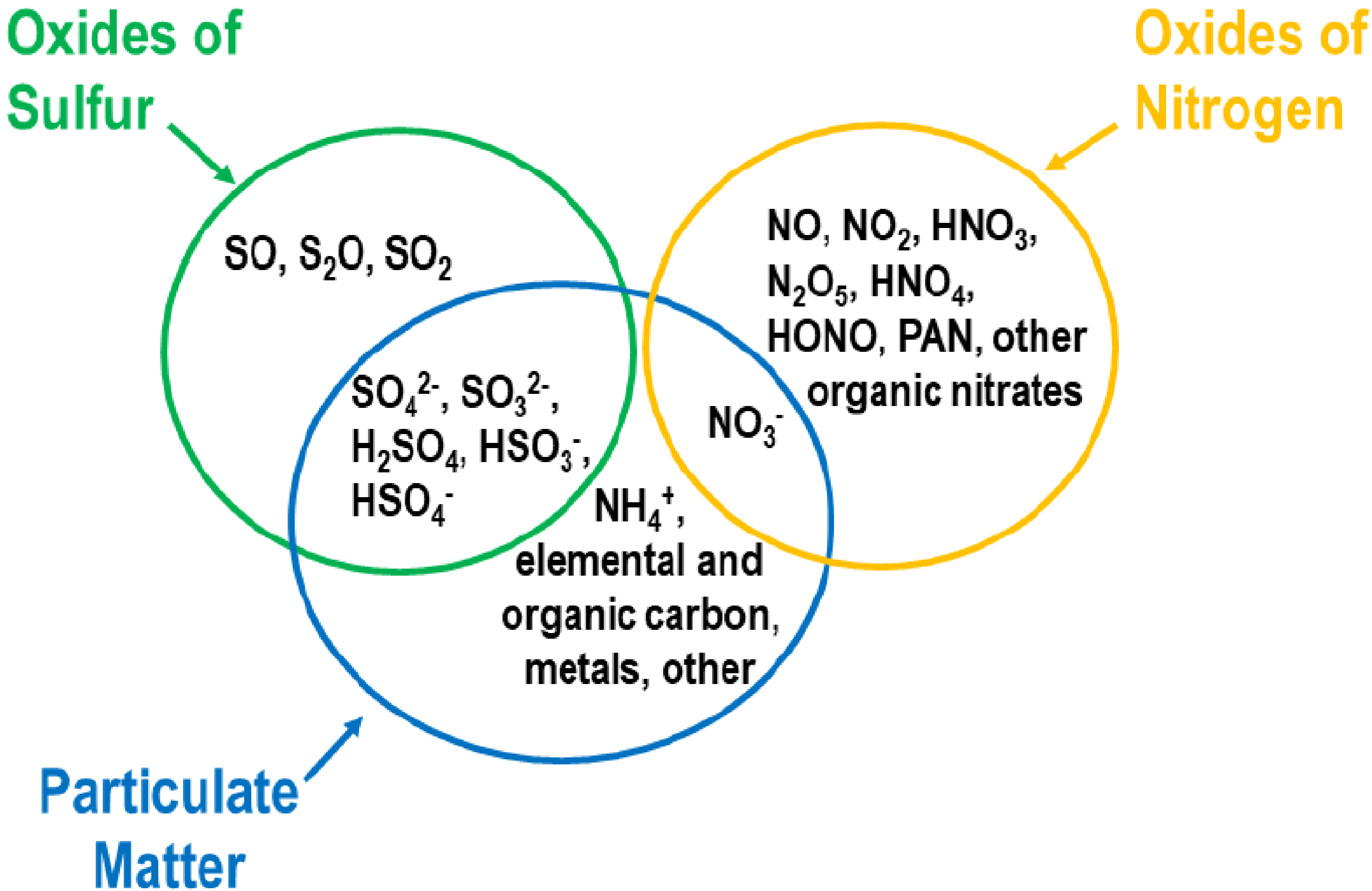


Figure 2-1. Schematic of most relevant individual pollutants that comprise oxides of nitrogen, oxides of sulfur, and particulate matter.

SOx/NOx/PM DEPOSITION

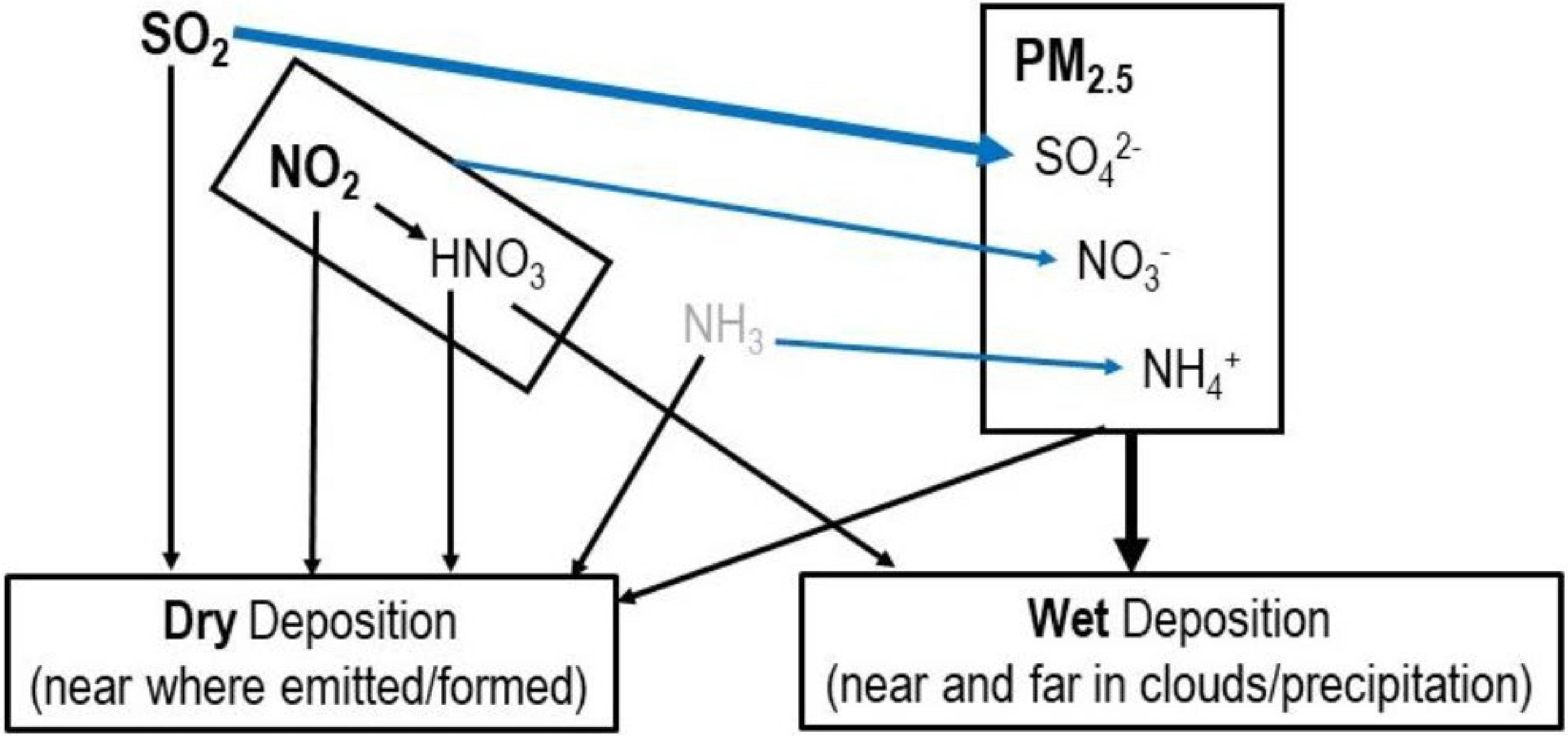


Figure 6-2. Primary pathways by which emitted pollutants are transformed and deposited. Blue arrows indicate that chemical transformation can occur during transport. Bold arrow indicates primary loss mechanism pathway. Bolded pollutants are NAAQS indicators; grey font is for non-criteria pollutant (ammonia).

ESTIMATING TOTAL DEPOSITION (TDEP)

- Unlike measurements of criteria pollutants, measurements of deposition are relatively sparse.
- The most utilized methodology in current publications is called TDEP (Total DEPosition), which is a hybrid approach that combines:
  - Wet deposition data from NADP/NTN (261 sites),
  - PRISM precipitation data,
  - Measured air concentrations from CASTNET data (101 sites), and
  - Modeled deposition velocity data from a photochemical air quality model simulation (e.g., CMAQ).

PRISM = Parameter-elevation Relationships on Independent Slopes Model
NADP = National Atmospheric Deposition Program
NTN = National Trends Network
CASTNET = Clean Air Status and Trends Network
CMAQ = Community Multiscale Air Quality model

ESTIMATING TOTAL DEPOSITION (TDEP)

- One shortcoming is that the measurement sites are often far apart and the TDEP interpolation does not fully capture variability between the measurement locations.
- Dry deposition is not directly measured; thus, accuracy depends on CMAQ's model performance which tends to be poorer in the western U.S. and in remote areas.
- Uncertainties in N deposition estimates are largest in regions with substantial NH_3 emissions.

TDEP – WET AND DRY

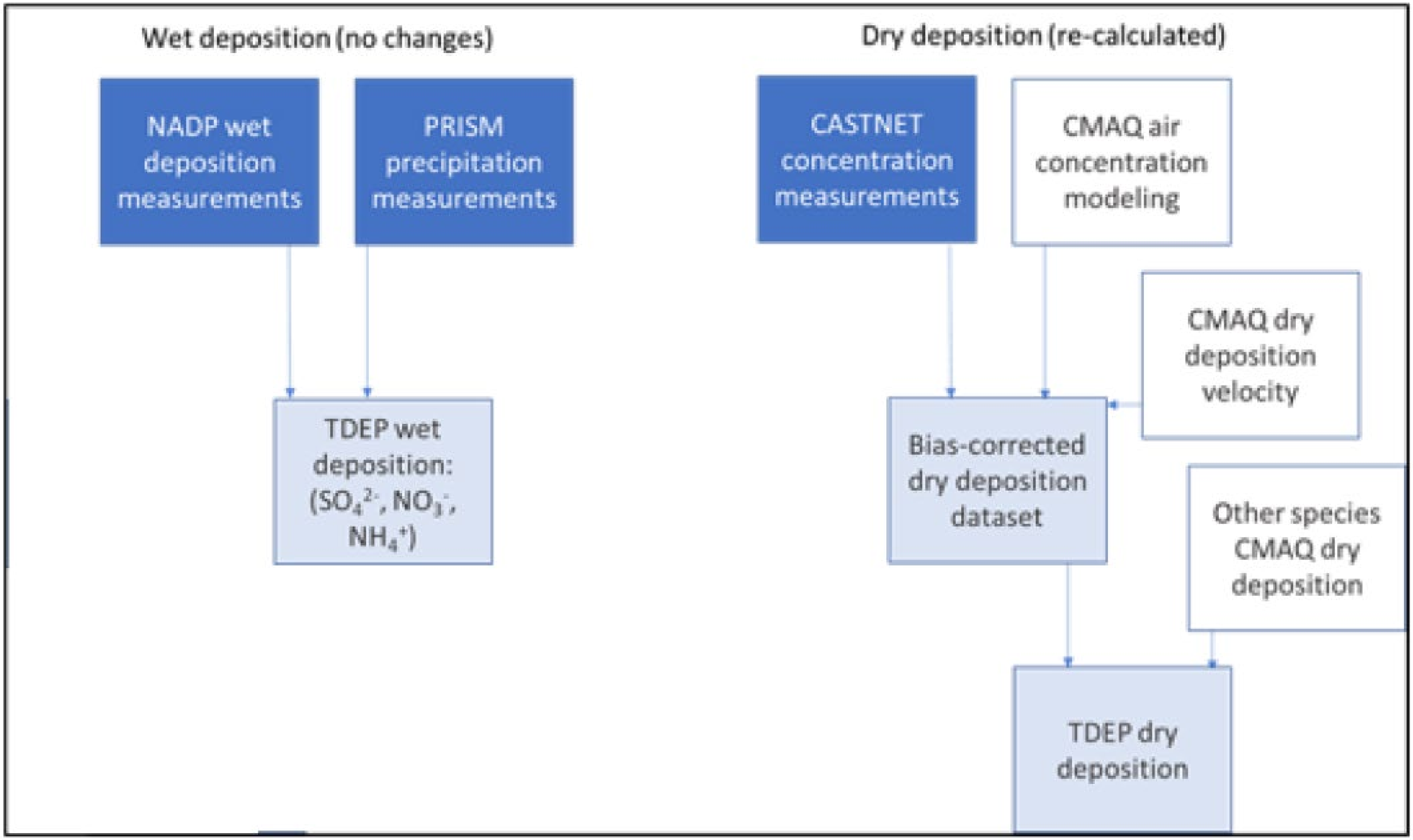
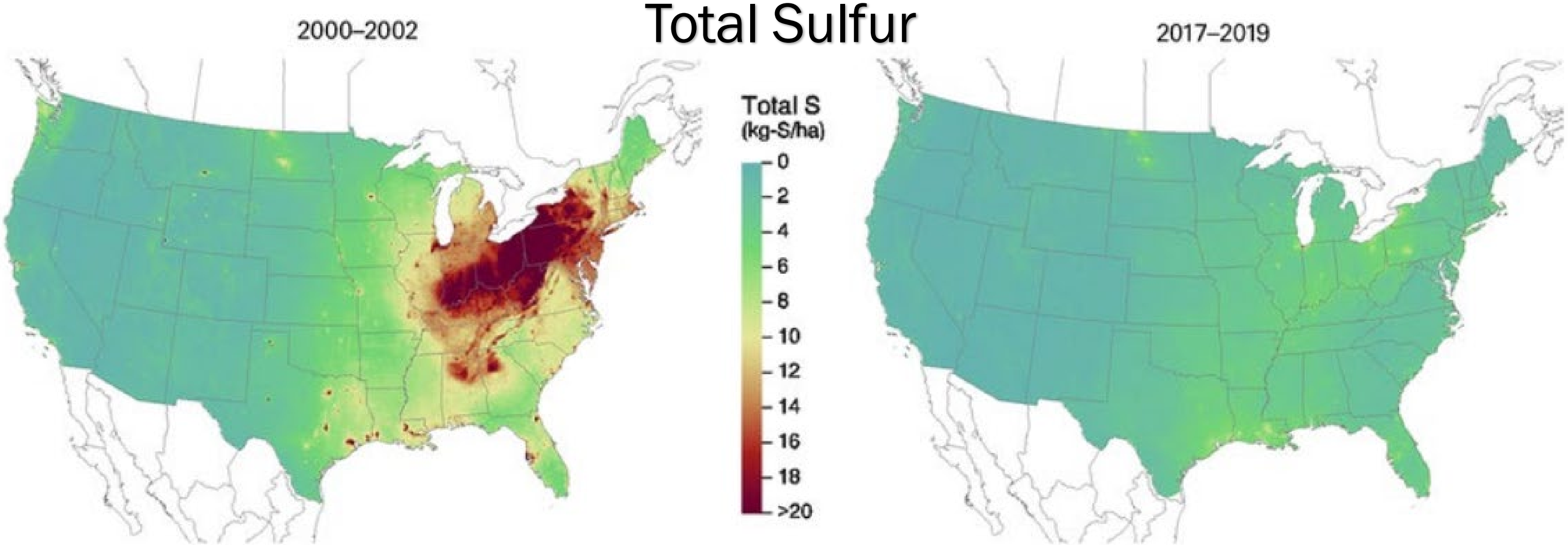


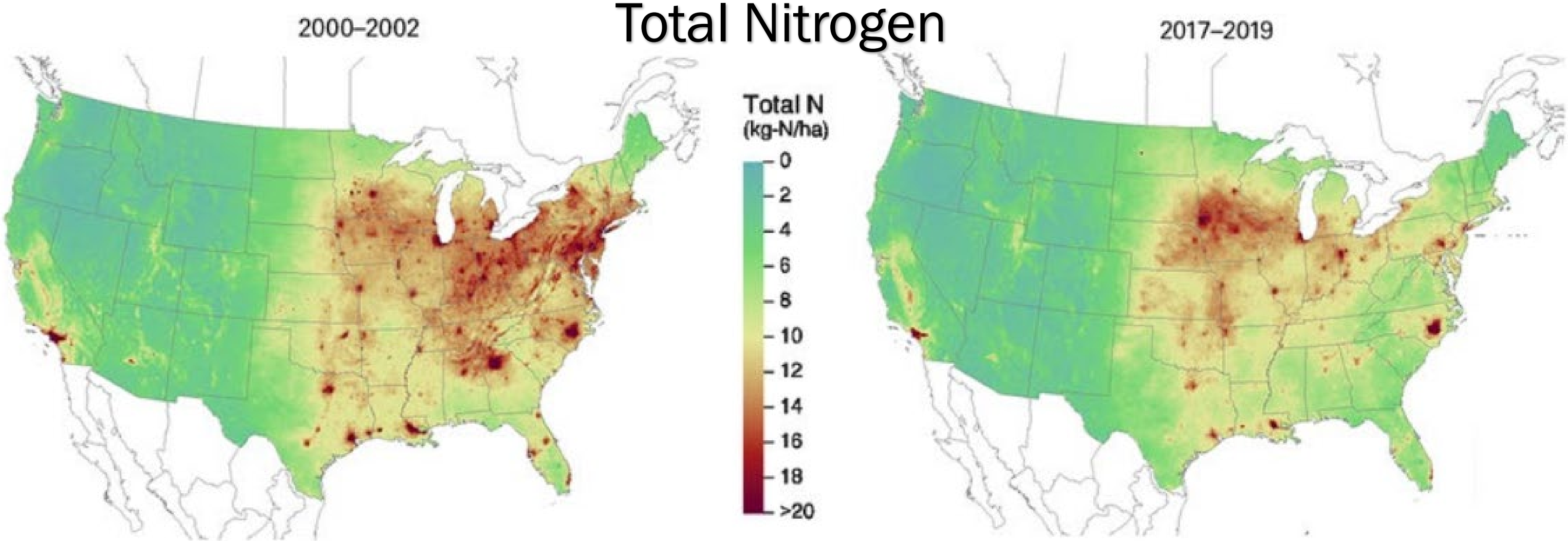
Figure 2-40. Data sources for calculating total deposition. Dark blue indicates observations, white boxes indicate chemical transport modeling results, and light blue boxes are the results of model-measurement fusion.

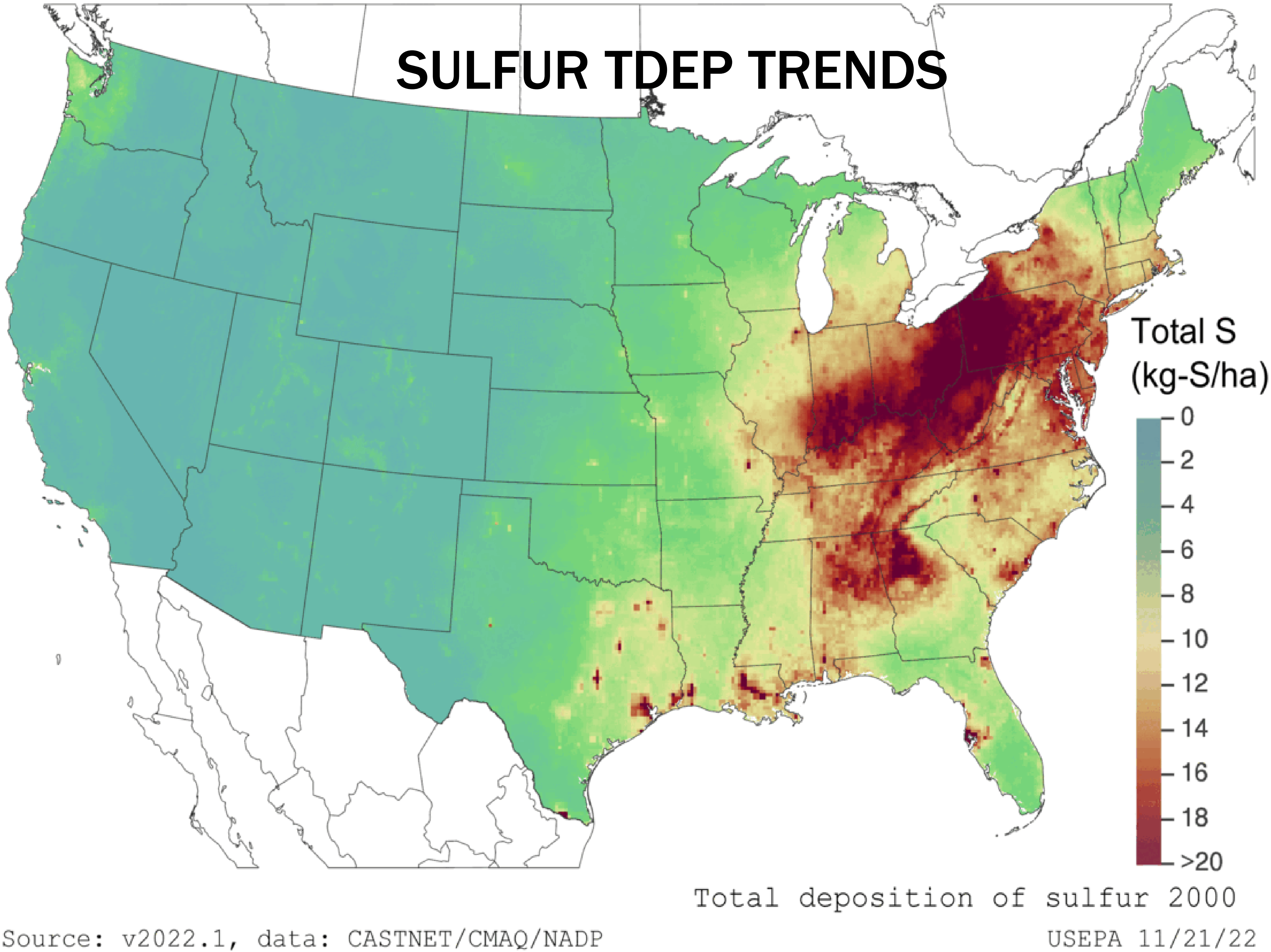
TDEP TRENDS

Total Sulfur

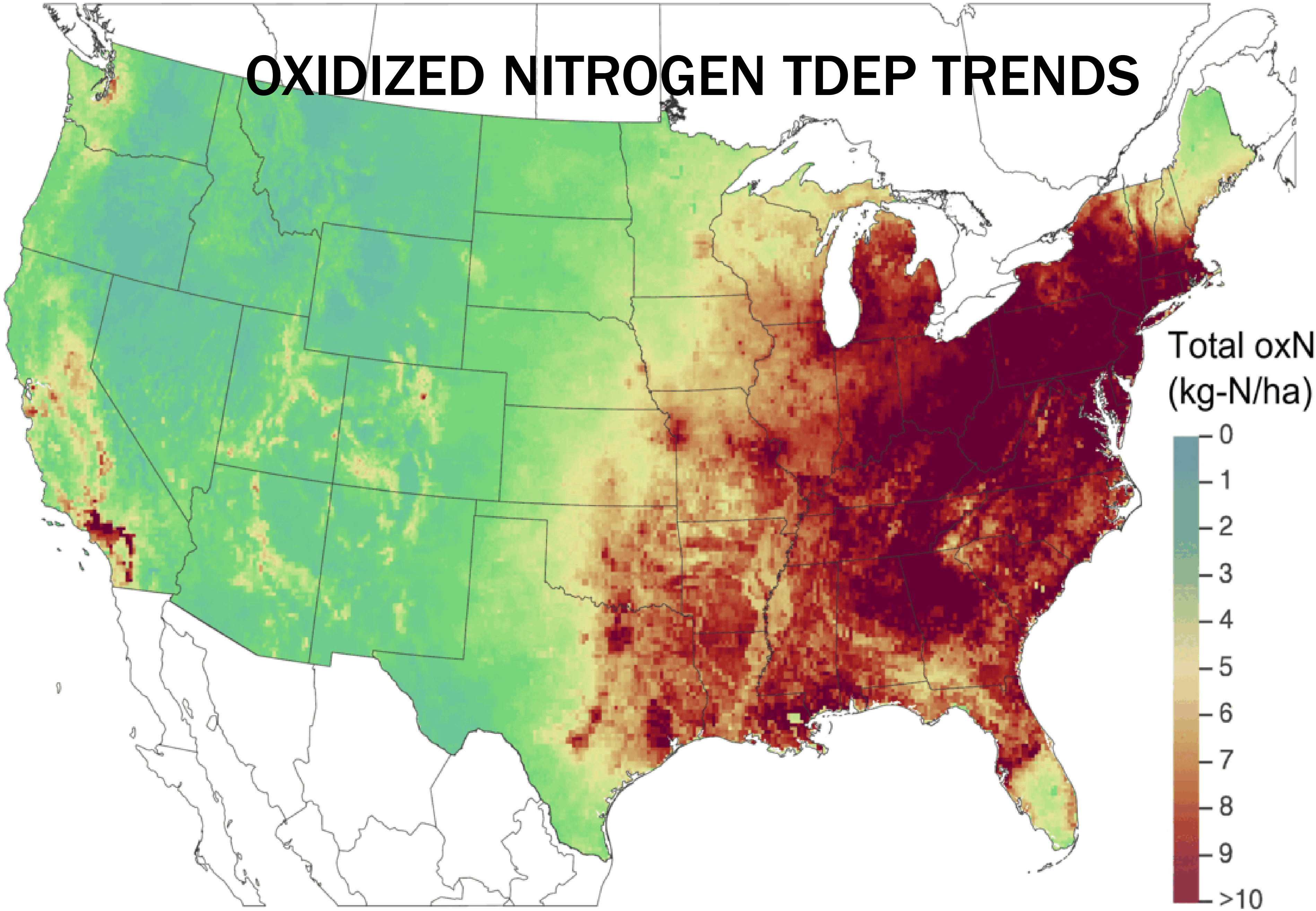


Total Nitrogen




SULFUR TDEP TRENDS
Total S
(kg-S/ha)
0
2
4
6
8
10
12
14
16
18
>20
Total deposition of sulfur 2000
Source: v2022.1, data: CASTNET/CMAQ/NADP
USEPA 11/21/22

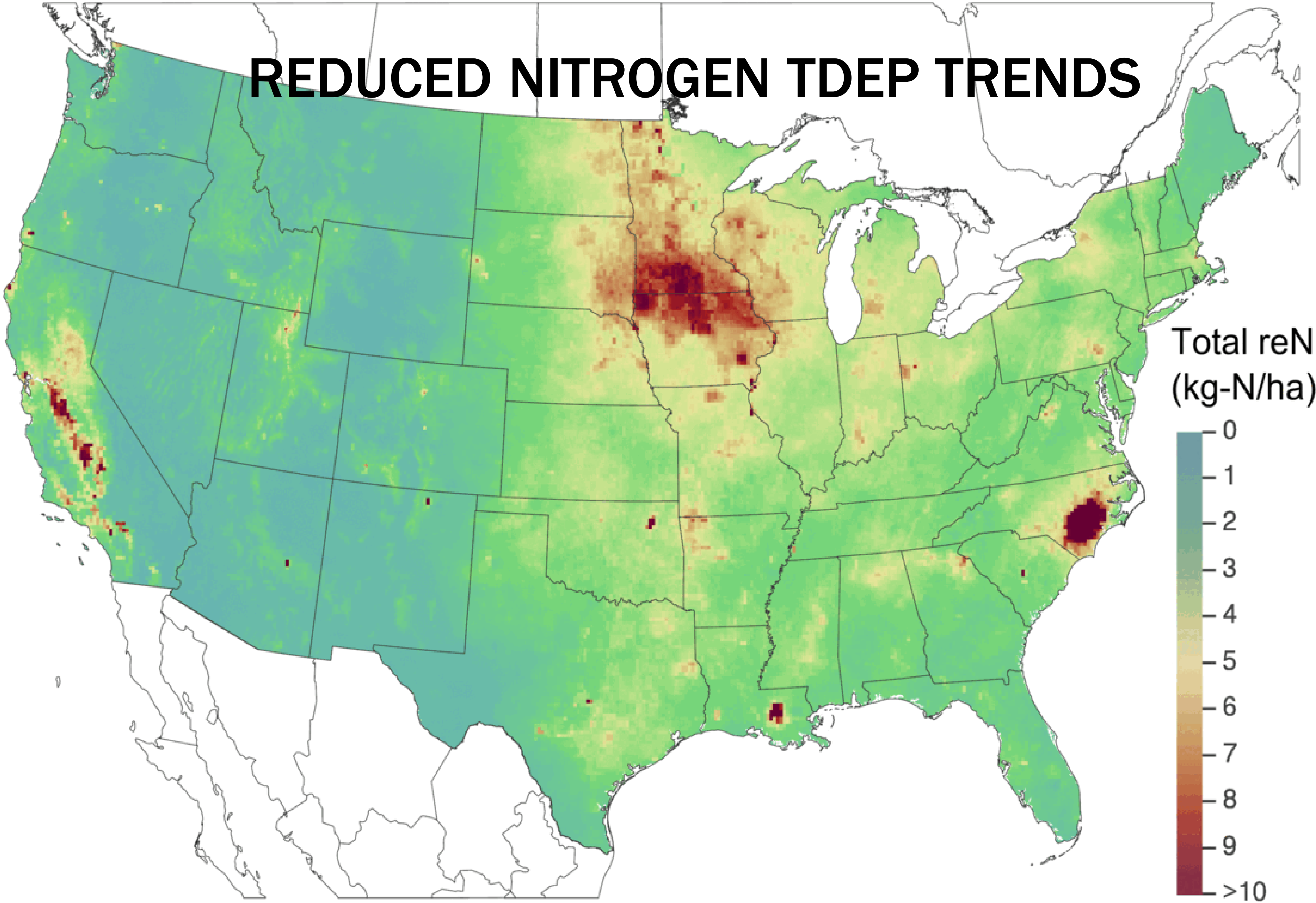
OXIDIZED NITROGEN TDEP TRENDS



Total deposition of oxidized N 2000

Source: v2022.1, data: CASTNET/CMAQ/NADP USEPA 11/21/22

REDUCED NITROGEN TDEP TRENDS



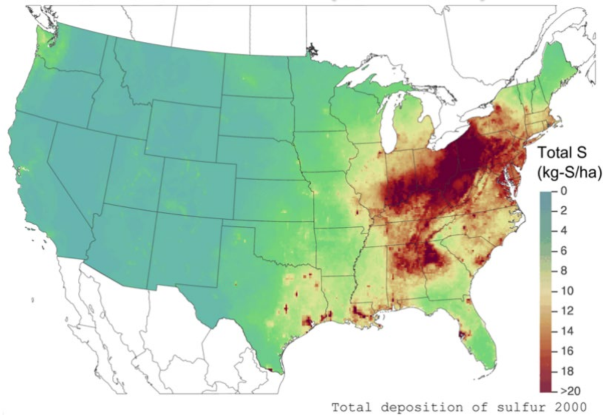
Total deposition of reduced N 2000

Source: v2022.1, data: CASTNET/CMAQ/NADP

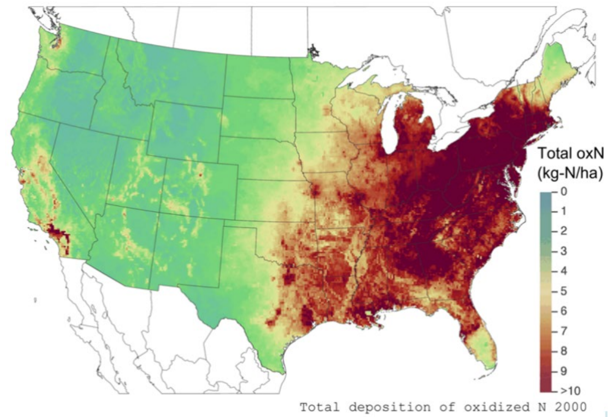
USEPA 11/21/22

S/N TDEP - 2000 vs. 2020

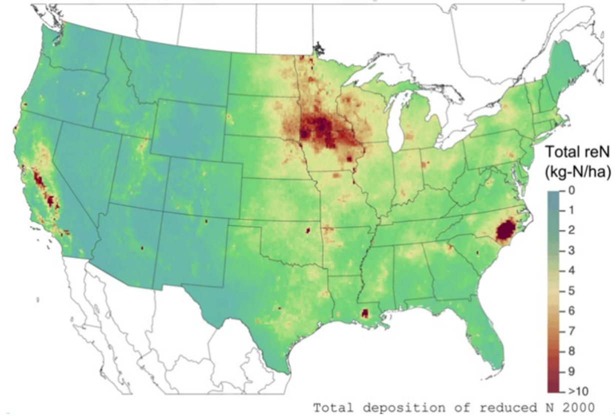
Sulfur (2000)



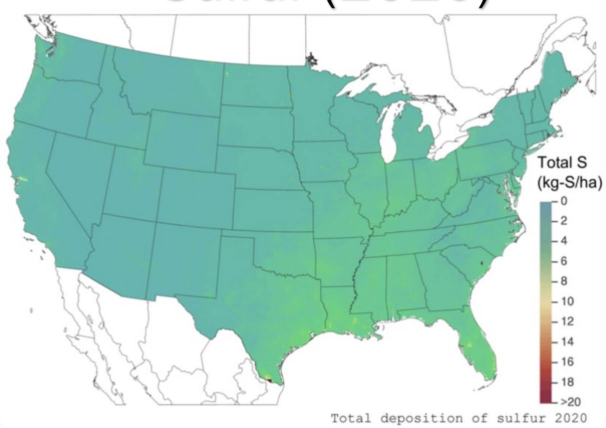
Oxidized N (2000)



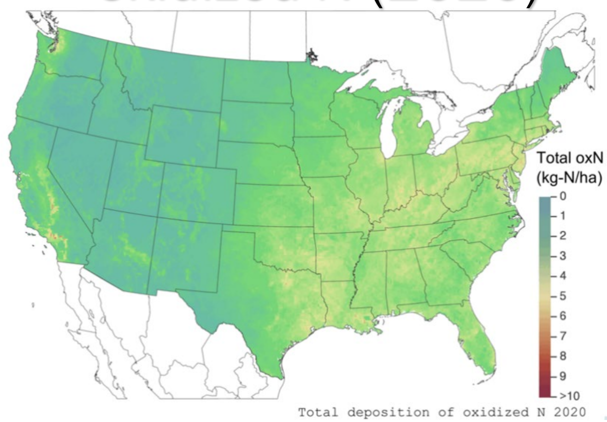
Reduced N (2000)



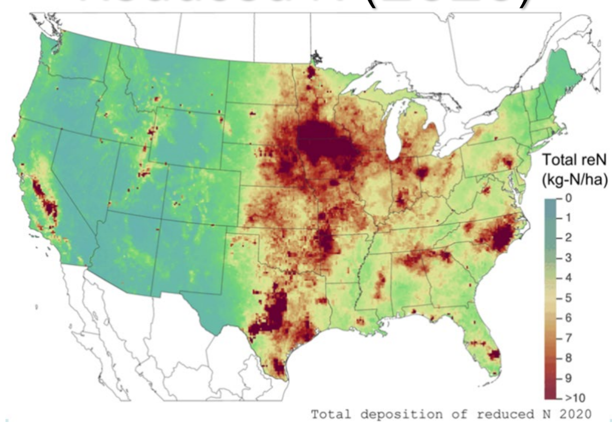
Sulfur (2020)



Oxidized N (2020)



Reduced N (2020)



EPA APPROACHES

- An important part of this review is consideration of the relationship between air concentrations and deposition.
- Understanding this relationship can help inform decisions regarding the best air quality metric(s) for a standard intended to protect against N and S deposition-related effects.
- The draft PA uses two separate approaches to assess the relationships between concentrations and deposition:
  - Evaluating relationships at (1) a limited set of Class I sites with collocated AQ and deposition data and (2) SLAMS sites with TDEP
  - Evaluating relationships nationally for 85 Ecoregion areas, by linking AQ data within an upwind "zone of influence" and downwind deposition data

CO-LOCATED MONITORING STATIONS

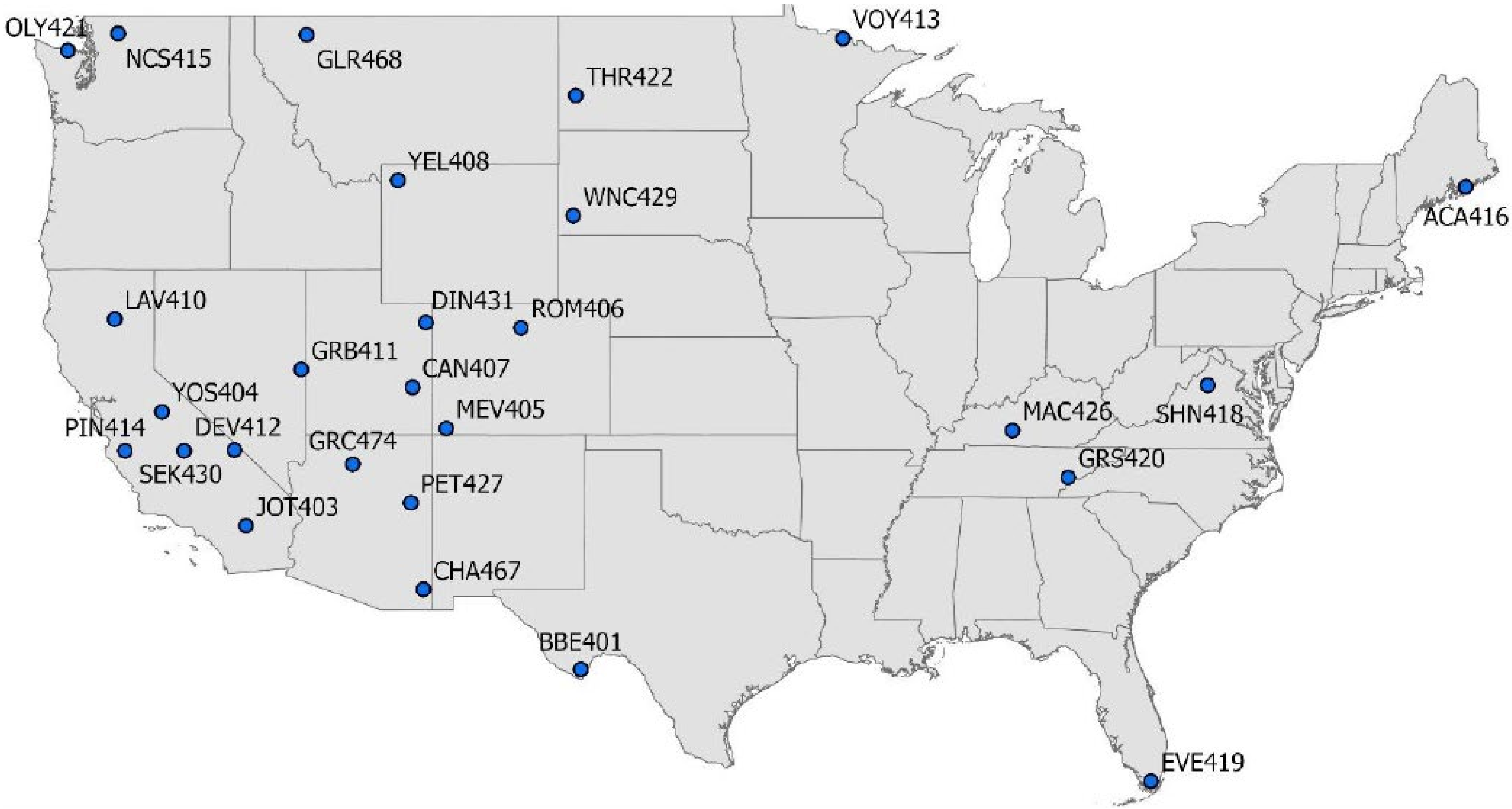


Figure 6-20. Locations of co-located CASTNET, NADP/NTN, and IMPROVE monitoring sites, denoted by CASTNET site identifier. The NADP/NTN and IMPROVE station identifiers are listed in Table 6-3.

IMPROVE/CASTNET vs. SULFUR TDEP

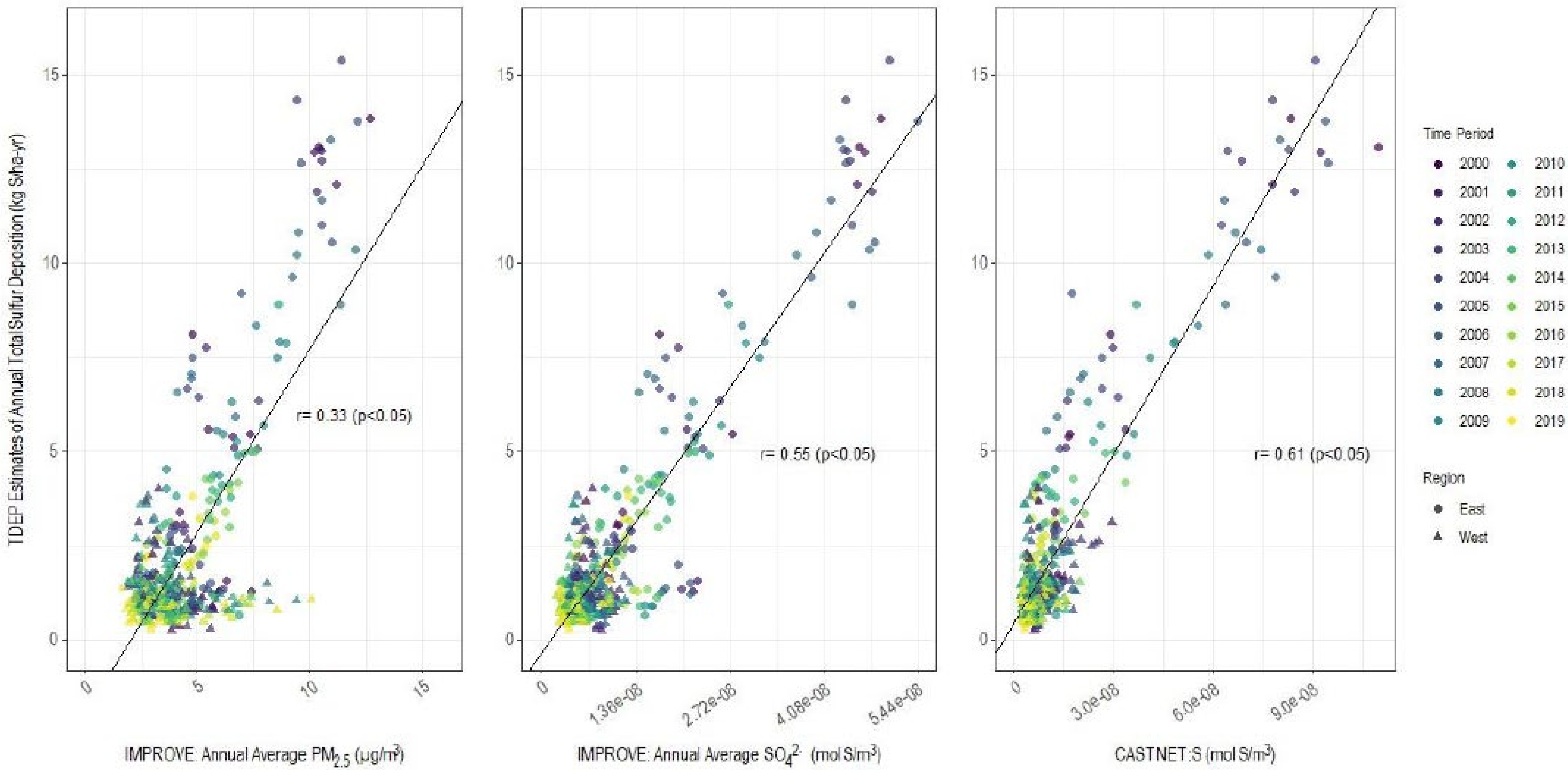


Figure 6-31. Total S deposition (TDep) *versus* annual average ambient air concentrations (2000–2019) of $PM_{2.5}$ (left; IMPROVE), SO_4^{2-} (center; IMPROVE) and total S (right; CASTNET) at 27 Class I area sites. Linear regressions are shown as black lines.

IMPROVE/CASTNET vs. NITROGEN TDEP

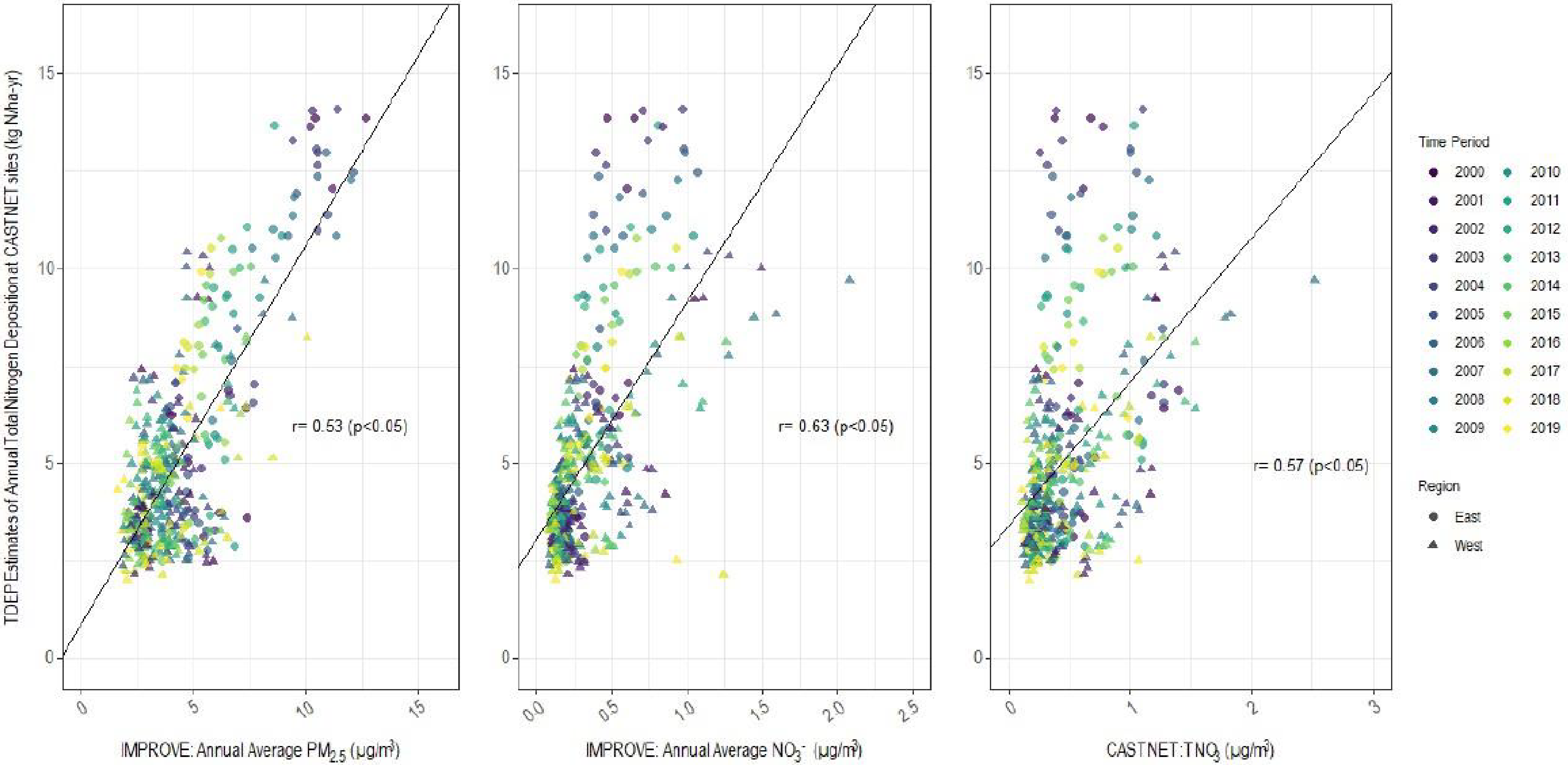


Figure 6-32. Total N deposition (TDep) *versus* annual average ambient air concentrations (2000-2019) of $PM_{2.5}$ (left; IMPROVE), annual average NO_3^- (center; IMPROVE), and TNO_3 (right; CASTNET) at 27 Class I area sites. Linear regressions are shown as black lines.

SLAMS NO_2 vs. NITROGEN TDEP

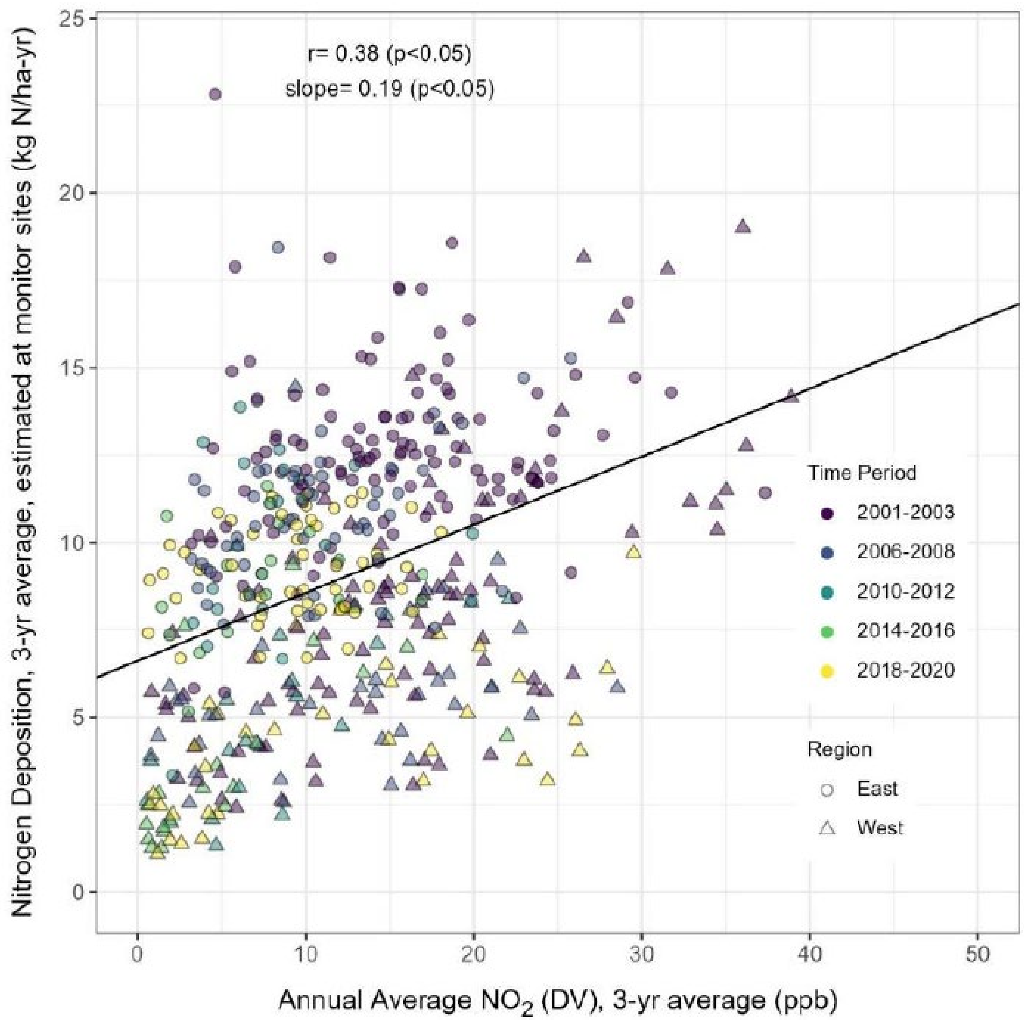


Figure 6-38. TDep-estimated N deposition and annual average NO_2 concentrations (3-year average) at SLAMS across the CONUS (upper), and in the East (lower).

ZONE OF INFLUENCE ANALYSIS

- To understand what upwind monitors were potentially contributing to each downwind ecoregion for each pollutant, and the extent of their contributions, HYSPLIT was utilized.
  - 48-hour forward trajectories, 500m release, 2016 meteorology
  - If >1% of the total hits for an ecoregion could be tracked back to a monitoring location, then that site was considered to be within a plausible "zone of influence"
- For each pollutant, EPA derived two types of Ecoregion Air Quality Metrics (EAQM) for each ecoregion based on pollutant DVs for that ecoregion's contributing monitors:
  - EAQM-Max DV → highest DV from contributing monitors
  - EAQM-Weighted DV → average of contributing monitor quasi-DVs, weighted by each monitor's percentage of the ecoregion's HYSPLIT hits

EXAMPLE ECOREGION PM MONITORS

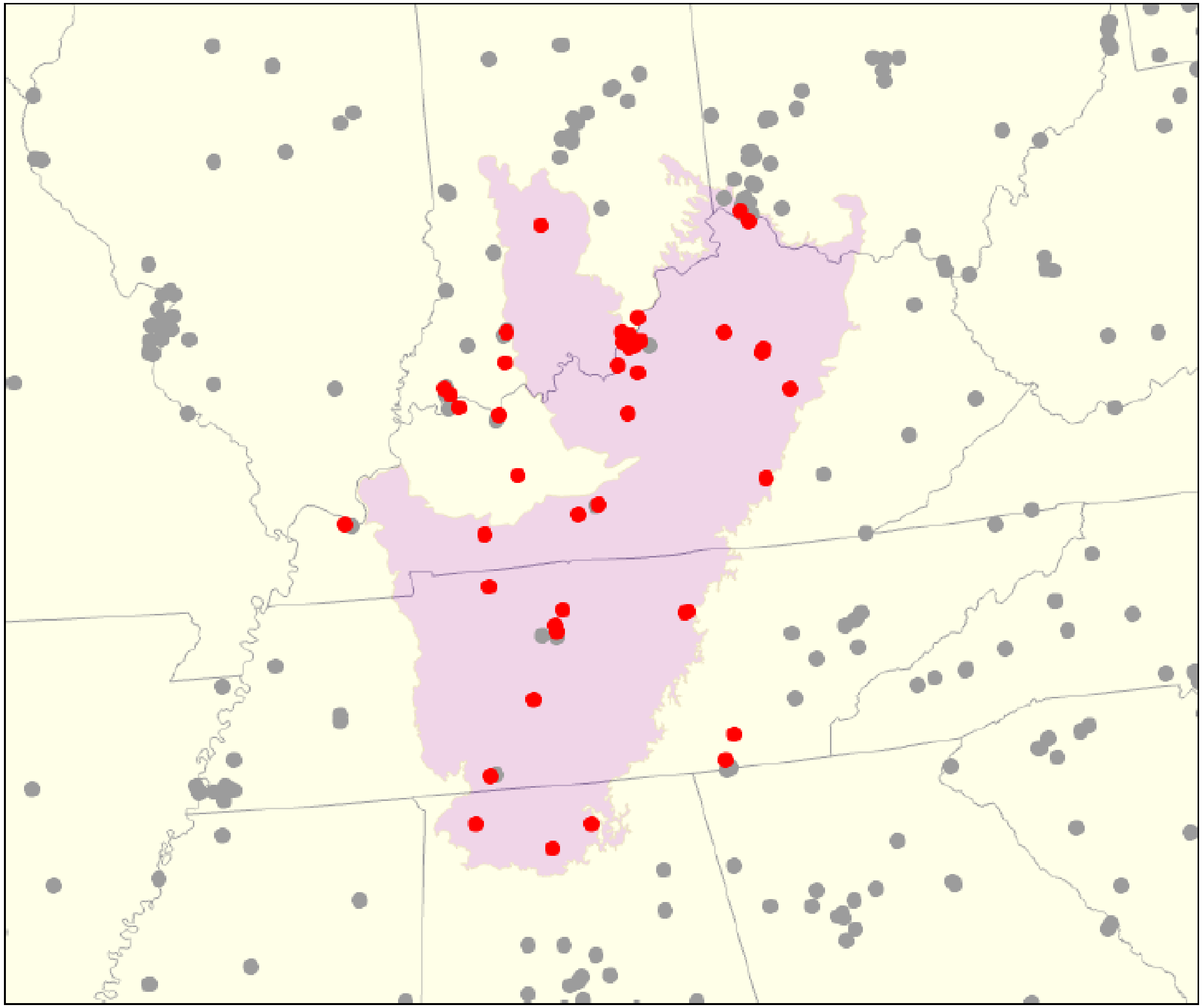


Figure 6A-4. Map of $PM_{2.5}$ monitoring sites of potential influence (red circles) for ecoregion 8.3.3 (purple shaded region) based on the original trajectories and a 1% hit rate as criterion for monitoring site inclusion. Other PM monitoring sites that did not meet the criterion are shown as gray circles.

CASAC COMMENTS ON EPA'S MODELING

- Appendix 6A needs to include the equations that were used to calculate EAQM-weighted concentrations, EAQM-max concentrations, and the median S and N deposition values.
- The appendix should provide a more detailed explanation of how the number of "hits" and percentage of hits were determined for each monitor.
- The CASAC recommends that the EPA run at least three years of meteorology to match number of years used to calculate design values.
- The EPA should clarify how many trajectories are released from each monitor location each day. Also, the start time for each trajectory should be documented.
- The EPA should justify why 48-hour trajectories were used.
- The EPA should justify why a 1% contribution threshold is appropriate.
- The EAQM approach based on HYSPLIT does not account for chemistry. Chemistry and thermodynamics should not be neglected when considering air/deposition relationships.
- The use of nearby SO_2 and NO_2 monitors to evaluate S and N deposition inside the ecoregion may not always give the best reflection of deposition.

CASAC COMMENTS ON EPA'S MODELING

- The current ambient monitoring network for SO_2 may not capture the impacts from many of the large SO_2 industrial emission sources.
- The current NO_2 ambient monitoring network is not designed to capture the impacts from large NO_2 industrial emission sources and is very scarce in many parts of the county.
- The EAQM values are based on transport patterns over the entire year and may not be indicative of the transport patterns during the "deposition season."
- The EPA's EAQM approach does not account for the significant contributions of nitric acid wet and dry deposition to N deposition.
- Total $PM_{2.5}$ may be a poor indicator of sulfate, nitrate, and ammonium. Based on the 2019-2021 speciated $PM_{2.5}$ data in Figure 2-26, only 20-40% of total $PM_{2.5}$ is ammonium sulfate and ammonium nitrate.
- EPA should perform sensitivity runs using different assumptions to evaluate the robustness of the relationships between deposition and EAQM values with regards to these assumptions and help quantify the uncertainty associated with this approach.

CASAC CONCLUSIONS ON EAQM

- Since the EAQM modeling work has not been peer reviewed, the results should be viewed with skepticism.
- However, some CASAC members find that the EAQM results are still useful since there are limited analyses available that compare SO_2, NO_2, and $PM_{2.5}$ design values to S and N deposition values.
- Other CASAC members find that the EAQM results are not scientifically sound and should not be used to inform the secondary standard recommendations for SO_2, NO_2, and $PM_{2.5}$.

CASAC LETTER TO THE ADMINISTRATOR

- The translation of deposition-based effects to an ambient concentration is fraught with difficulties and complexities.
- Based on the wording of section 109(b)(2) of the Clean Air Act (CAA), the CASAC sees no reason why NAAQS could not be based on atmospheric deposition.
- Having a deposition-based standard would be a cleaner, more defensible approach because ecosystem effects are largely characterized and quantified based on deposition.
- The CASAC recommends that the EPA incorporate the advice provided throughout this report into a Second Draft PA. This Second Draft PA should be brought back to the CASAC for review.

EXAMPLE ECOREGION SO_2 MONITORS

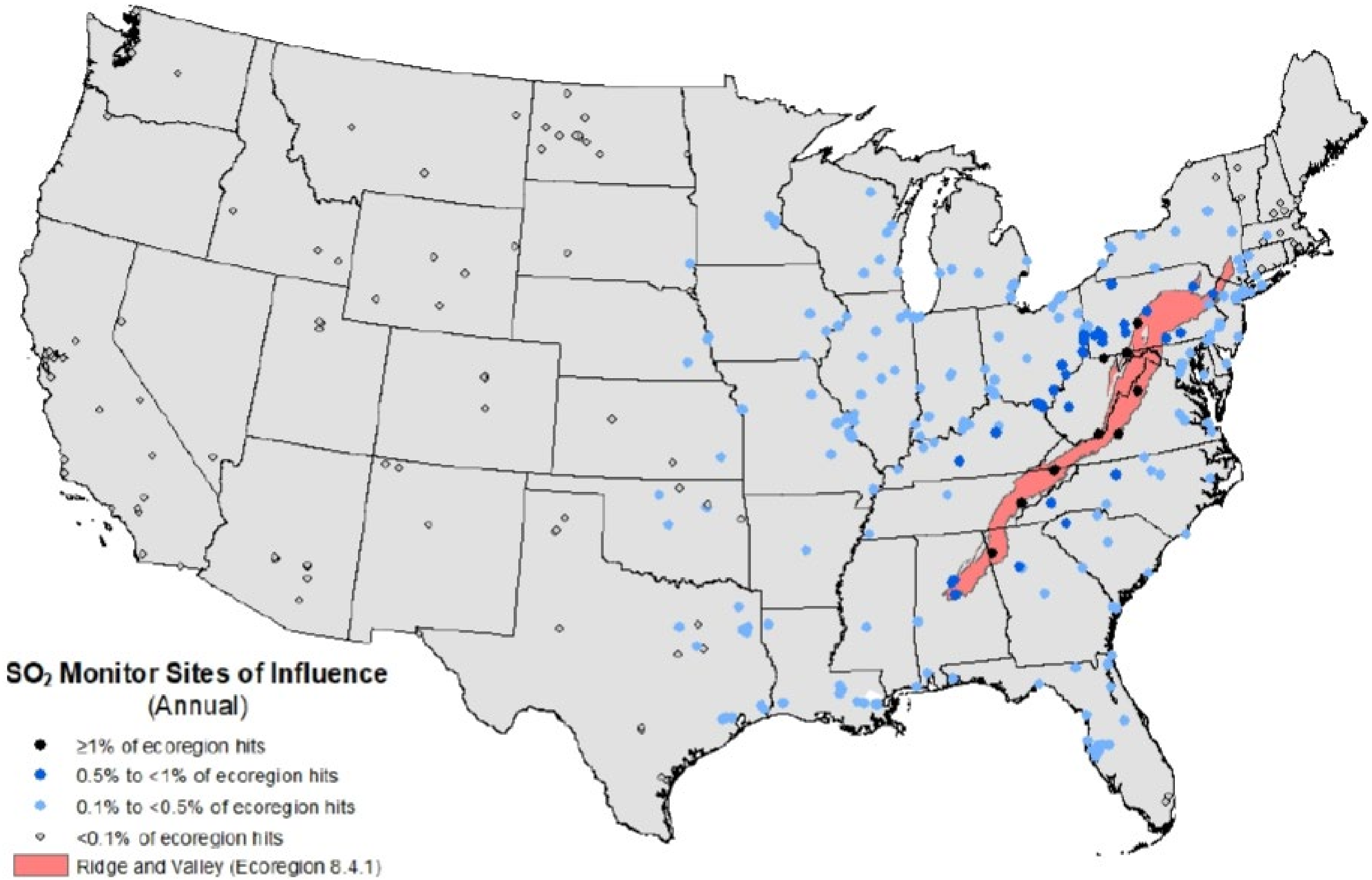


Figure 6A-15. Monitoring sites (annual SO_2 metric) of potential influence for ecoregion 8.4.1 (red shaded region).

SO_2 WEIGHTED ANNUAL AVERAGE

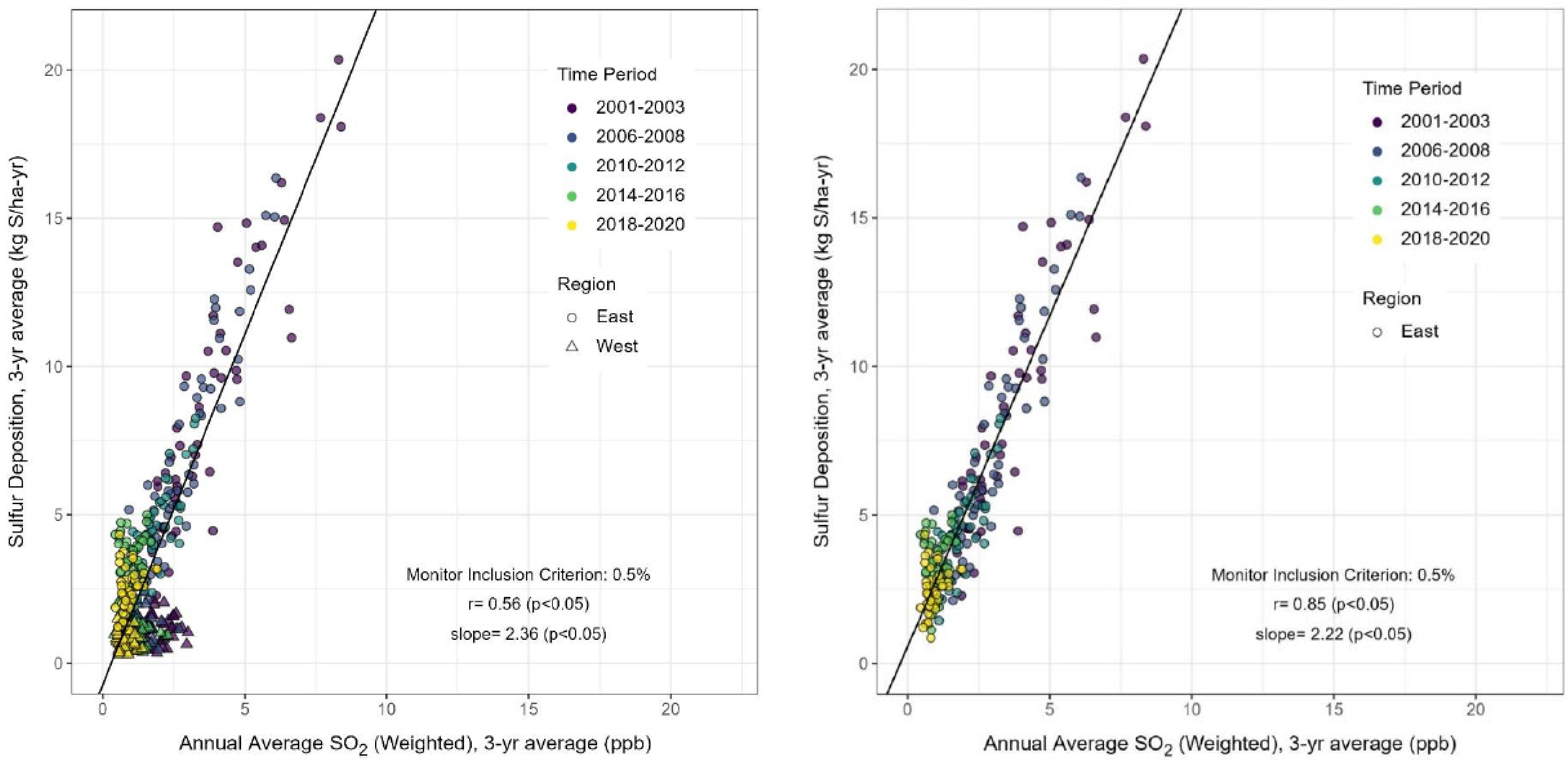


Figure 6-40. TDep-estimated median S deposition in all ecoregions (upper) and eastern ecoregions (lower) *versus* upwind annual SO_2 EAQM-weighted values.

NO_2 WEIGHTED ANNUAL AVERAGE

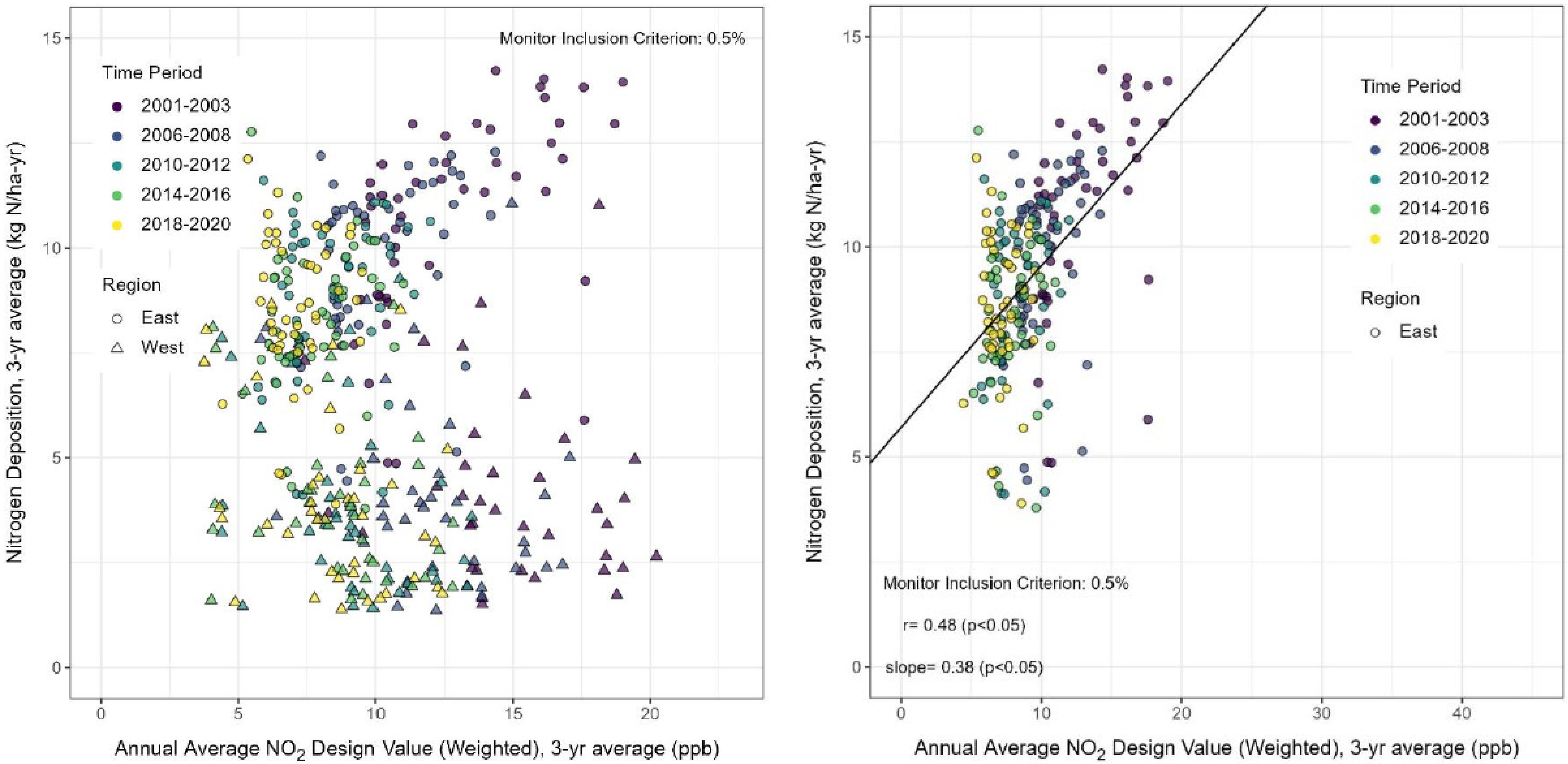
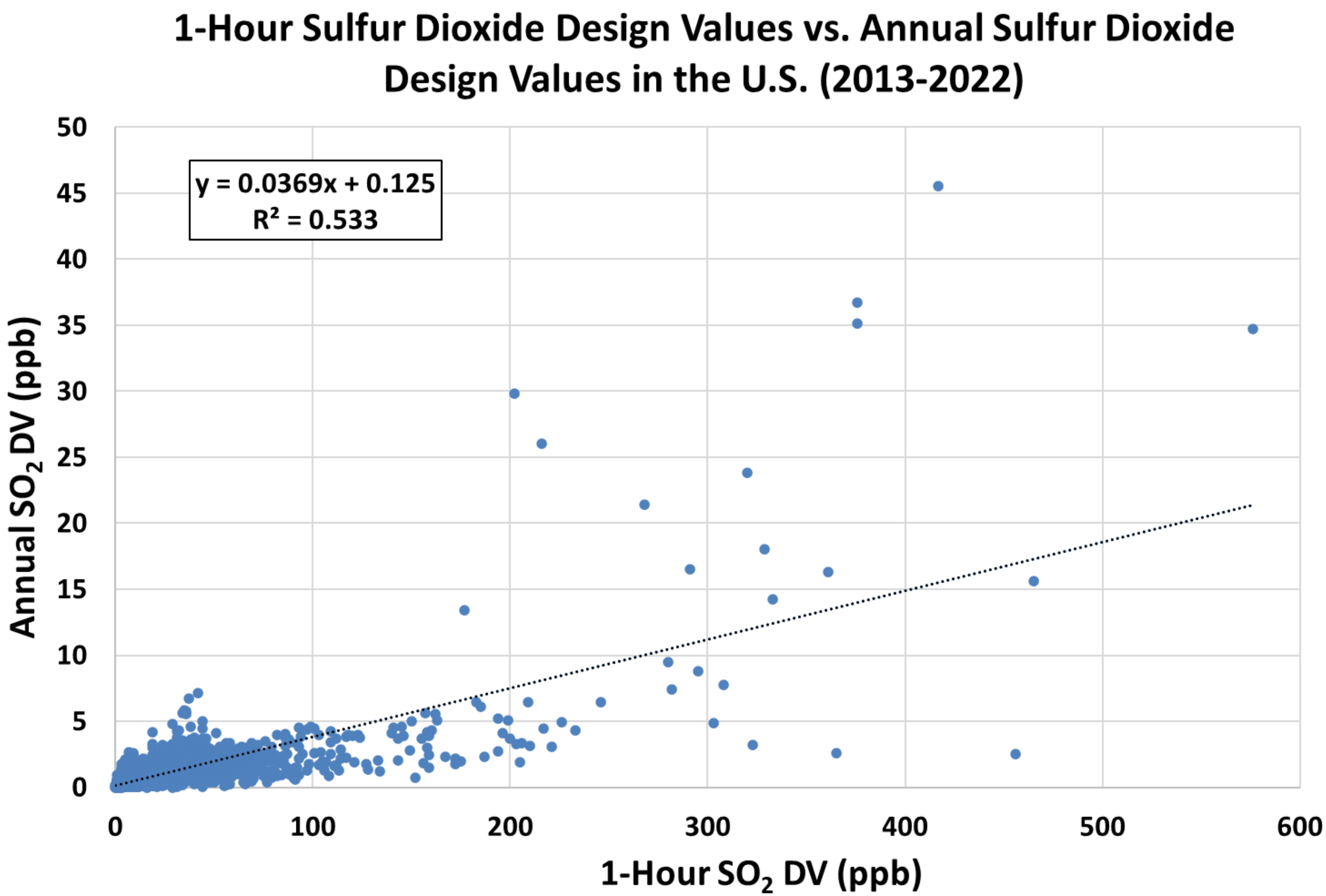


Figure 6-44. TDep-estimated median N deposition in all ecoregions (upper) and eastern ecoregions (lower) versus upwind annual NO_2 EAQM-weighted values.

EPA AND CASAC SUMMARY

Pollutant	EPA Draft PA	CASAC (Majority)	CASAC (Minority)	EPA Final PA	EPA Proposed Rule
SO_2	200-400 ppb (3-hour average, not to be exceeded more than once/year or 10-22 ppb (annual average over three years)	10-15 ppb (annual)	75 ppb (99th percentile of 1-hour daily maximum concentrations, averaged over 3 years)	5-15 ppb (annual average over three years)	10-15 ppb (annual average over three years)
NO_2	Less than 53 ppb (annual) to as low as 40 ppb	<10-20 ppb (annual)	100 ppb (98th percentile of 1-hour daily maximum concentrations, averaged over 3 years)	Retain 53 ppb (annual) or lower the level as low as 35-40 ppb (annual)	Retain 53 ppb (annual)
Annual $PM_{2.5}$	Retain 15 µg/m³ or lower the level as low as 12 µg/m³	6-10 µg/m³ (annual)	12 µg/m³ (annual average over three years)	Retain 15 µg/m³ or lower the level as low as 12 µg/m³	Retain 15 µg/m³ (annual average over three years)
Daily $PM_{2.5}$	35 µg/m³ (98th percentile of 24-hour conc. averaged over 3 years)	25 µg/m³ or a level of 20-25 deciviews	35 µg/m³ (98th percentile of 24-hour conc. averaged over 3 years)	Retain 35 µg/m³ (98th percentile of 24-hour conc. averaged over 3 years)	Retain 35 µg/m³ (98th percentile of 24-hour conc. averaged over 3 years)

1-HOUR SO_2 vs. ANNUAL SO_2



1-HOUR/3-HOUR SO_2 vs. ANNUAL SO_2

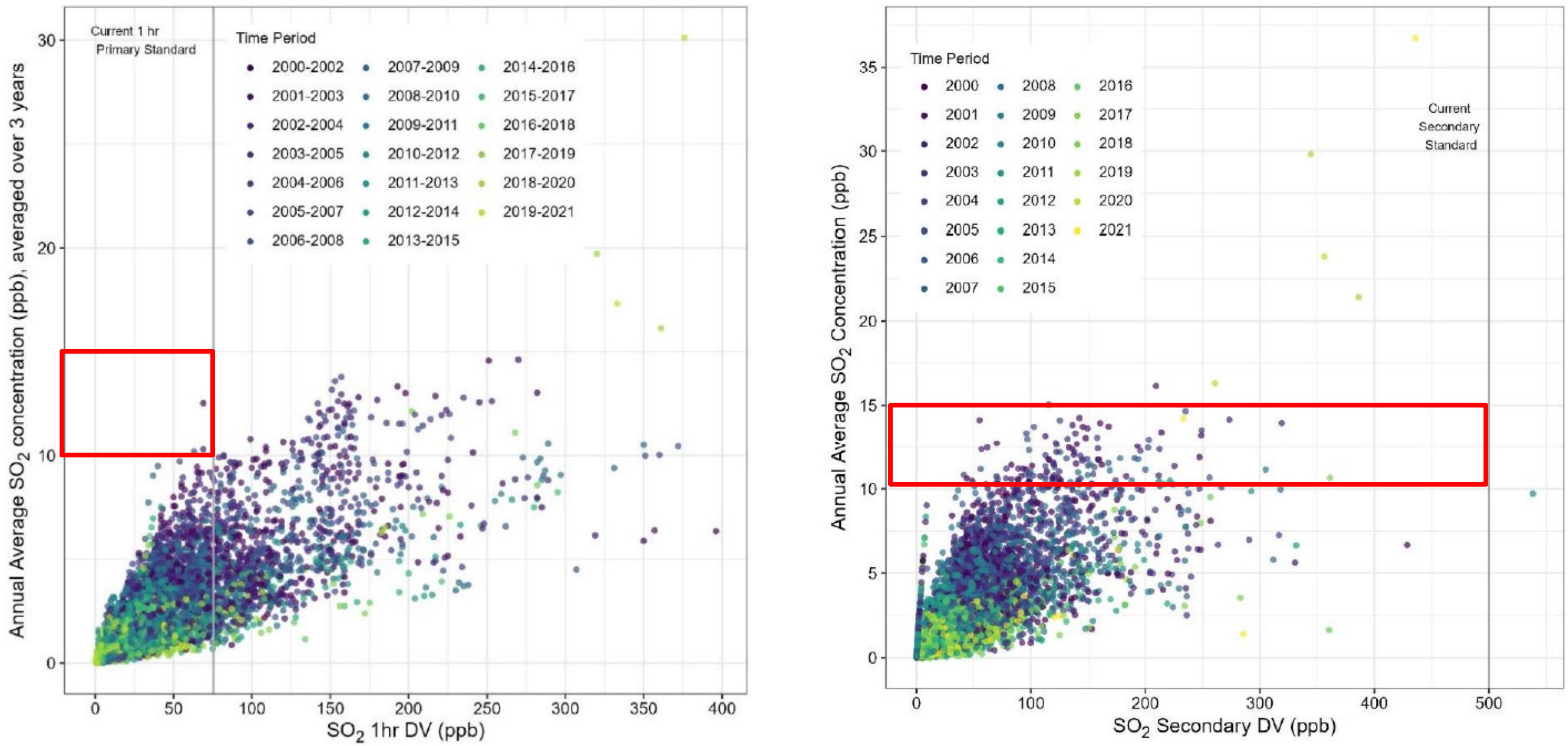
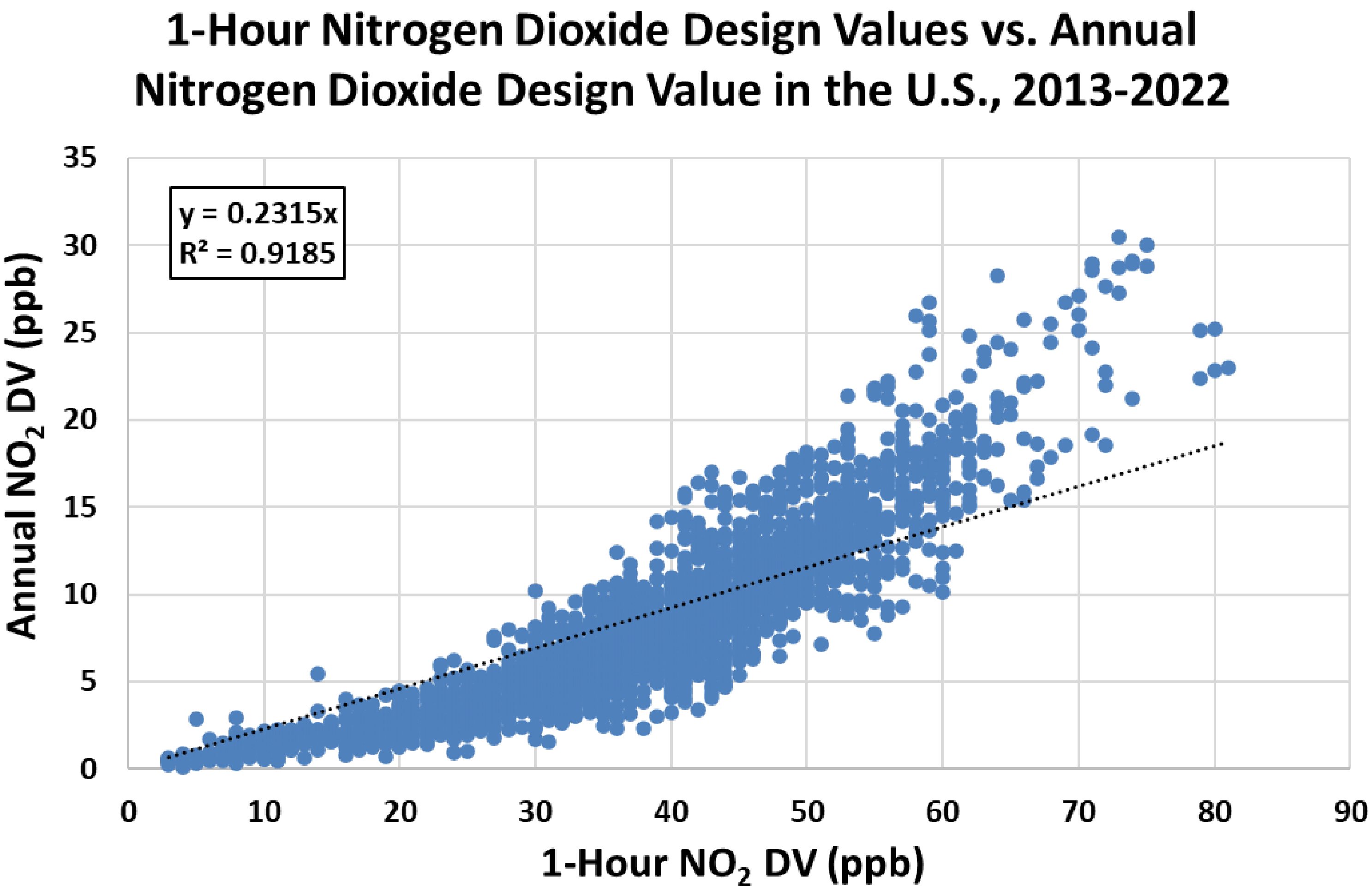


Figure 2-29. Relationship of annual SO_2 concentrations, averaged across three years, to design values for the current 3-hr secondary standard (upper) and the 1-hr primary standard (lower) at SLAMS (2000-2021). Sites in Hawaii excluded.

1-HOUR NO_2 vs. ANNUAL NO_2



1-HOUR NO_2 vs. ANNUAL NO_2

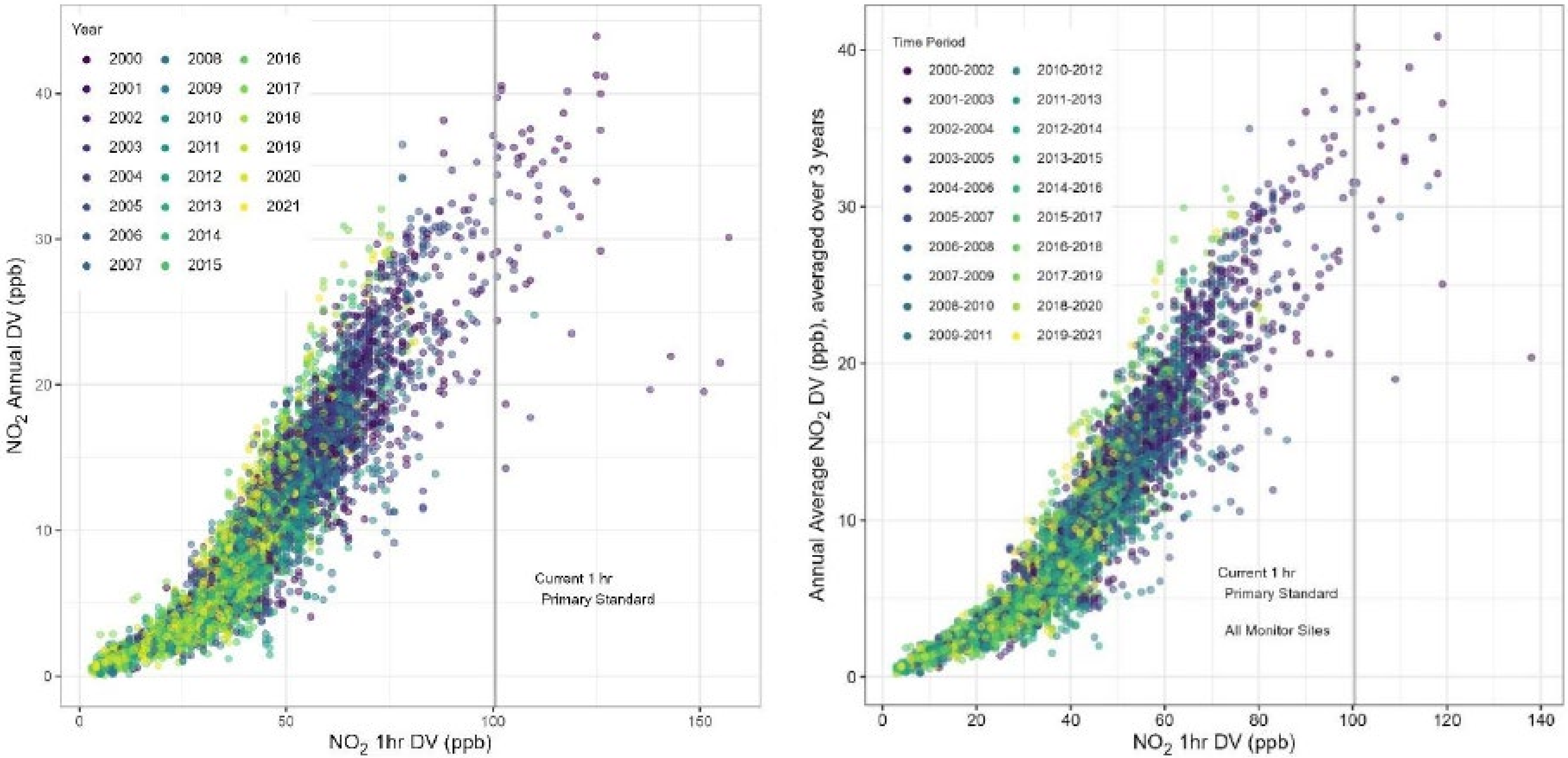


Figure 7-10. Annual NO_2 design values (left) and annual NO_2 concentrations, averaged over three years (right) associated with 1-hour NO_2 design values at SLAMS.

FINAL POLICY ASSESSMENT – NO_2 MAJORITY

- The CASAC majority recommended revision of the existing annual NO_2 standard level to a value below 10 to 20 ppb.
- As described in section 7.3 above, however, the basis for this advice relates to a graph in the draft PA of the dataset of results from the trajectory-based analyses for the weighted annual NO_2 metric (annual NO2 EAQM-weighted).
- These CASAC members additionally recognized that these results found no correlation between the ecoregion deposition and the EAQM-weighted values at upwind locations, and as described in section 6.2.4.3 above the correlation coefficients are negative for N deposition with both annual NO_2 EAQMs (-0.17 and -0.06).
- Accordingly, the information highlighted by these members for relating N deposition levels to ambient air concentrations cannot reasonably be concluded to provide support for the identified levels.

FINAL POLICY ASSESSMENT – NO_2 MINORITY

- Recognizing that among the NO_2 primary and secondary NAAQS, the 1-hour primary standard (established in 2010) may currently be the controlling standard for ambient air concentrations, we note that annual average NO_2 concentrations, averaged over three years, in areas that meet the current 1-hour primary standard have generally been below approximately 35 to 40 ppb.
- We note that an annual standard with a level within this range would appear to have conceptual consistency with the advice from the CASAC minority.

FINAL POLICY ASSESSMENT – $PM_{2.5}$

- The CASAC majority recommended revision of the standard level to a value within the range from 6 to 10 μg/m^3, although we note that the specific rationale for the ends of this range is unclear."
- "It may be appropriate to consider levels below the current level of 15 μg/m^3, such as a level of 12 μg/m^3 (the level of the currently controlling primary standard), recognizing uncertainty with regard to the extent of N deposition-related control and associated protection that might be achieved. In so doing, we note that this option is that recommended by the CASAC minority.

PROPOSED RULE

- Comment are due on or before June 14, 2024.
- EPA is proposing revisions to the data handling procedures for the proposed annual secondary SO_2 standard.
- EPA is not proposing any modifications to the existing SO_2 minimum monitoring requirements.
- EPA is soliciting comment on an analysis that could support an alternative compliance demonstration for PSD permitting. This alternative would allow sources to demonstrate compliance with a revised secondary SO_2 NAAQS by showing compliance with the existing primary SO_2 NAAQS.

CONTACT INFORMATION

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