UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

April 30, 2024

MEMORANDUM

SUBJECT: Supplement to the Guidance on Significant Impact Levels for Ozone and Fine Particles in the Prevention of Significant Deterioration Permitting Program

FROM: Richard Wayland, Director
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TO: Regional Air Division Directors, Regions 1 – 10

The Environmental Protection Agency (EPA) has reassessed the significant impact levels (SILs) for the 8-hour ozone National Ambient Air Quality Standard (NAAQS) and the annual and 24-hour fine particulate matter ($PM_{2.5}$) NAAQS and Prevention of Significant Deterioration (PSD) increments that the Agency recommends using in the PSD permitting program considering, new ambient air quality data and the recent revision to the primary annual $PM_{2.5}$ NAAQS.[1] Based on this reassessment, the EPA has developed new SILs for the primary annual $PM_{2.5}$ NAAQS and PSD increments and recommends continuing to use the same values for ozone and 24-hour $PM_{2.5}$. The attached document supplements a 2018 EPA guidance[2] and provides these new SIL values for $PM_{2.5}$ that permitting authorities may use to help determine whether a proposed PSD source causes or contributes to a violation of the primary annual $PM_{2.5}$ NAAQS or PSD increments. The EPA recommends using these new SIL values for annual $PM_{2.5}$ instead of the SIL values presented in the 2018 guidance. This supplement also provides a summary of the technical analysis used for the reassessment of the ozone and 24-hour SILs and the development of the replacement annual $PM_{2.5}$ SILs. The presentation of these values is not final Agency action and does not create any binding requirements on permitting authorities, permit applicants or the public.

[1] 89 FR 16202 (February 7, 2024).
[2] Memorandum from Peter Tsirigotis, EPA Office of Air Quality Planning and Standards, Guidance on Significant Impact Levels for Ozone and Fine Particles in the Prevention of Significant Deterioration Permitting Program, April 17, 2018.

Please share this guidance with permitting authorities in your region. If you have questions regarding the supplement, please contact Tyler Fox at *fox.tyler@epa.gov* or (919) 541-5562, and Rochelle King at *king.rochelle@epa.gov* or (919) 541-1390.

Attachment

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Attachment

Supplement to the 2018 Guidance on Significant Impact Levels for Ozone and Fine Particles in the Prevention of Significant Deterioration Permitting Program

I. INTRODUCTION

In 2018, the EPA released the Guidance on Significant Impact Levels for Ozone and Fine Particles in the Prevention of Significant Deterioration (PSD) Permitting Program (hereafter referred to as the 2018 guidance) to provide recommended significant impact level (SIL) values for the 8-hour ozone National Ambient Air Quality Standard (NAAQS) and the annual and 24-hour $PM_{2.5}$ NAAQS and PSD increments.[2] SILs are a compliance demonstration tool that can be used to determine whether a proposed PSD source causes or contributes to a violation of the corresponding NAAQS or PSD increment. The 2018 guidance details the application of SILs in the PSD permitting program and provides recommended SIL values for ozone and $PM_{2.5}$. That guidance also includes a technical document that provides a detailed discussion of the peer-reviewed[3] technical analysis used in the development of these values and a legal memorandum that provides further detail on the legal basis that permitting authorities may choose to adopt to support using SILs to show that requirements for obtaining a PSD permit are satisfied.[4]

The method used to develop the ozone and $PM_{2.5}$ SILs in 2018 was based on the inherent variability in the historical ambient monitoring data and the level of the corresponding standard. Since the release of the 2018 guidance, the level of the primary annual $PM_{2.5}$ NAAQS has been revised[5] and more recent ambient monitoring data are available for ozone and $PM_{2.5}$ to inform EPA's method. Given the changes in these two inputs to the Agency's method for determining inherent variability used to develop the 2018 SILs, the EPA reassessed the SIL values for ozone and $PM_{2.5}$ recommended in the 2018 guidance. As a result of the reassessment, the EPA considers it appropriate to update and replace its recommended SILs corresponding to the annual $PM_{2.5}$ NAAQS and PSD increments. The EPA continues to recommend the SILs corresponding to the ozone and 24-hour $PM_{2.5}$ NAAQS and 24-hour $PM_{2.5}$ PSD increments that were provided in the 2018 guidance because the level of these NAAQS remains unchanged and the inherent variability in the new ambient data was not meaningfully different than the results presented in 2018. This supplement to the 2018 guidance provides new SILs corresponding to the primary annual $PM_{2.5}$ NAAQS and annual $PM_{2.5}$ PSD increments with supporting technical analyses that permitting authorities may choose to use to make the required air quality demonstration in particular PSD permitting actions. This supplement provides solely a technical update to the SIL values recommended by EPA and in no way modifies the EPA's recommendations regarding the application of these and other SIL values in the PSD permitting program or the legal basis that

[3] The methods, analysis, and application to the PSD program was subject to a peer review. The results of that peer-review and the subsequent changes to the analysis are detailed in the report, U.S. EPA, 2018, Peer review report for the technical basis for the EPA's development of significant impact thresholds for $PM_{2.5}$ and ozone, RTP, NC, EPA 454/S-18-001, available from the U.S. EPA RTP library.
[4] "Technical Basis for the EPA's Development of Significant Impact Thresholds for $PM_{2.5}$ and Ozone," EPA-454/R-18-001, April 2018; "Legal Memorandum: Application of Significant Impact Levels in the Air Quality Demonstration for Prevention of Significant Deterioration Permitting under the Clean Air Act," April 2018.
[5] On March 6, 2024, the EPA revised the level of the primary annual $PM_{2.5}$ NAAQS from 12 ug/m^3 to 9 ug/m^3 (78 FR 3086).

permitting authorities may choose to adopt to support using SILs to show that requirements for obtaining a PSD permit are satisfied.[6]

As stated in the 2018 guidance, permitting authorities retain discretion to use or not to use EPA's recommended SILs in particular PSD permitting actions. If a permitting authority chooses to use these new SIL values to support a case-by-case permitting decision, as with any SIL values, the permitting authority must justify the values and their use in the administrative record for the permitting action.

As was the case with EPA's 2018 guidance, this update of the SIL value corresponding to the primary annual $PM_{2.5}$ NAAQS is not a final Agency action and does not reflect a final determination by the EPA that any particular proposed source with a projected impact below the new recommended SIL value does not cause or contribute to a violation. A determination that a proposed source does not cause or contribute to a violation can only be made by a permitting authority on a permit-specific basis after consideration of the permit record. This memorandum is not legally binding and does not affect the rights or obligations of permit applicants, permitting authorities, or others. The SIL values identified by the EPA have no practical effect unless and until permitting authorities decide to use those values in particular permitting actions. Permitting authorities retain the discretion to apply and justify different approaches and to require additional information from the permit applicant to make the required air quality impact demonstration, consistent with the relevant PSD permitting requirements.

II. SUPPLEMENT TO RECOMMENDED SIL VALUES FOR USE IN AIR QUALITY IMPACT DEMONSTRATION REQUIRED TO OBTAIN A PSD PERMIT

The 2018 guidance recommends the use of a quantitative threshold to determine whether increased emissions from proposed construction or modification of a PSD source will cause or contribute to a violation of the ozone and $PM_{2.5}$ NAAQS. The recommended SILs were developed based on the level, averaging period, and statistical form of its corresponding NAAQS. Specifically, the recommended primary annual $PM_{2.5}$ NAAQS SIL was selected based on the ambient air quality variability and the level of the associated standard.[7] The EPA believes that a change in the level of the NAAQS makes it appropriate for the EPA to calculate a new SIL value to provide PSD permit applicants with a quantitative threshold consistent with that revised standard level and one that reflects the most recent state of the nation's atmosphere. Considering the revision of the primary annual $PM_{2.5}$ NAAQS and the more recent ambient data that are used in the method to develop the SIL values recommended in the 2018 guidance, the EPA has reassessed the SILs for the ozone and $PM_{2.5}$ NAAQS and $PM_{2.5}$ PSD increments. The SIL values presented in this supplement may be used in PSD compliance demonstrations on or after the effective date of the PM NAAQS rule.[8]

In a 2010 rule, the EPA established that a $PM_{2.5}$ impact greater than 1.2 ug/m^3 for the 24-hour $PM_{2.5}$ NAAQS or an impact greater than 0.3 ug/m^3 for the annual $PM_{2.5}$ NAAQS will be considered to cause or

[6] The "Application of SILs" section of the 2018 guidance provides a robust information regarding EPA's recommendations for the application of SILs under the PSD permitting program.

[7] The primary annual $PM_{2.5}$ NAAQS at the time of release of the 2018 Guidance on Significant Impact Levels for Ozone and Fine Particles in the PSD Permitting Program was 12 ug/m^3 which was set in the 2013 rulemaking (78 FR 3086) and retained in the 2020 final decision (85 FR 82684).

[8] The final rule on the Reconsideration of the National Ambient Air Quality Standards for Particulate Matter will be effective May 6, 2024 (89 FR 16202).

contribute to a violation of the relevant NAAQS.[9] Therefore, the discretion of the EPA and other permitting authorities is constrained in developing higher SIL values for these NAAQS. Because ozone is not addressed in 40 CFR 51.165(b)(2), permitting authorities are not precluded from developing a higher ozone NAAQS SIL value than recommended in this supplement to the 2018 guidance. Likewise, 40 CFR 51.165(b)(2) does not address PSD increments and, thus does not constrain the discretion of a permitting authority to develop a higher SIL value and use it for PSD increment purposes. Permitting authorities also retain the discretion to develop and apply SIL values that are lower than those recommended by EPA in this memorandum.

Technical Basis for Update of Recommended SILs for $PM_{2.5}$

Prior to the release of the 2018 guidance, the EPA sought to develop a stronger analytical foundation for the selection of a degree of change in concentration that permitting authorities may use to represent an insignificant impact on air pollutant concentrations for ozone and $PM_{2.5}$ for PSD permitting purposes. The 2018 guidance recommended SIL values for ozone and $PM_{2.5}$ based on the air quality variability approach, which assesses the variability in pollutant concentrations across the national monitoring network. This peer-reviewed[3] approach relies upon the fact that there is inherent variability in observed ambient data due to the intrinsic variability of emissions and meteorology controlling transport and formation of pollutants. The approach uses statistical theory and methods to model that intrinsic variability to identify a level of change in ambient concentrations that is acceptably similar to the measured ambient concentrations, thereby representing an insignificant change in air quality.

Based on observed ambient data, the variability of the air quality levels of ozone and $PM_{2.5}$ were estimated by applying the bootstrapping statistical approach. The bootstrap technique, as applied in this analysis, models multiple scenarios to quantify the degree of air quality variability at an ambient monitoring site to account for the inherent spatial and temporal variability in observed ambient data. Through recreating numerous iterations of the sample (i.e., the observed ambient air data), one is able to determine confidence intervals (CIs) to determine a statistically significant deviation from the design value for each monitor site across the nation. To develop the recommended SIL values, EPA selected the 50 percent CI to quantify the bounds of change in air quality that can be considered an "insignificant impact" for the purposes of meeting requirements under the PSD program.[10] The EPA then determined recommended SIL values by multiplying the inherent variability indicator (i.e., median statistic of the relative variability from the 50 percent CIs from the entire U.S. ambient monitoring network) by the level of the associated NAAQS.[11]

The SIL values recommended in the 2018 guidance were selected based on the level of air quality variability in the most recently available observed ambient data at the time (2014-2016) and the level of the applicable NAAQS. Given the strengthening of the PM NAAQS, the EPA re-assessed the annual $PM_{2.5}$ SIL for PSD permitting purposes based on the new level of the primary annual $PM_{2.5}$ NAAQS. This reassessment also provided the opportunity to incorporate more recent ambient monitoring data. EPA

[9] 75 FR 64864 (October 20, 2010).

[10] The 2018 guidance and technical basis provide an in-depth explanation as to why the 50 percent CI was selected for determining an appropriate SIL value for the ozone and $PM_{2.5}$ NAAQS.

[11] As described in the 2018 guidance, the relative variability was selected over the absolute variability in calculating the SILs because the technical analysis showed that the relative variability is fairly consistent across a range of design values.

thus replicated the air quality variability analysis based on the most recently available years of data (2020-2022) for ozone and $PM_{2.5}$. The most recently available monitoring data were used to ensure that the SILs recommended in this supplement reflect the most recent state of the nation's atmosphere. The replicated air quality variability analysis used the same peer-reviewed method as described in the 2018 technical document. Results from the updated technical analysis are described in the Appendix. The resulting relative variability of the three most recent design value years (i.e., 2018-2020, 2019-2021, 2020-2022) were used along with the level of the respective NAAQS to determine the EPA recommended SIL values for primary annual $PM_{2.5}$ for PSD permitting purposes.[12]

SILs for Ozone and $PM_{2.5}$ NAAQS

In the 2018 guidance, the EPA presented SIL values for the 8-hour ozone NAAQS and the annual and 24-hour $PM_{2.5}$ NAAQS. These recommended SIL values are consistent with the level, averaging period, and statistical form of its corresponding NAAQS. Considering the new level of the primary annual $PM_{2.5}$ NAAQS, the EPA has determined a new SIL based on the updated technical analysis and new NAAQS level. The recommended SIL values for the 8-hour ozone and 24-hour $PM_{2.5}$ NAAQS that were provided in 2018 have been retained. Table 1 lists these SIL values. The EPA recommends that PSD permitting authorities use the following values as SILs on a case-by-case basis, in the manner described in the 2018 guidance and subject to the limitations described in that guidance.

Table 1. Recommended SIL Values for Ozone and $PM_{2.5}$ NAAQS

Criteria Pollutant (NAAQS level)	NAAQS SIL concentration
Ozone 8-hour (70 ppb)	1.0 ppb
$PM_{2.5}$ 24-hour (35 ug/m^3)	1.2 ug/m^3*
$PM_{2.5}$ annual (9 ug/m^3 or 15 ug/m^3)	0.13 ug/m^3

*The table accounts for the significance level for the 24-hour $PM_{2.5}$ NAAQS in 40 CFR 51.165(b)(2). Refer to the discussion below for details.

For the 8-hour ozone NAAQS, the SIL value that EPA continues to recommend is 1.0 part per billion (ppb). Consistent with the form of the NAAQS, this value is based on the annual 4th highest daily maximum 8-hour concentration, averaged over 3 years.[13] The recommended SIL value for ozone is the same as the derived value from the updated air quality variability analysis using 2020-2022 design value years.

For the 24-hour $PM_{2.5}$ NAAQS, the SIL value the EPA continues to recommend is 1.2 ug/m^3. The derived value from the air quality variability analysis using 2020-2022 design value years is 1.6 ug/m^3. This value is consistent with the form of the NAAQS where the design value is the 3-year average of the annual 98th percentile 24-hour concentrations. However, 40 CFR 51.165(b)(2) still lists 1.2 ug/m^3 as the significance level for the 24-hour $PM_{2.5}$ NAAQS. In the 2010 rulemaking, the EPA determined that an impact above this value will be considered to cause or contribute to a violation of the 24-hour $PM_{2.5}$

[12] The resulting relative variability for each design value year represents the median statistic of the relative variability from the 50 percent CI.

[13] The 3-year average of the annual 4th highest daily maximum 8-hr average is often referred to as the MDA8 ozone concentration.

NAAQS at any location that does not meet this standard. In the same rule, the EPA also sought to establish that an impact below this value would not cause or contribute to a violation of this NAAQS but acknowledged that there could be circumstances where this conclusion was not always valid. Even though the ambient air quality variability approach indicates that an impact below 1.6 ug/m^3 is not significant, the significance levels for $PM_{2.5}$ remain in the EPA's regulations at 40 CFR 51.165(b)(2) and the EPA is presently bound by its prior conclusion that an impact above 1.2 ug/m^3 is significant and will cause or contribute to a violation of the 24-hour $PM_{2.5}$ NAAQS. Thus, the EPA cannot conclude at this time that an impact between 1.2 ug/m^3 and 1.6 ug/m^3 is an insignificant impact or an impact that will not cause or contribute to a violation of the NAAQS. However, based on the ambient air quality variability approach, the EPA can conclude that impacts below 1.2 ug/m^3 are insignificant at any location and can generally be determined not to cause or contribute to a violation of the NAAQS.[14]

For the primary annual $PM_{2.5}$ NAAQS, the EPA recommends 0.13 ug/m^3 as the SIL value. This value was determined based on the updated air quality variability analysis using 2020-2022 design value years and the revised level of NAAQS. This value is lower than the value of 0.3 ug/m^3 listed in 40 CFR 51.165(b)(2). Since 40 CFR 51.165(b)(2) does not address whether an impact below 0.3 ug/m^3 causes or contributes to a violation of the NAAQS, the EPA and other permitting authorities retain the discretion under this provision to determine on a case-by-case basis whether an impact below 0.3 ug/m^3 will cause or contribute to a violation of the primary annual $PM_{2.5}$ NAAQS. However, based on the ambient air quality variability approach, the EPA's judgement is that an impact below 0.13 ug/m^3 generally will not be significant and can therefore be determined not to cause or contribute to any violation of the primary annual $PM_{2.5}$ NAAQS that is identified.

We continue to recommend applying these SIL values to the NAAQS everywhere, regardless of the class of the airshed, for the reasons discussed in the 2018 guidance.

SILs for PSD Increments

In the 2018 guidance, the SIL values for $PM_{2.5}$ PSD increments were derived from the recommended NAAQS SIL values. Considering the revised level of the primary annual $PM_{2.5}$ NAAQS and the associated SIL, the SIL values for PSD increments have also been updated to reflect these changes. The SIL values developed in 2018 for the 24-hour $PM_{2.5}$ PSD increments are retained. Table 2 lists the PSD increment SILs for the annual and 24-hour $PM_{2.5}$ PSD increments. For Class II and III areas, we recommend that the values of the NAAQS SILs also be used for PSD increment SILs. For Class I areas, we are recommending PSD increment SIL values lower than the NAAQS SIL values to uphold a higher level of protection. The Class I PSD increment SILs were calculated by applying the ratios of the Class I and Class II allowable PSD increments to the NAAQS SIL values derived in the technical analysis.[15]

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[14] 40 CFR 51.165(b)(2) provides that a source impact higher than one of the listed significance levels is to be considered significant. A source impact exactly equal to a significance level need not be considered significant. In contrast, in this supplement, consistent with the 2018 guidance, EPA recommends that a value exactly equal to a recommended SIL be considered significant. Thus, these two approaches treat a value equal to the stated level differently. In practice, we do not expect this to be a practical difference because it would be very unusual for a source's impact to exactly equal one of the recommended SIL values.

[15] To derive the Class I PSD increment SIL values, we used the same method used for the PSD SILs presented in the 2018 guidance which starts with the corresponding NAAQS SIL value as the base number and adjusts the NAAQS SIL by the ratio of the associated Class I and II PSD increments. For the annual $PM_{2.5}$ increment, we reduced the NAAQS SIL value by the ratio of 1:4,

Table 2. Recommended SIL Values for $PM_{2.5}$ PSD Increments

Criteria Pollutant (averaging period)	PSD increment SIL concentration		
	Class I	Class II	Class III
$PM_{2.5}$ (24-hour)	0.27 ug/m^3	1.2 ug/m^3	1.2 ug/m^3
$PM_{2.5}$ (annual)	0.03 ug/m^3	0.13 ug/m^3	0.13 ug/m^3

III. APPENDIX

Summary of the Updated Air Quality Variability Approach

The SIL values recommended in this supplement were derived using the same air quality variability approach detailed in the 2018 technical basis document. The bootstrap technique was applied to ambient monitoring data for ozone and $PM_{2.5}$ to quantify the degree of air quality variability at an ambient monitoring site. This technique allows one to determine confidence intervals which are used to inform the degree of air quality change that can be considered an "insignificant impact" for PSD applications. The updated air quality variability approach incorporates more recent design value (DV) data to analyze the current state of air quality across the nation. With the addition of 6 new 3-year DV periods[16], the updated analysis is based on 21 years (2000-2022) of nationwide ambient ozone and $PM_{2.5}$ measurement data from the EPA's air quality system (AQS) database[17] to generate re-sampled datasets for ozone and $PM_{2.5}$ DVs at each monitor from which the appropriate DVs are calculated.[18]

The ambient data used in the updated analysis consisted of 24-hr averaged samples for ambient $PM_{2.5}$ concentrations and 8-hr averaged ozone concentrations. The bootstrapping method was applied to each individual monitoring site for ozone and $PM_{2.5}$ for each calendar year. Each year of data from each site was re-sampled 20,000 times.[19] The bootstrap samples were calculated in a manner consistent with the DV calculations, then averaging the three annual values, each of the 20,000 estimates for year 1 were averaged with the corresponding 20,000 estimates for year 2 and year 3, giving 20,000 estimates for the DV. From the 20,000 estimates, the mean, median, standard deviation, maximum, minimum, 25%, 50%, 68%, 75% and 95% CIs for the mean were computed and further used during the selection of the recommended SIL values.

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because the Class I PSD increment is 1 ug/m^3 and the Class II PSD increment is 4 ug/m^3. We used the ratio of 2:9 for the 24-hour $PM_{2.5}$ increment.

[16] A 3-year design value period is the 3 years of ambient data required to compute a DV for the ozone and $PM_{2.5}$ NAAQS. We included DV periods of 2015-2017, 2016-2018, 2017-2019, 2018-2020, 2019-2021, and 2020-2022 to the updated analysis in addition to the ambient data used in the 2018 technical analysis.

[17] The EPA's AQS database contains ambient air pollution data collected by state, local, and tribal air pollution control agencies, as well as EPA and other federal agencies from monitoring stations varying in spatial scale. The spatial scale of a monitor is generally associated with the size of the area that the pollutant monitor represents. The ambient air monitor spatial scales are defined in 40 CFR part 58, Appendix D.

[18] Definitions of how the design values for the primary ozone, primary annual $PM_{2.5}$ NAAQS, and 24-hr $PM_{2.5}$ NAAQS are detailed in section 2.1 of the 2018 technical basis.

[19] During development of the air quality variability analysis, 20,000 re-samples were selected to conservatively ensure that stable results were obtained for all cases.

Results of the Updated Air Quality Variability Approach

This section provides results on characterizing the variability of air quality for ozone and $PM_{2.5}$ based on the EPA's air quality variability approach.

$PM_{2.5}$ Bootstrap Results (Annual and 24-hr)

The results from the bootstrap analysis for the 2020-2022 DVs are shown in Figure 1 and 2. The top two panels of Figure 1 show the upper and lower limits of the 25%, 50%, 68%, 75%, and 95% CIs for the median as well as the mean, median, minimum, and maximum DVs calculated from the 20,000 bootstrap samples as a function of the DV determined from the original dataset. Variability remains greater for the 24-hr $PM_{2.5}$ NAAQS than the annual $PM_{2.5}$ NAAQS. The mean and median bootstrap DVs for the annual $PM_{2.5}$ NAAQS almost perfectly replicate the actual DV for the original site data, especially at lower concentration levels. The 24-hr PM NAAQS bootstrap DVs show greater variability when compared to the annual. This is generally to be expected given that the mean is generally more stable than the 98^{th} percentile of a dataset. The presence of a few very high concentration values (i.e., outliers) in the original dataset increase the variability of the higher CIs which can be seen clearly for both the annual and 24-hr NAAQS higher DV concentration levels.

The relative variability (i.e., the difference between the bounds of the bootstrapped CI and the actual DV for a single monitoring site, divided by the actual DV for the site is also shown in Figure 1, with distributions of the relative differences for each CI across monitoring sites shown in Figure 2. Similar to the results seen in the 2018 analysis, the relative variability for the annual NAAQS shows very small differences in the variability values for almost all CIs with a notable increase in DV difference in the values corresponding to the 95% CI. The 24-hr NAAQS had much greater DV differences with a steady increase in variability in the higher CIs.

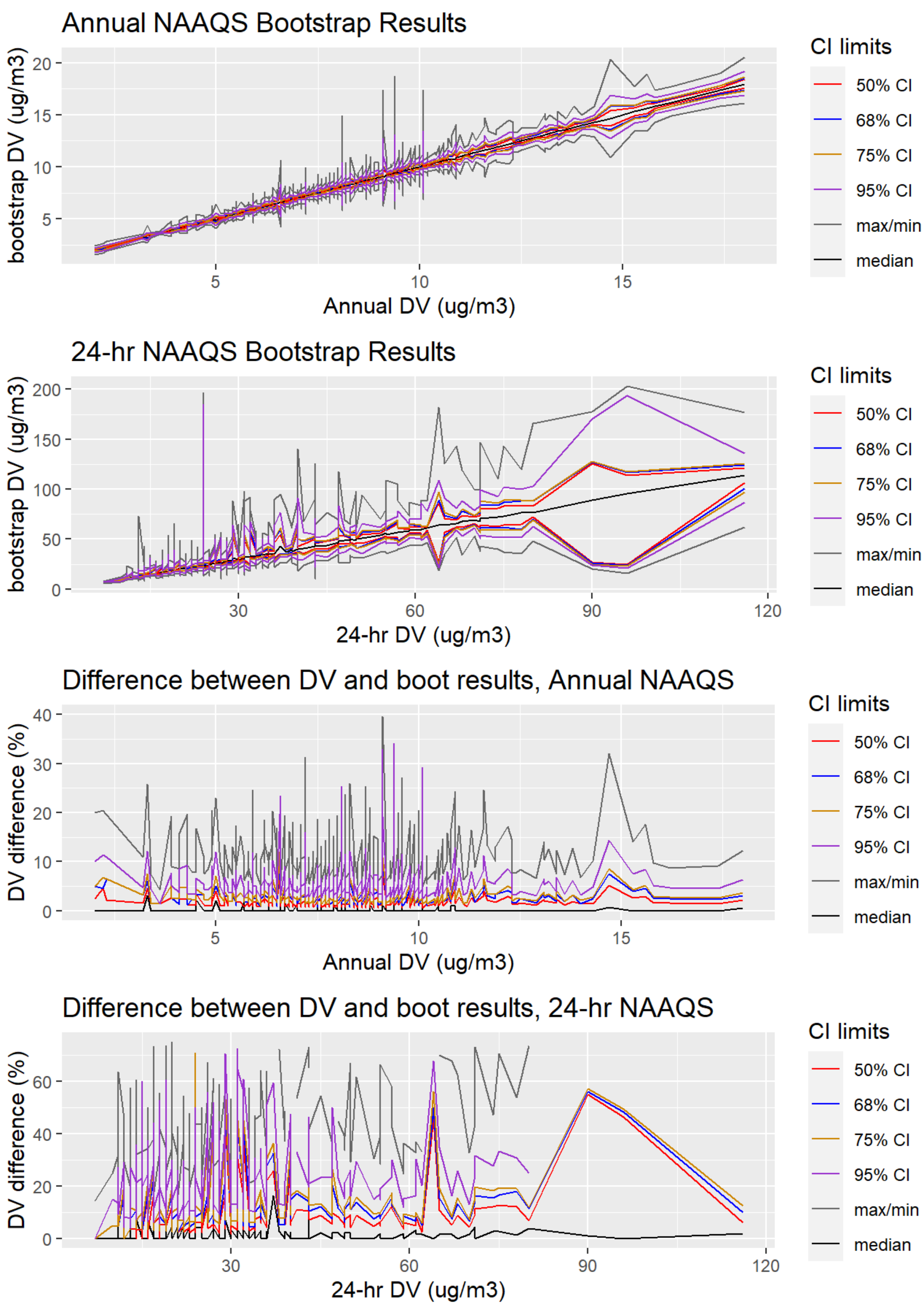


Figure 1. Bootstrap results for the $PM_{2.5}$ 2020-2022 DVs (25%, 50%, 68%, 75%, and 95% CIs, along with the mean and median bootstrap DVs). The top two panels show the values for the DVs at the various CIs, while the bottom two panels show the average of the percent difference between the upper and lower bounds of the CI and the actual DV.

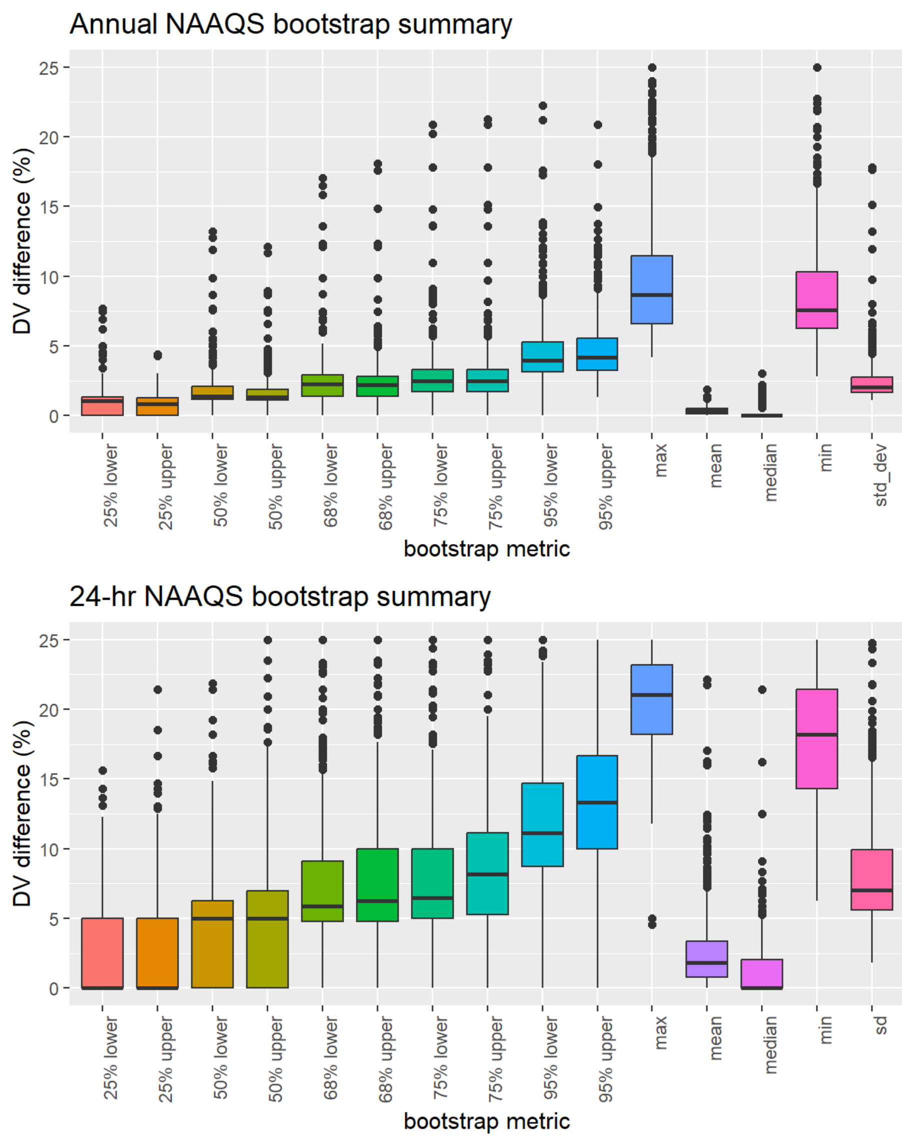


Figure 2. Bootstrap results for the $PM_{2.5}$ 2020-2022 DVs, showing distribution of the relative differences between the upper and lower bounds of the bootstrap DVs and the actual DV at the 25%, 50%, 68%, 75%, and 95% CIs, along with the mean, median, maximum, minimum, standard deviations of the relative differences.

Analysis for $PM_{2.5}$

Figure 3 shows, for each monitoring site, the half-width of the 50% CI divided by the DVs for both the annual and 24-hr $PM_{2.5}$ NAAQS. Consistent with the results seen in the 2018 technical analysis, the relative variability is more stable across the range of baseline air quality levels while the absolute variability increased as the baseline air quality levels increase.[20] For the annual $PM_{2.5}$ NAAQS, the values of relative variability remain concentrated between 1-3% with numerous outliers exceeding 5%. The outliers present in the annual data likely causes a slight increase in the relative variability however when assessed as a whole, the resulting relative variability is lower than the annual relative variability

[20] The rounding conversions for $PM_{2.5}$ result in striations in the bootstrap resulting data as seen in Figure 3. These striations do not represent actual trends.

reported in the 2018 technical analysis. This increase in overall relative variability is likely due to a decrease in precursor emissions that lead to secondary formation of $PM_{2.5}$. The 24-hr NAAQS relative variability data are concentration around 4-5% with a few extreme outliers. These few outliers are likely the result of an atypical air quality event present in the monitored ambient data that may have been caused by a natural source. Despite the small number of outliers in the 24-hr results, there was a slight increase in the resulting median relative variability when compared to the results presented in the 2018 analysis. For both the annual and 24-hr relative and absolute variability, the mean was higher than the median due to the presence of the outliers in the dataset. Hence, the median relative variability was selected for use in the selection of the recommended SILs because it is less influenced by the outliers present in the data.

Figure 4 presents the spatial distribution of the relative variability for sites which had data during the 2020-2022 DV period[21] and are colored according to each site's respective relative variability level. Visual inspection of these results reveals there appears to be no notable large-scale spatial trends in highest relative variability in the annual or 24-hr $PM_{2.5}$ NAAQS results. For the annual relative variability, the locations of higher relative variability appear to be isolated sites throughout the U.S. aside from a small grouping of sites in Oregon where the highest relative variability is located. Areas of highest relative variability in the 24-hr results appear primarily across the Western U.S. with a few isolated sites located in the South. This is likely due to the nature of high PM events in the western half of the U.S. where the background $PM_{2.5}$ levels are generally lower than other parts of the U.S. but the vents that do occur produce much higher concentrations than the typical background concentration level.

[21] Spatial results from additional DV periods are presented in the extended appendix which is available upon request.

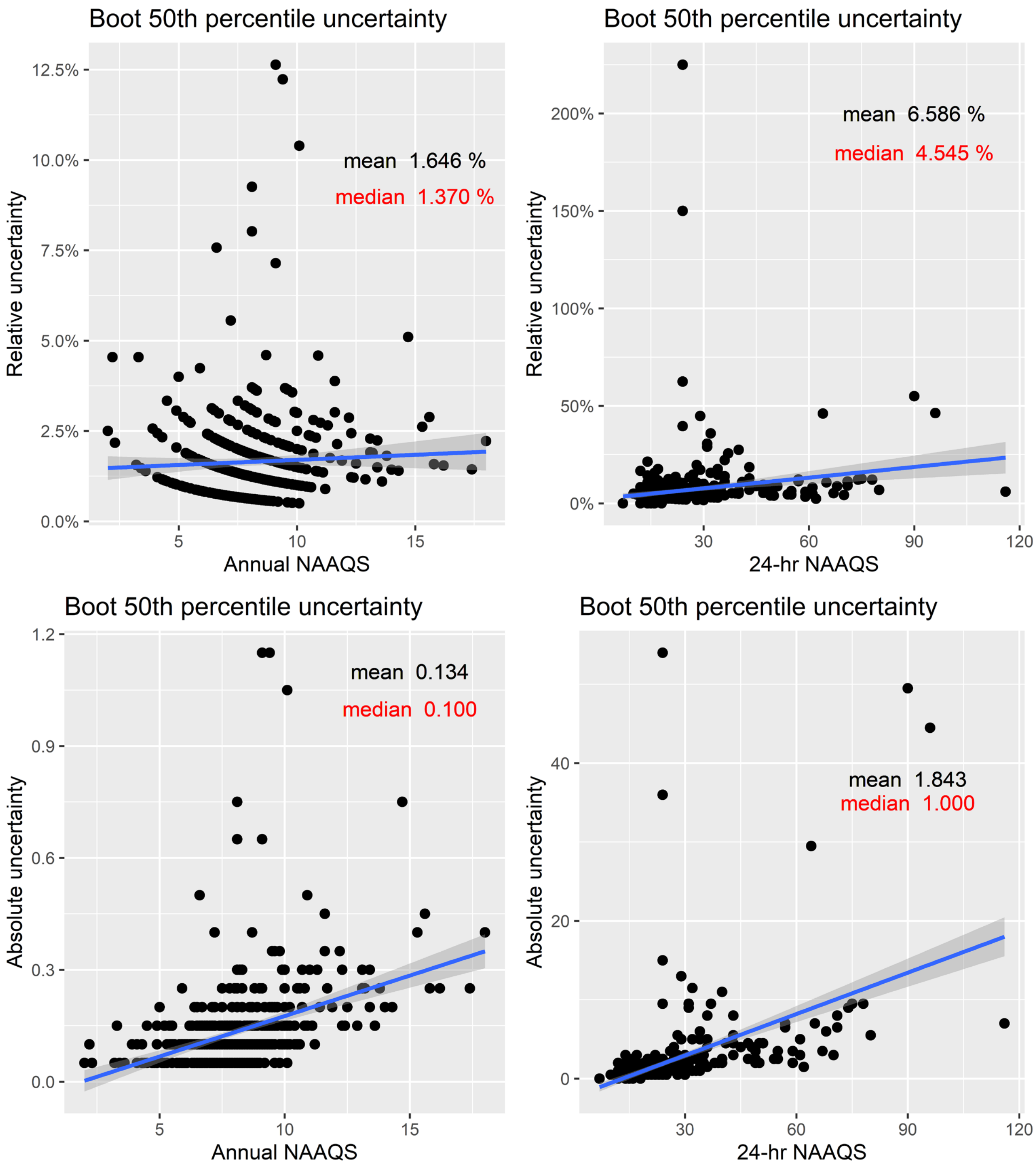
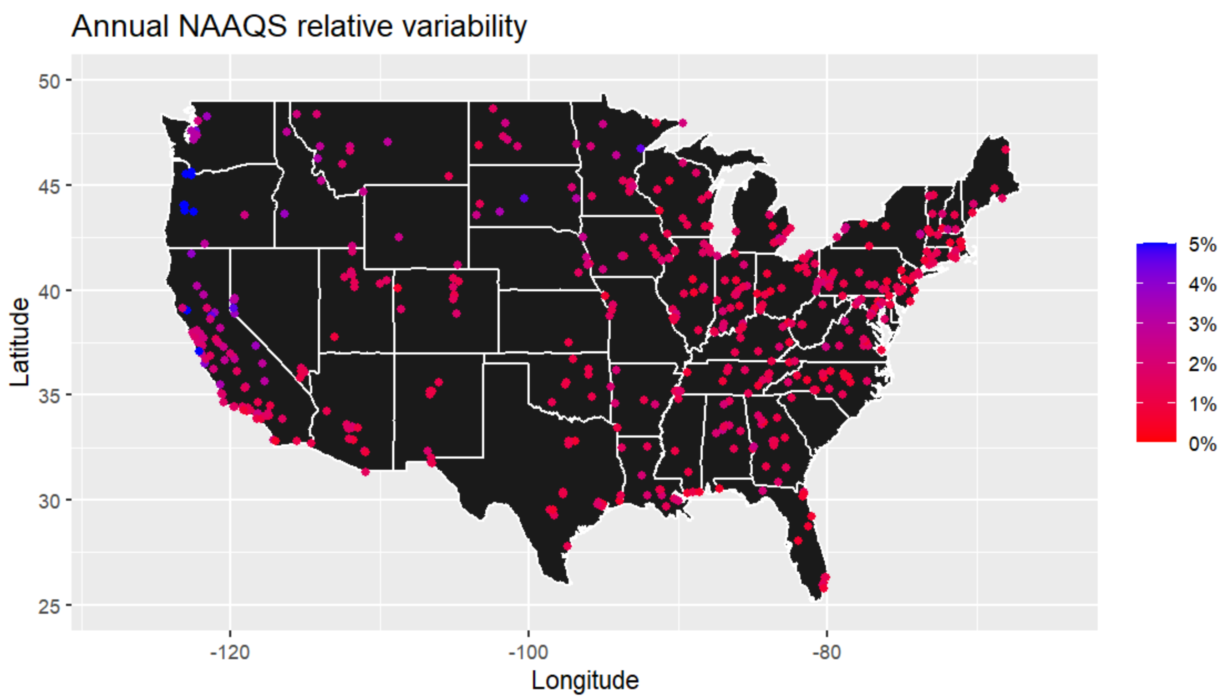


Figure 3 – Bootstrap results from the 50% CIs for the 2022 $PM_{2.5}$ DVs. The top two panels show the relative difference between the span of the CI and the actual DV across the range of actual DV, and the bottom two panels show the absolute difference between the values across the same range. The bootstrap results plotted earlier represent all sites.



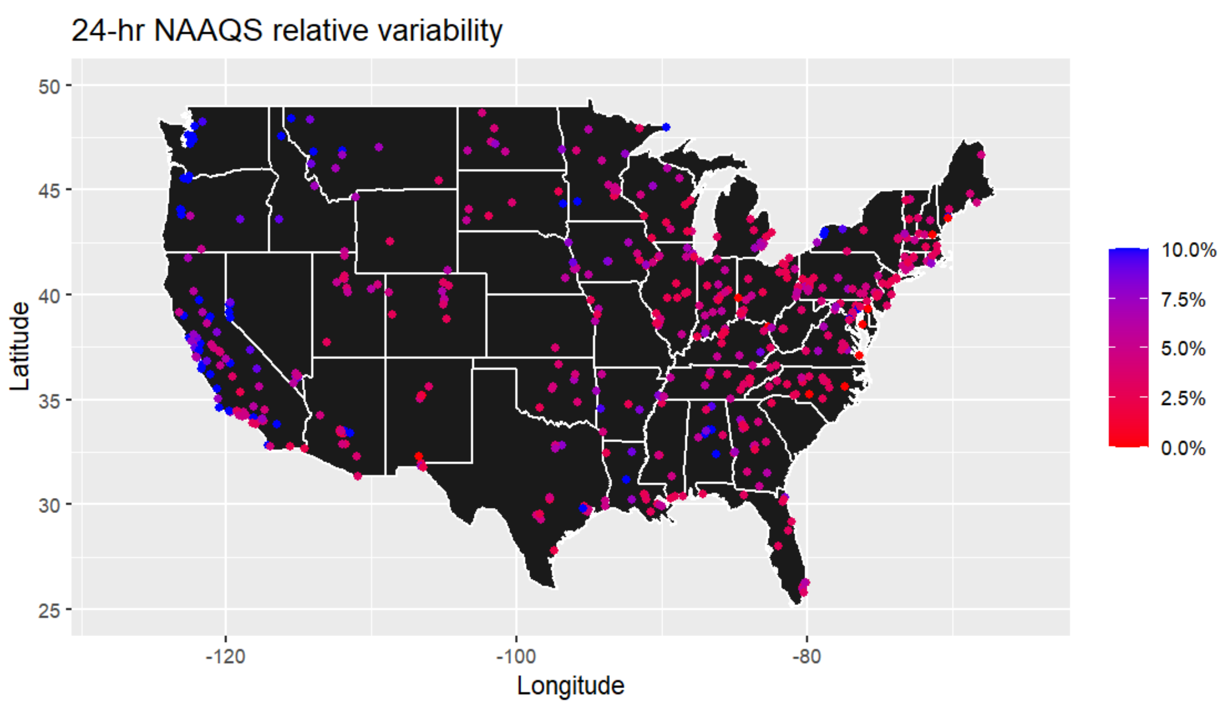


Figure 4 – Spatial distribution of the relative difference between the span of the 50% CI and the actual DV for the 2020-2022 $PM_{2.5}$ DV for all sites across the contiguous U.S.

$PM_{2.5}$ Temporal Trends

The median air quality variability from the 21 DV periods for both the annual and 24-hr $PM_{2.5}$ NAAQS are shown in Figure 5. In the most recent DV periods (i.e., 2017 to 2022) there were an increase in variability in the 24-hr $PM_{2.5}$ results with a significant jump in 2020. This notable increase represents the outliers seen in the relative variability data discussed in the section above and is likely due to the presence of an atypical even in the monitored ambient data record. The variability in the annual $PM_{2.5}$ results shows a steady decline across the DV periods analyzed. The median air quality variability at the 50% CI for the three most recent DV periods (i.e., 2018-2020, 2019-2021, 2020-2022) is shown in Table 1. When averaged across the three DV periods, they result in an average relative variability of 1.40% for the annual $PM_{2.5}$ NAAQS (9 ug/m^3) and 4.62% for the 24-hr $PM_{2.5}$ NAAQS (35 ug/m^3). These values correspond to SIL values of 0.13 ug/m^3 at the level of 9 ug/m^3 for the annual $PM_{2.5}$ NAAQS and 1.6 ug/m^3 at the level of 35 ug/m^3 for the 24-hr $PM_{2.5}$ NAAQS.

Table 1. Summary of $PM_{2.5}$ annual and 24-hr bootstrap results for three design periods, 2018-2020, 2019-2021, and 2020-2022.

Year/NAAQS	2020 annual	2021 annual	2022 annual
Difference, median bootstrap vs actual DV	0.05%	0.08%	0.09%
Avg. 25% CI span	0.68%	0.67%	0.67%
Avg. 50% CI span	1.41%	1.43%	1.37%
Avg. 68% CI span	2.11%	2.14%	2.08%
Avg. 75% CI span	2.46%	2.50%	2.34%
Avg. 95% CI span	4.17%	4.14%	3.98%
Year/NAAQS	2020 24-hr	2021 24-hr	2022 24-hr
Difference, median bootstrap vs actual DV	1.21%	1.19%	1.30%
Avg. 25% CI span	2.50%	2.50%	2.50%
Avg. 50% CI span	4.55%	4.76%	4.55%
Avg. 68% CI span	6.64%	6.64%	6.82%
Avg. 75% CI span	7.50%	7.50%	7.50%
Avg. 95% CI span	13.16%	13.57%	13.64%
Number of sites	492	506	527

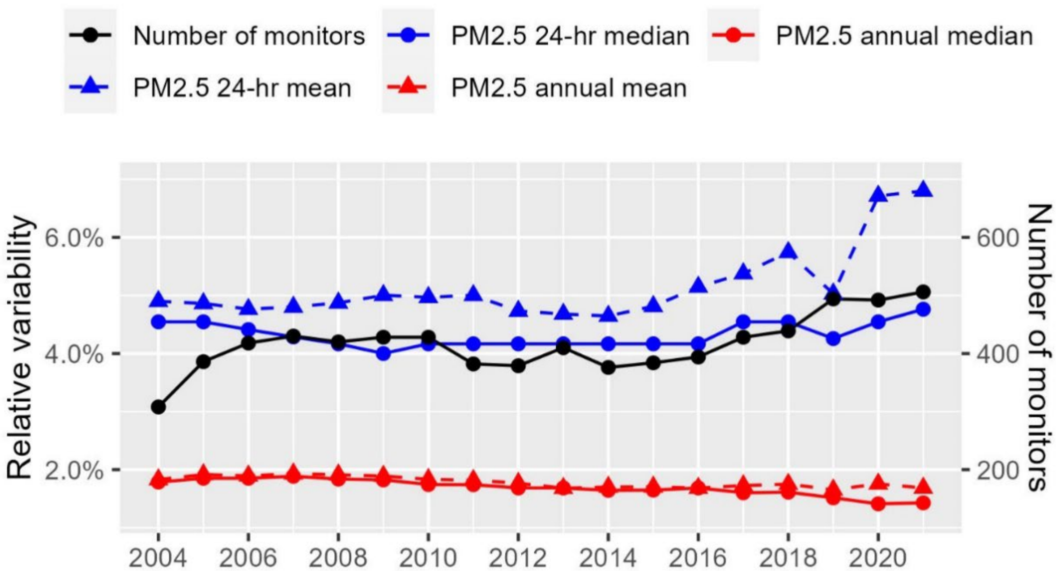


Figure 5 – Median and mean variability in the $PM_{2.5}$ network determined from the bootstrap analysis (50% CI) for the 15 DV periods from 2002-2022 for $PM_{2.5}$ (each DV period represents 3 years of data, and the data is plotted on the ending year: i.e., the 2022 DV period is from 2020-2022 and plotted at 2022).

Ozone Results

The results from the bootstrap analysis for the 2020-2022 ozone DVs are shown in Figure 6, which shows the mean, median, minimum, and maximum bootstrap DVs for each monitor, as well as the upper and lower bounds of the 25%, 50%, 68%, 75%, and 95% CIs for the median DV calculated from the 20,000 bootstrap samples as a function of the DV determined from the original dataset (top panel), the relative differences between the CI DVs and the actual DVs (middle panel), and box-and-whisker plots of the distribution of the relative difference at each CI (bottom plot). Similar to the results we saw in 2018 analysis, the mean and median of the bootstrap DVs replicate the actual ozone DV data fairly well. The magnitude of relative variability was also consistent with the previous results with ozone bootstrap DVs ranging from 1-5% and maximums around 25%. The 2018 analysis determined that the relative variability in the DV for the ozone NAAQS is stable across various levels of ozone concentrations which is validated when comparing results between the previous and updated variability analysis.

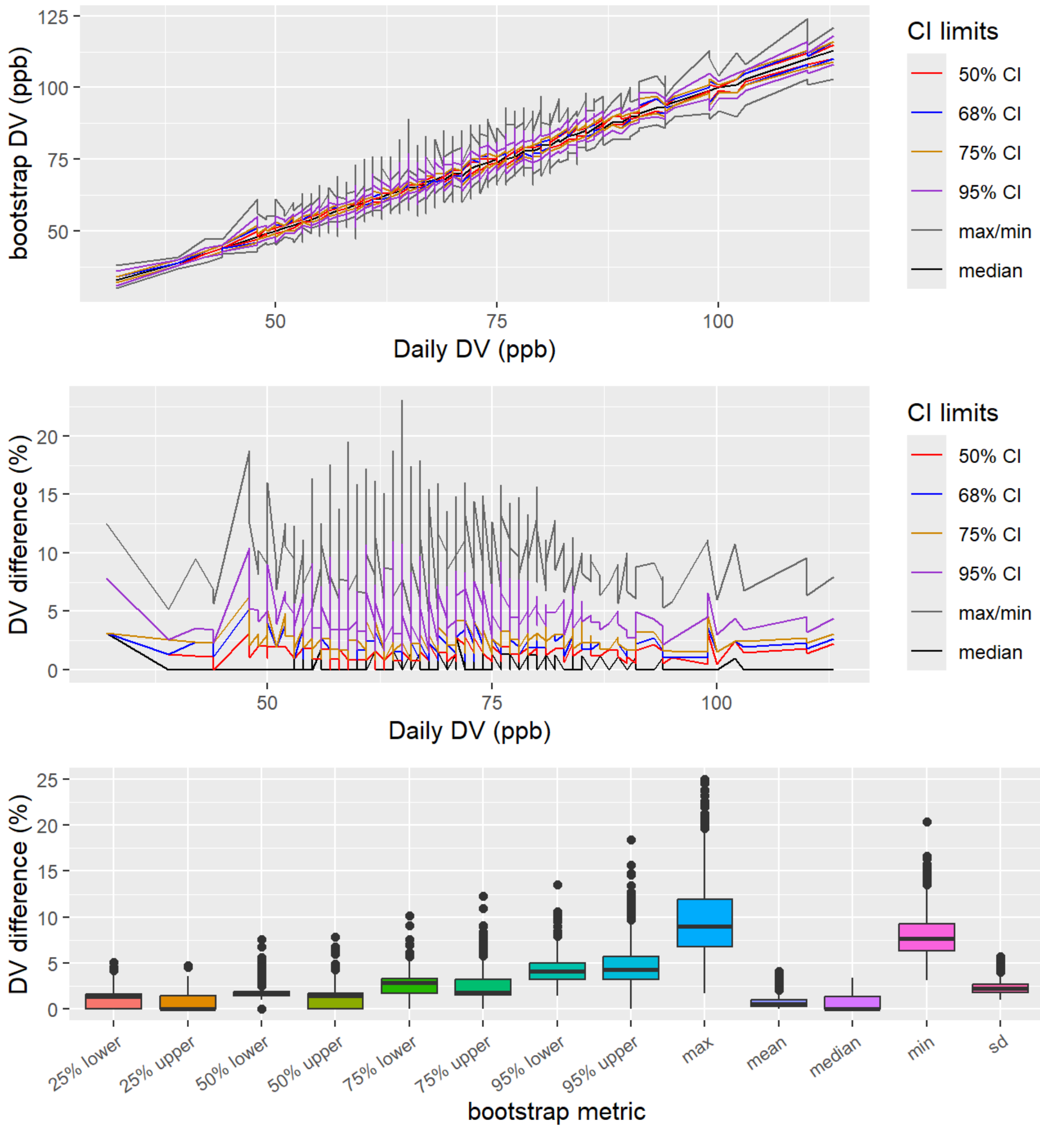


Figure 6. Bootstrap results for the ozone 2020-2022 DVs (25%, 50%, 68%, 75%, and 95% Cis, along with the mean and median bootstrap DVs) Top panel shows the values for the DVs at the various CIs, the middle panel shows the average of the relative difference between the upper and lower bounds of the CI and the actual DV, and the bottom panel shows the distribution of the relative differences between the CI and the actual DV.

Analysis for Ozone

Figure 7 shows, for each monitoring site, the half-width of the 50% CI divided by the actual DV from the 2020-2022 data for the ozone NAAQS.[22] Similar to the results seen in the 2016 data, the more recent data has variability that is consistent across the range of baseline air quality levels, indicating that there is still no particular trend with actual DV in the site level variability. Figure 7 also shows the spatial distribution of the relative variability from the 50% CI for the 2020-2022 DV period. The points are

[22] The banding in the results is a feature of the truncation conventions that were applied to the AQS data prior to the air quality variability analysis.

colored according to their relative variability and sites with insufficient data during the DV period are shown in grey. Visual analysis of the map presented in Figure 7 shows that there are no notable large-scale trends in the spatial distribution of relative variability across the nation. There are small clusters of higher variability in the Northeast, surrounding Lake Michigan, and scattered across the west coast states however these areas seem relatively isolated.

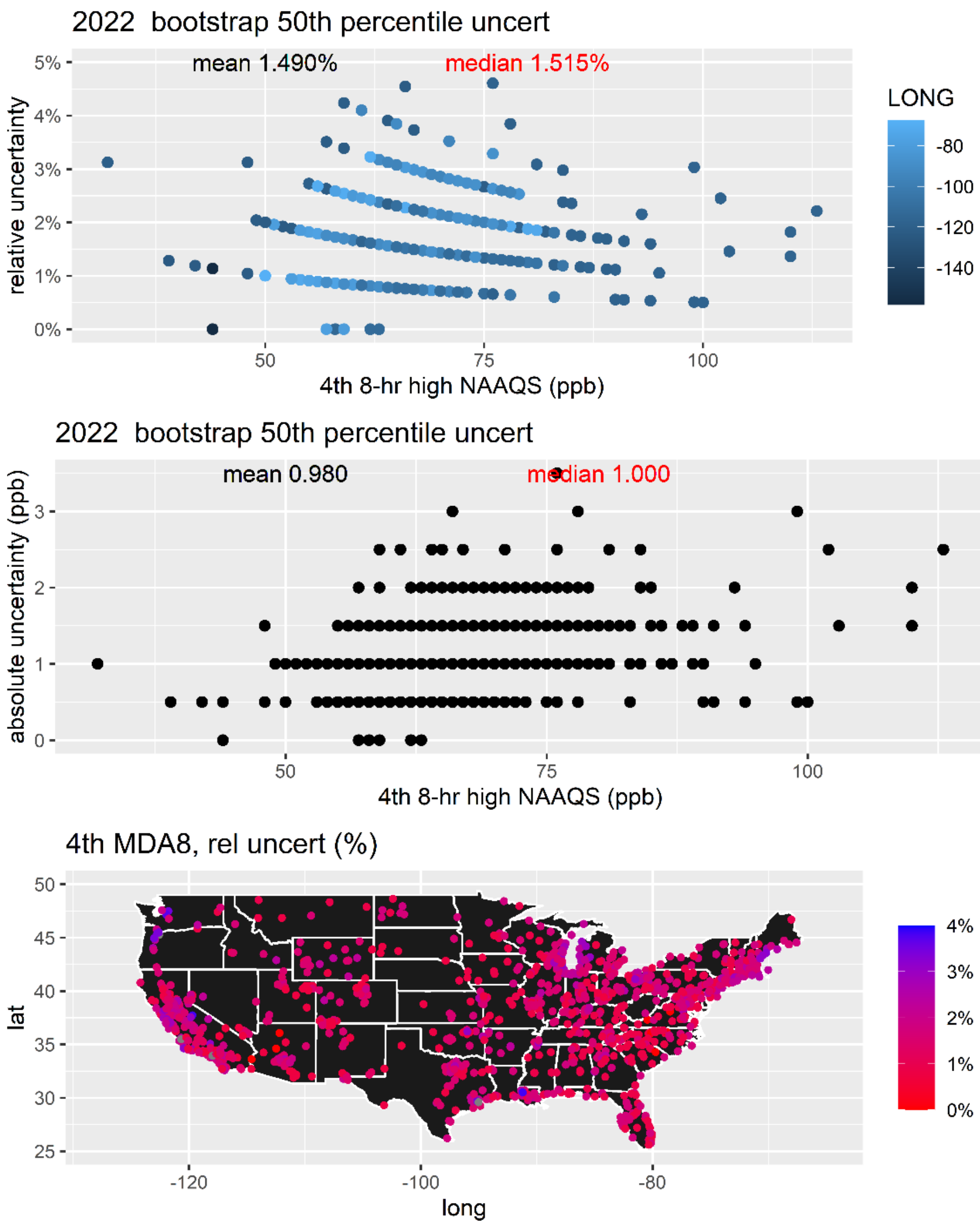


Figure 7 – Bootstrap results from the 50% CIs for the 2022 ozone DVs. The top panel shows the relative difference between the span of the CI and the actual DV across the range of actual DVs, the middle panel shows the absolute difference between the values across the same range, and the bottom panel shows the spatial distribution of the relative difference between the values at each site.

Ozone Temporal Trends

The median air quality variability from the 20 DV periods for ozone are shown in Figure 8 (each period is 3 years). Overall, there has been a decrease in variability across all DV periods. The relative variability remained nearly constant between 2014-2019 followed by a slight increase in the most recent years of DV data. Since 2018, the number of monitoring sites has decreased which may be the cause of the slight increase in variability. The median air quality variability values at the 50% CI for the three most recent DV periods (*i.e.,* 2018-2020, 2019-2021, 2020-2022) as shown in Table 2, when averaged result in a SIL value for the ozone 8-hour NAAQS of 1.5%. This corresponds to 1.0 ppb at the level of the 2015 ozone NAAQS of 70 ppb.[23]

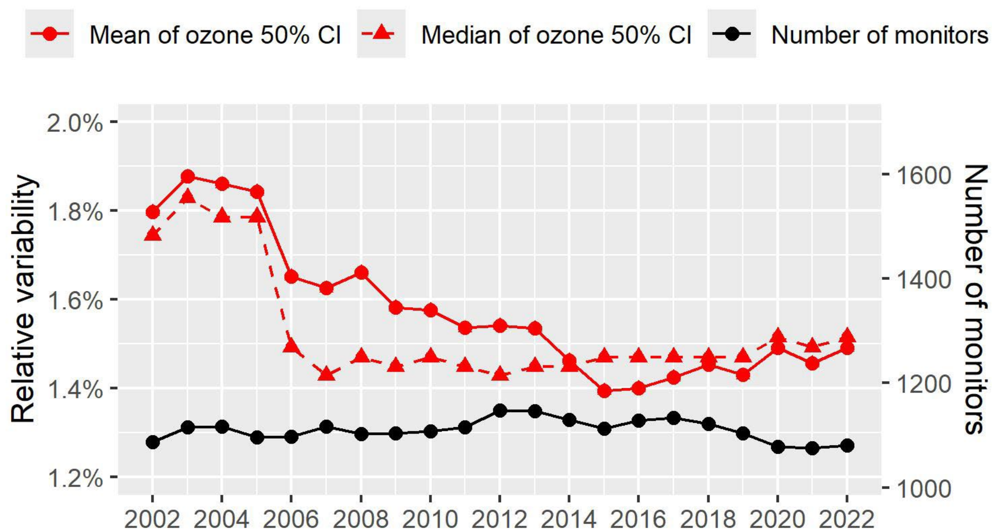


Figure 8 – Median and mean variability in the network determined from the bootstrap analysis for the 21 DV periods from 2002 to 2022 for ozone (each DV period represents 3 years of data, and the data are plotted on the ending year, i.e., the 2022 DV period is from 2020-2022 and plotted at 2022).

Table 2. Summary of ozone bootstrap results for three DV periods, 2018-2020, 2019-2021, and 2020-2022.

Year/NAAQS	2020	2021	2022
Difference, median bootstrap vs actual DV	0.44%	0.39%	0.47%
Avg. 25% CI span	0.77%	0.77%	0.78%
Avg. 50% CI span	1.50%	1.47%	1.52%
Avg. 68% CI span	2.16%	2.08%	2.17%
Avg. 75% CI span	2.38%	2.38%	2.46%
Avg. 95% CI span	4.11%	4.08%	4.23%
Number of sites	1078	1076	1081

[23] After review in 2020, the EPA decided to retain the existing ozone NAAQS established in 2015 (85 FR 87256). The primary and secondary standards, established in 2015, are 0.070 parts per million (ppm), as the fourth-highest daily maximum 8-hour concentration, averaged across 3consecutive years (80 FR 65291).