Background Ozone and Its Importance in Relation to the Policy Assessment for the Review of the Ozone National Ambient Air Quality Standards Document

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Executive Summary

We believe that the role, levels, and relevance of background tropospheric O_3 should be an important component in determining both the risk and attainability of a revised O_3 standard. The determination of background O_3 levels from photochemical models and the fidelity of these modeled O_3 levels in comparison with observed O_3 amounts under conditions likely to be representative of "background" conditions were discussed in the ISA and have been commented on in our previous testimony to CASAC in documents submitted for the record to EPA (Lefohn and Oltmans, 2012). Recent published work and ongoing research (Zhang et al., 2011; Lin et al., 2012; Lefohn et al., 2014a; Zhang et al., 2013; Lapina et al., 2014; Fiore et al., 2014; Lefohn et al., 2014b) reinforce the important contribution of North American background O_3, including a significant stratospheric component, on 8-hour maximum daily average O_3 (MDA8) at or near current air quality standards. While these researchers suggest that an important use of models (e.g., GEOS-Chem and AM3) is to assist the EPA in identifying exceptional O_3 events in the West and Intermountain West when the O_3 NAAQS is exceeded, we see a larger role for models in characterizing background O_3 levels and how these levels affect EPA's REA risk outcomes and the attainability of the O_3 NAAQS. While important differences in the magnitude and spatial and temporal variability of background O_3 estimates exist among the various models used to predict background O_3, the models can assist in assessing both human health risk estimates and the attainability of the NAAQS. The important contribution of North American background O_3, on 8-hour maximum daily average O_3 (MDA8) emphasizes the need to provide a balanced view that recognizes the significant contribution of background O_3 to observed (total) O_3 and the part that background O_3 plays in the standard-setting process.

We acknowledge that the EPA believes that attainability and technical feasibility are not relevant consideration in the setting of a NAAQS. The EPA is clear when it states that the Clean Air Act requires the NAAQS to be set at a level requisite to protect public health and welfare. The Agency believes that there is a framework for considering the contributions of US anthropogenic, international anthropogenic, and natural sources, within the context of considering the health evidence and CASAC advice, when evaluating various potential

alternative standards. EPA believes that from policy perspective, background O_3 episodic events must be viewed in the context of their relative infrequency and the existing mechanisms within the Clean Air Act that help ensure States are not required to control for events that are inherently outside their ability to influence. The EPA notes that, while background O_3 levels can approach and periodically exceed the NAAQS at some locations, these conditions are not a constraining factor in the selection of a NAAQS.

In our comments on the Health REA (Lefohn and Oltmans, 2014), we discussed the EPA's air quality results as emissions are reduced and the resulting distribution of O_3 concentrations that are associated with the risk estimates. Based on the information provided in the REA, as well as in the published literature, as emission reductions of anthropogenic sources occur at urban-influenced sites, the following is anticipated to occur:

- The highest concentrations experienced currently, as well as the lowest values of the distribution of concentrations experienced currently will be eliminated and the frequency of mid-level concentrations will increase;

- The percentage of background O_3 compared to total observed O_3 will increase in the mid-range concentrations of 25-55 ppb as emissions are reduced;

- As the frequency of mid-level concentrations increases as a result of emission reductions, based on the REA findings, the highest concentrations in the remaining O_3 distribution will occur during the springtime (i.e., April-May) versus the summertime (June-August);

- The contribution of non-US anthropogenic sources such as stratospheric intrusions and international transport, which peak during the spring months (EPA, 2013), will enhance estimated risk as well as contribute to potential NAAQS violations;

- As emissions are reduced, background O_3, which includes stratospheric intrusions and international transport, will increase its contribution to total O_3 at all O_3 monitoring sites, especially during the spring months; and

- The consequences of the 5 items above will be a more predominant contribution of background O_3 to both the epidemiological and lung function risk estimates characterized in the REA.

The EPA notes in the REA (page 9-24) that the distribution of risk tends to be centered in the 25-55 ppb range of 8-hour daily maximum concentrations after just meeting an alternative standard of 60 ppb. Further investigating the data in Fig. 7-B1 in the REA Appendix for Chapters 7-9 on page 7B-3, in most cases it appears that the greatest percentage of risk tended to also be in the 25-55 ppb range for recent conditions (2007), current standard (75 ppb), alternative standard (70 ppb), alternative standard (65 ppb), and alternative standard (60 ppb). Fig. E1 illustrates that reducing emissions to attain the various standards increased the percent of total risk in the 25-55

ppb mid-range concentrations from the current conditions and this range of concentrations made up the greatest percentage of the risk.

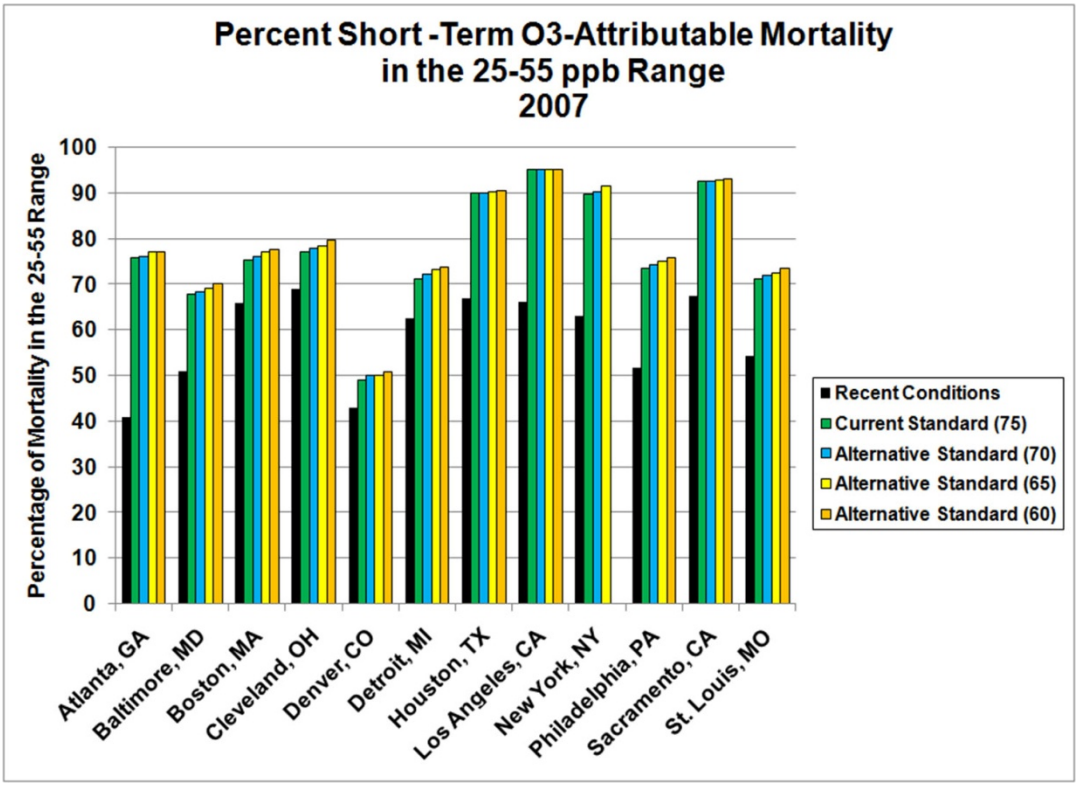


Fig. E1. Percent short-term O_3-attributable mortality in the 25-55 ppb range for various exposure conditions for 2007. (Source: Data from Fig. 7-B1 on page 7-B3 of the REA Appendix).

Compared to the mortality and morbidity risk assessments summarized above, as pointed out on page 9-44 of the REA, the lung function risk analysis is less sensitive to increases at the very low O_3 concentrations because the risk function is logistic and shows little response when ambient concentrations are generally less than 20 ppb for the 10 percent FEV1 decrement and generally less than 40 ppb for the 15 percent FEV1 decrement. For estimating the distribution of daily FEV1 decrements ≥ 10% across ranges of 8-hour average ambient O_3 concentrations for cities and air quality scenarios, we have reviewed the distributions of composite monitor 8-hour daily maximum values for 12 urban case study areas in the epidemiology-based risk assessment (Fig. E2). The plots depict values based on ambient measurements (base), and values obtained with the HDDM adjustment methodology showing attainment of 75, 70, 65 and 60 ppb standards. Based on the distribution of concentrations shown in Fig. E2 reproduced from page 4-25 of the REA, we would anticipate as discussed in our REA comments that a large percentage of daily instances of FEV1 decrements ≥ 10% would be predicted to occur when 8-hour average ambient concentrations were in the 25-55 ppb range for attainment of the 75, 70, 65 and 60 ppb standards.

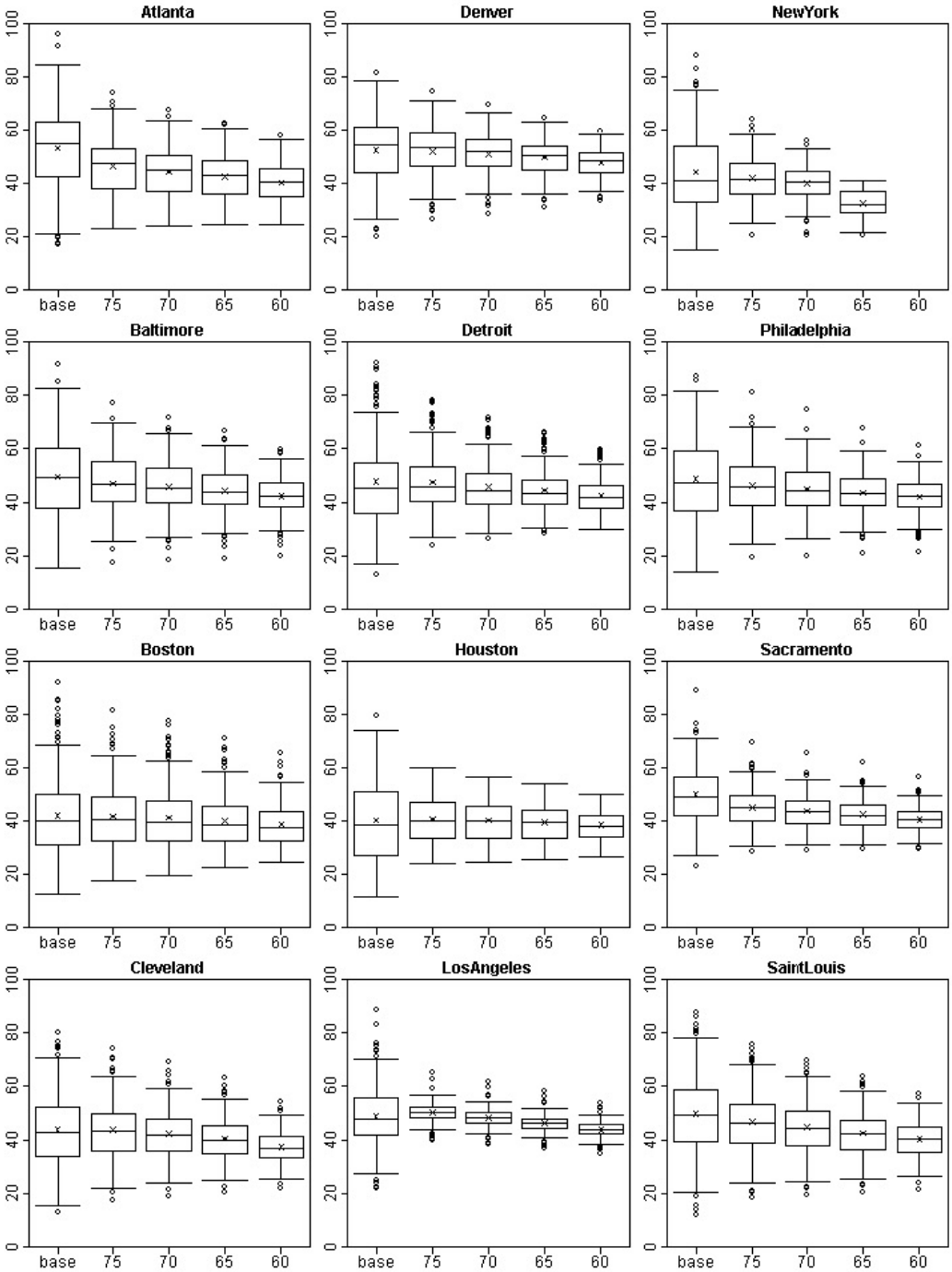


Fig. E2. Distributions of composite monitor 8-hour daily maximum values for the 12 urban case study areas in the epidemiology-based risk assessment. Plots depict values based on ambient measurements (base), and values obtained with the HDDM adjustment methodology showing attainment of 75, 70, 65 and 60 ppb standards. Values shown are based on CBSAs for April-October of 2007. Note that the HDDM 8 adjustment technique was not able to adjust air quality to show attainment of a 60 ppb standard in New York, so no boxplot is shown for that case. (Source: Fig. 4-9 of REA page 4-25).

The mid-range concentrations of 25-55 ppb have been highlighted both in the EPA's REA and in our comments. As we noted above, the mid-level range of concentrations has an important effect on the estimated epidemiological and lung function risks. As anthropogenic emissions are reduced, increases in risks occur with the result that a large percentage of the risks are accumulated in the 25-55 ppb range of concentrations. In reviewing Fig. E3, which is presented in our REA comments, the contribution of hourly background O_3 to total observed O_3 in the 25-55 ppb range is large. Lefohn et al. (2014a) characterized Emissions-Influenced Background (EIB) O_3 for 23 sites across the US. EIB O_3 as presented in the figures represents "titrated" background O_3 by anthropogenic sources. Appendix A provides figures that describe the percent contribution of background O_3 to total observed O_3 for the 23 sites. Background O_3 concentrations make up an important amount in comparison to the total observed O_3. For example, at Yellowstone NP, the contribution of background O_3 in the range of 25-55 ppb is greater than 80% of total O_3; at Denver, background O_3 generally contributes between 70-80% to total O_3 in the 25-55 ppb range; and at Atlanta, EIB O_3 contributes to total O_3 approximately 50-70% in this range of concentrations.

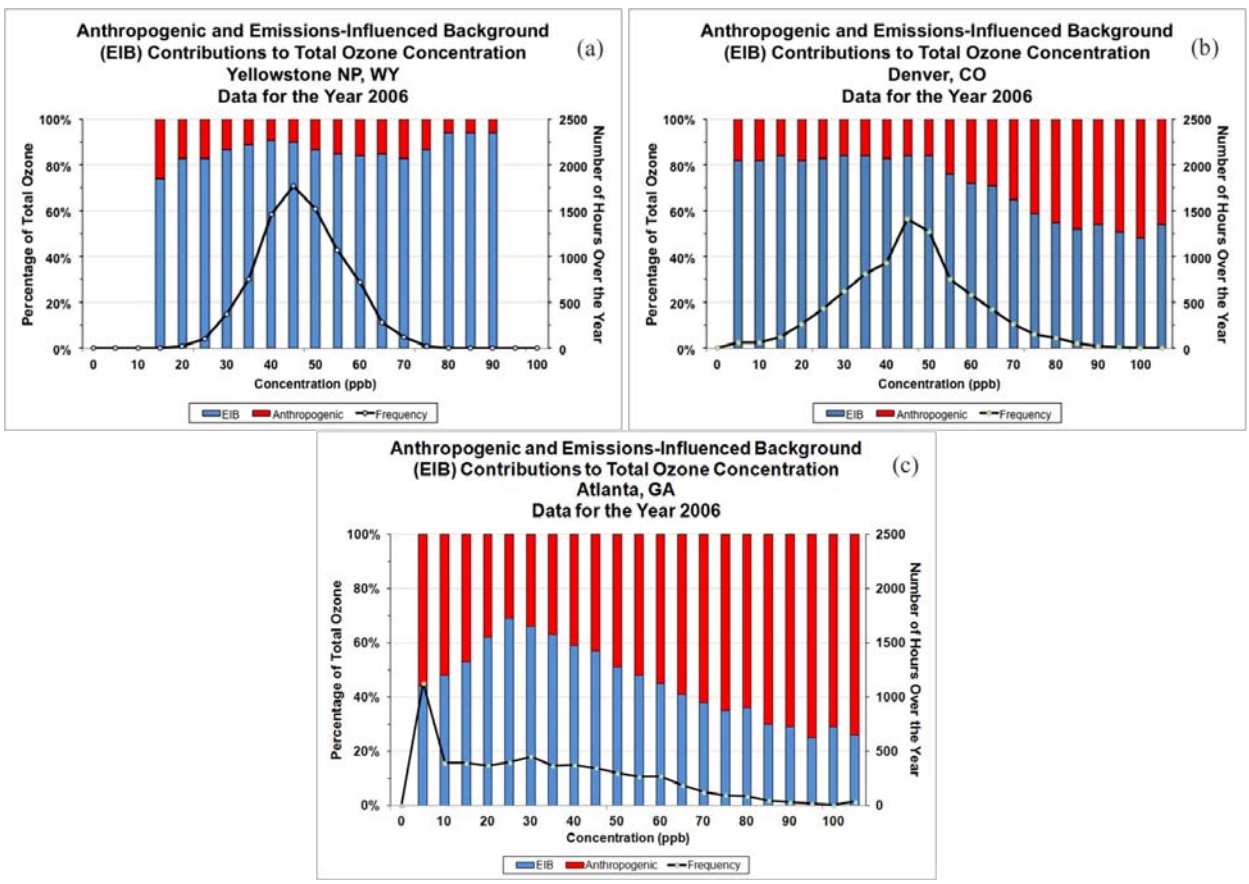


Fig. E3. Binned (5 ppb) frequency distribution of observed hourly total O_3 (black curve; right axis) and average relative binned contributions of maximum hourly EIB and anthropogenic O_3 (bars; left axis) for a) Yellowstone NP, b) Denver, and c) Atlanta. (Source: Lefohn et al., 2014a).

In the analysis of background O_3 we present in our comments, we find that that background O_3 was generally in the range of 30-70 ppb for the high-elevation sites and 30-45 ppb for the low-elevation site background site at Trinidad Head (CA). A similar range of background O_3 concentrations was observed for other low-elevation sites. For estimating background O_3, we used results from the GEOS-Chem/CAMx (Lefohn et al., 2014a) and AM3 models (Lefohn et al., 2014b). As noted in our comments, for estimating values of EIB O_3 and NAB O_3, adjustments were required as described in Lefohn et al. (2014a, b) to account for likely underestimates (GEOS-Chem/CAMx) and overestimates (AM3) of background O_3 (as noted by Fiore et al., 2014).

It is important to note that EPA reported in the PA (page 2-18, 2A-36, and 2A-37) a large percentage (i.e., >50%) of the 8-hour concentrations measured across the US consists of background O_3. In the West, Intermountain West, and the Northeast, the percentage contribution of background O_3 to the seasonal mean 8-hour concentration is 70% or greater (Fig. E4). This is consistent with the findings reported by Lefohn et al. (2014a) as presented in Fig. E3 and in the Appendix of this document.

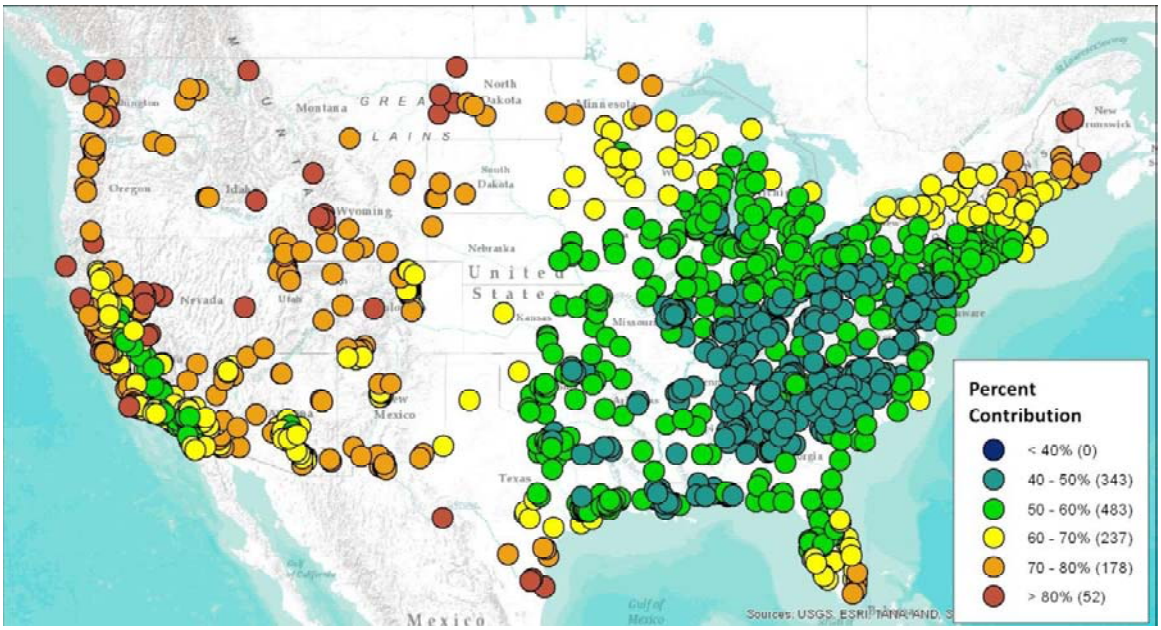


Fig. E4. Map of apportionment-based U.S. background percent contribution to seasonal mean O_3 based on 2007 CAMx source apportionment modeling. (Source: page 2-18 of PA).

While the EPA believes that attainability and technical feasibility are not relevant consideration in the setting of a NAAQS, background O_3 still remains a very important issue that we believe that the Administrator will have to take into consideration when recommending a level for the NAAQS. The cumulative risk estimates are used to advise the EPA Administrator on the level of the O_3 standard. We believe that the Agency has provided information that allows one to assess the relative contribution of (1) anthropogenic (i.e., controllable) O_3 and (2) background O_3 (non controllable) to its human health risk estimates. As noted in the REA, the lung function and epidemiological risk estimates for attaining the 75, 70, 65 and 60 ppb

standards indicate that a large percentage of the risks are associated with 8-hour average ambient concentrations in the 25-55 ppb range, which is the range of concentrations associated with background O_3 and these concentrations are not controllable. ***Therefore, because risk estimates assist the EPA Administrator in deciding the level of the O_3 standard and background O_3 is tightly linked to the risk estimated for the current as well as the alternative O_3 standards, we believe that background O_3 (i.e., EIB O_3 and NAB O_3) is a major player in the decision-making process that evaluates the level of the O_3 standard.***

The final PA is to present a transparent evaluation of EPA staff conclusions regarding policy considerations related to reaching judgments about the adequacy of the current standards and what, if any, revisions may be appropriate to consider. When final, the Agency's PA evaluation and associated conclusions on the range of policy options that could be supported by the available scientific evidence and exposure/risk information will inform the Administrator's decisions as to whether the existing primary and/or secondary O_3 standards should be revised and, if so, what revised standard or standards is/are appropriate. It is our opinion that background O_3 deserves to have a place not just at the table, but at the head of the table when the final standard-setting decisions are made.

1. Attainability and Technical Feasibility

We believe that the role, levels, and relevance of background tropospheric O_3 should be an important component in determining both the risk and attainability of a revised O_3 standard. The determination of background O_3 levels from photochemical models and the fidelity of these modeled O_3 levels in comparison with observed O_3 amounts under conditions likely to be representative of "background" conditions were discussed in the ISA and have been commented on in our previous testimony to CASAC in documents submitted for the record to EPA (Lefohn and Oltmans, 2012). Recent published work and ongoing research (Zhang et al., 2011; Lin et al., 2012; Lefohn et al., 2014a; Zhang et al., 2013; Fiore et al., 2014; Lefohn et al., 2014b) reinforce the important contribution of North American background O_3, including a significant stratospheric component, on 8-hour maximum daily average O_3 (MDA8) at or near current air quality standards. In particular during the spring and early summer NAB O_3 over the western US is routinely elevated. This elevated background is a persistent feature in the spring and early summer in the western US and is likely not easily identifiable as an exceptional event. These findings emphasize the need to provide a balanced view that recognizes the significant contribution of NAB to observed (total) O_3 and the achievement of an O_3 standard.

We acknowledge that the EPA believes that attainability and technical feasibility are not relevant consideration in the setting of a NAAQS (page 1-6 of the PA). The EPA notes on page (2-17 of the PA) that the Clean Air Act requires the NAAQS to be set at a level requisite to protect public health and welfare. According to the EPA, case law makes it clear that attainability and technical feasibility are not relevant considerations in the setting of a NAAQS. In previous reviews, EPA has assessed the proximity of O_3 concentrations to peak background

levels only as a secondary consideration between potential threshold levels, where health and welfare was determined to have been protected.

On page 1-25 of the PA, the Agency summarizes the following in regard to case law:

> In 1979, the EPA set a 1-hour O_3 standard with a level of 0.12 ppm. Following the final decision in that review, the City of Houston argued that the standard was arbitrary and capricious because natural O3 concentrations and other physical phenomena in the Houston area made the standard unattainable in that area. The D.C. Circuit rejected this argument, stating that attainability and technological feasibility are not relevant considerations in the promulgation of the NAAQS. The Court also noted that the EPA need not tailor the NAAQS to fit each region or locale, pointing out that Congress was aware of the difficulty in meeting standards in some locations and had addressed this difficulty through various compliance related provisions in the Act.
>
> More recently, in the 1997 review of the O_3 NAAQS, the Administrator set an 8-hour standard with a level of 0.08 ppm (84 ppb). In reaching this decision, the EPA identified several reasons supporting its decision to reject a more stringent standard of 0.07 ppm. Most importantly, the EPA pointed out the scientific uncertainty at lower concentrations and placed significant weight on the fact that no CASAC panel member supported a standard level set lower than 0.08 ppm (62 FR 38868). In addition to noting the uncertainties in the health evidence for exposure concentrations below 0.08 ppm and the advice of CASAC, the EPA noted that a standard set at a level of 0.07 ppm would be closer to peak background concentrations that infrequently occur in some areas due to nonanthropogenic sources of O_3 precursors (62 FR 11 38856, 38868; July 18, 1997).
>
> In subsequent litigation, the D.C. Circuit upheld the EPA's decision as the product of reasoned decision-making. The Court made clear that the most important support for the EPA's decision was the health evidence and the concerns it raised about setting a standard level below 0.08 ppm. The Court also pointed to the significant weight that the EPA properly placed on the advice it received from CASAC. Finally (as noted in section 1.2.2 above), the Court noted that the EPA could also consider relative proximity to peak natural background O_3 when evaluating alternative standards. See ATA III, 283 F.3d at 379 (D.C. Cir. 2002).

The EPA believes that these cases provide a framework for considering the contributions of US anthropogenic, international anthropogenic, and natural sources, within the context of

considering the health evidence and CASAC advice, when evaluating various potential alternative standards.

As indicated above, the attainability and technical feasibility according to the EPA are not relevant considerations in the setting of a NAAQS. Previously the Agency has focused on the infrequent occurrence of episodic background O_3 enhancements. On page 2A-42 of the PA, the Agency notes that while it believes it is important to recognize that most high O_3 days (i.e., potential exceedance days) are estimated to be driven predominantly by non-background emissions, the recent EPA modeling also shows times and locations in which background contributions are estimated to approach 60-80 ppb. While the modeling was not expressly developed to capture these types of events, ambient observations have also shown relatively rare events where background O_3 sources (i.e., wildfires, stratospheric intrusions) have overwhelmingly contributed to an O_3 exceedance. EPA believes that from policy perspective, these background events must be viewed in the context of their relative infrequency and the existing mechanisms within the Clean Air Act (e.g., exceptional event policy, 179B international determinations) that help ensure States are not required to control for events that are inherently outside their ability to influence. While background O_3 levels can approach and periodically exceed the NAAQS at some locations, the Agency notes that these conditions are not a constraining factor in the selection of a NAAQS.

2. Ranges of Ozone Concentrations Important to the Risk Analyses

In our comments on the Health REA (Lefohn and Oltmans, 2014), we discussed the EPA's air quality results as emissions are reduced and the resulting distribution of O_3 concentrations that are associated with the risk estimates. Based on the information provided in

the REA, as well as in the published literature, as emission reductions of anthropogenic sources occur at urban-influenced sites, the following is anticipated to occur:

- The highest concentrations experienced currently, as well as the lowest values of the distribution of concentrations experienced currently will be eliminated and the frequency of mid-level concentrations will increase;

- The percentage of background O_3 compared to total observed O_3 will increase in the mid-range concentrations of 25-55 ppb as emissions are reduced;

- As the frequency of mid-level concentrations increases as a result of emission reductions, based on the REA findings, the highest concentrations in the remaining O_3 distribution will occur during the springtime (i.e., April-May) versus the summertime (June-August);

- The contribution of non-US anthropogenic sources such as stratospheric intrusions and international transport, which peak during the spring months (EPA, 2013), will enhance estimated risk as well as contribute to potential NAAQS violations;

- As emissions are reduced, background O_3, which includes stratospheric intrusions and international transport, will increase its contribution to total O_3 at all O_3 monitoring sites, especially during the spring months; and

- The consequences of the 5 items above will be a more predominant contribution of background O_3 to both the epidemiological and lung function risk estimates characterized in the REA.

The EPA notes in the REA (page 9-24) that the distribution of risk tends to be centered in the 25-55 ppb range of 8-hour daily maximum concentrations after just meeting an alternative standard of 60 ppb. Further investigating the data in Fig. 7-B1 in the REA Appendix for Chapters 7-9 on page 7B-3, in most cases it appears that the greatest percentage of risk tended to also be in the 25-55 ppb range for recent conditions (2007), current standard (75 ppb), alternative standard (70 ppb), alternative standard (65 ppb), and alternative standard (60 ppb). Fig. 1 illustrates that reducing emissions to attain the various standards increased the percent of total risk in the 25-55 ppb mid-range concentrations from the current conditions and this range of concentrations made up the greatest percentage of the risk.

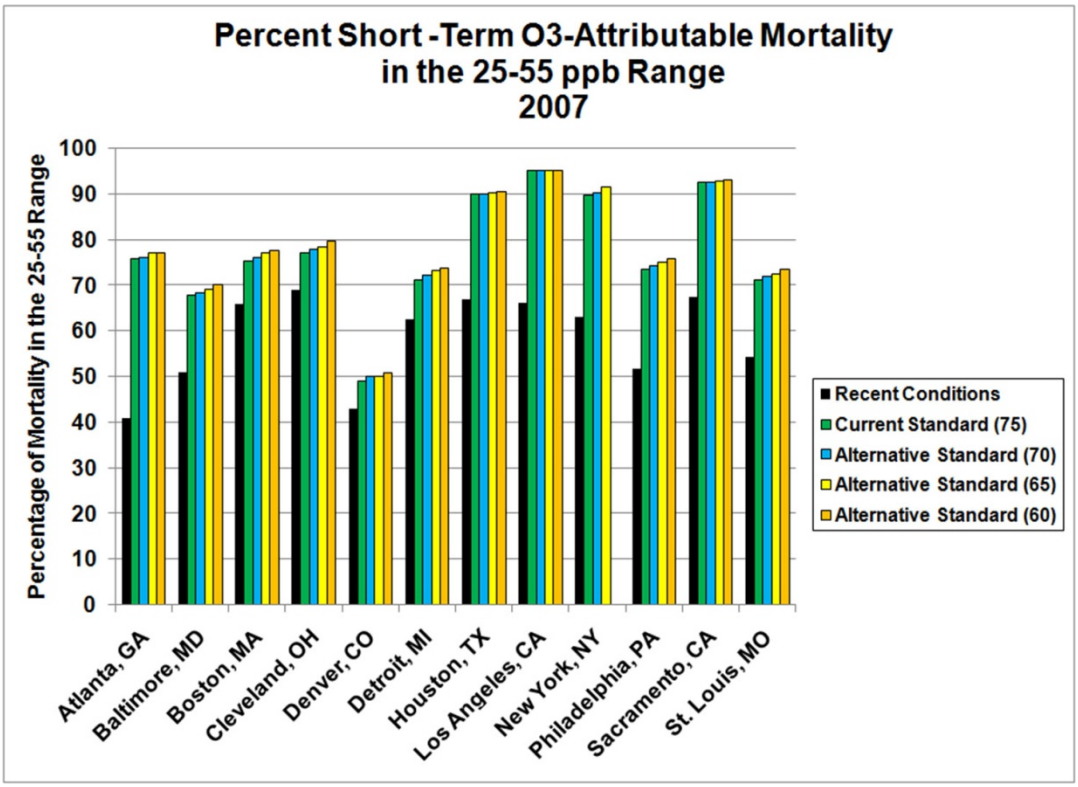


Fig. 1. Percent short-term O_3-attributable mortality in the 25-55 ppb range for various exposure conditions for 2007. (Source: Data from Fig. 7-B1 on page 7-B3 of the REA Appendix).

Compared to the mortality and morbidity risk assessments summarized above, as pointed out on page 9-44 of the REA, the lung function risk analysis is less sensitive to increases at the very low O_3 concentrations because the risk function is logistic and shows little response when ambient concentrations are generally less than 20 ppb for the 10 percent FEV1 decrement and generally less than 40 ppb for the 15 percent FEV1 decrement. For estimating the distribution of daily FEV1 decrements ≥ 10% across ranges of 8-hour average ambient O_3 concentrations for cities and air quality scenarios, we have reviewed the distributions of composite monitor 8-hour daily maximum values for 12 urban case study areas (Fig. 2). The plots depict values based on ambient measurements (base), and values obtained with the HDDM adjustment methodology

showing attainment of 75, 70, 65 and 60 ppb standards. Based on the distribution of concentrations shown in Fig. 2 reproduced from page 4-25 of the REA, we would anticipate as discussed in our REA comments that a large percentage of daily instances of FEV1 decrements ≥ 10% would be predicted to occur when 8-hour average ambient concentrations were in the 25-55 ppb range for attainment of the 75, 70, 65 and 60 ppb standards.

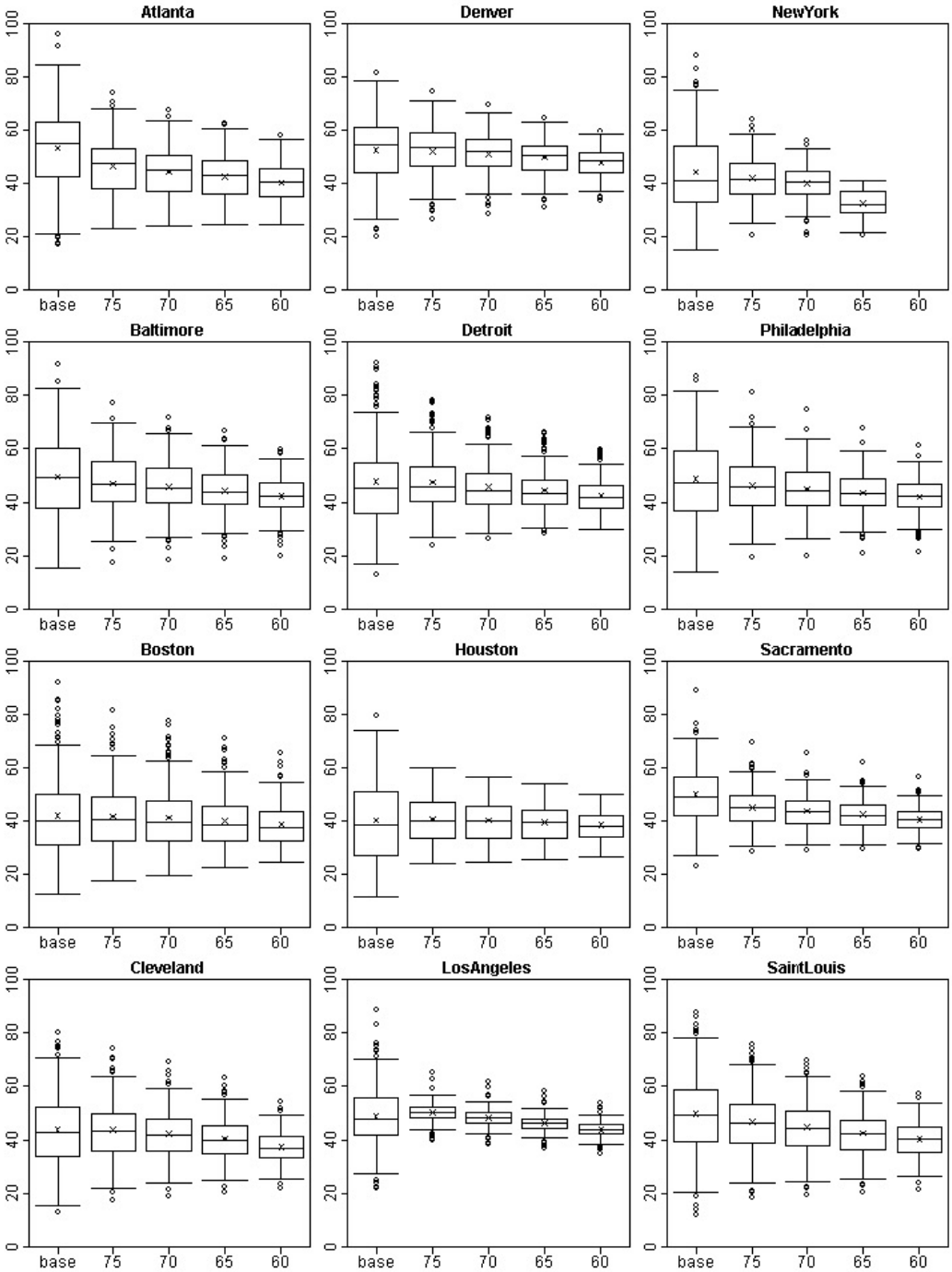
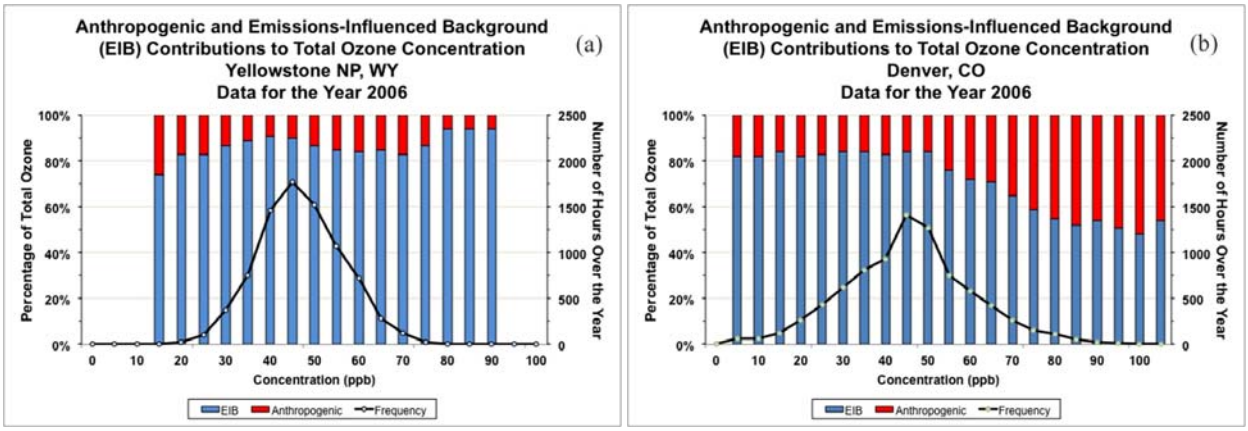


Fig. 2. Distributions of composite monitor 8-hour daily maximum values for the 12 urban case study areas in the epidemiology-based risk assessment. Plots depict values based on ambient measurements (base), and values obtained with the HDDM adjustment methodology showing attainment of 75, 70, 65 and 60 ppb standards. Values shown are based on CBSAs for April-October of 2007. Note that the HDDM 8 adjustment technique was not able to adjust air quality to show attainment of a 60 ppb standard in New York, so no boxplot is shown for that case. (Source: Fig. 4-9 of REA page 4-25).

3. The Range of Background Ozone Concentrations

The mid-range concentrations of 25-55 ppb have been highlighted both in the EPA's REA and in our comments. As we noted above, the mid-level range of concentrations has an important effect on the estimated epidemiological and lung function risks. As anthropogenic emissions are reduced, increases in risks occur with the result that a large percentage of the risks are accumulated in the 25-55 ppb range of concentrations. In reviewing Fig. 3, which is presented in our REA comments, the contribution of hourly background O_3 to total observed O_3 in the 25-55 ppb range is large. Lefohn et al. (2014a) characterized Emissions-Influenced Background (EIB) O_3 for 23 sites across the US. EIB O_3 is "titrated" background O_3 by anthropogenic sources. Appendix A provides figures that describe the percent contribution of background O_3 to total observed O_3 for the 23 sites. Background O_3 concentrations make up an important amount in comparison to the total observed O_3. For example, at Yellowstone NP, the contribution of background O_3 in the range of 25-55 ppb is greater than 80% of total O_3; at Denver, background O_3 generally contributes between 70-80% to total O_3 in the 25-55 ppb range; and at Atlanta, EIB O_3 contributes to total O_3 approximately 50-70% in this range of concentrations.



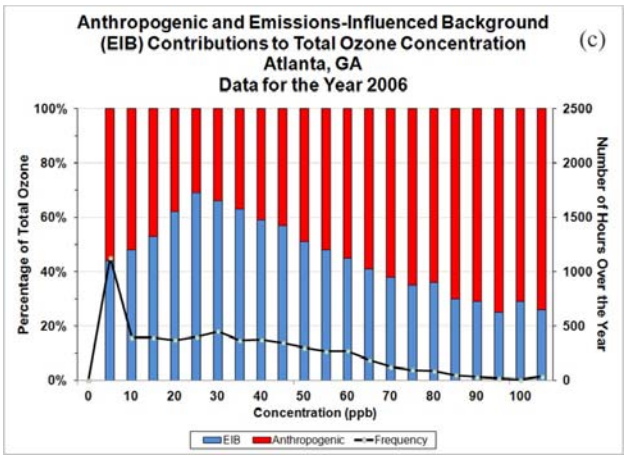


Fig. 3. Binned (5 ppb) frequency distribution of observed hourly total O_3 (black curve; right axis) and average relative binned contributions of maximum hourly EIB and anthropogenic O_3 (bars; left axis) for a) Yellowstone NP, b) Denver, and c) Atlanta. (Source: Lefohn et al., 2014a).

In the REA, we described our results from the (1) GEOS-Chem/CAMx model (Lefohn et al., 2014a) and (2) ozonesonde data from several sites to evaluate the AM3 model performance (Lefohn et al., 2014b) in apportioning background O_3 (i.e., EIB O_3 and NAB O_3) to the total measured MDA8 O_3 at several sites. These results allowed us to quantitatively assess the range of background O_3 concentrations associated with various sites across the US. While the models evaluated in Fiore et al. (2014) agree on the significant impact of NAB O_3 in the western US in meeting the existing or proposed O_3 standard, they differ in several areas in attributing the cause of high NAB O_3 levels. Fiore et al. (2014) note that the model biases are largest during spring months when the fourth highest MDA8 values are found in the western and northeastern US. The authors indicate that bias correction techniques may be useful in quantifying accurate NAB estimates at specific locations. Two recent efforts (Lefohn et al., 2014a, b) have shown that it is feasible under the appropriate conditions to evaluate components of these biases. While several researchers (e.g., Zhang et al., 2013; Fiore et al., 2014) suggest that an important use of models (e.g., GEOS-Chem and AM3) is to assist the EPA in identifying exceptional O_3 events in the

West and Intermountain West when the O_3 NAAQS is exceeded, we see a larger role for models in characterizing background O_3 levels and how these levels affect EPA's REA risk outcomes and the attainability of the O_3 NAAQS. While important differences in the magnitude and spatial and temporal variability of background O_3 estimates exist among the various models used to predict background O_3, the models can assist in assessing both human health risk estimates and the attainability of the NAAQS.

In the analysis of background O_3 we present in our REA comments, we find that that background O_3 was generally in the range of 30-70 ppb for the high-elevation sites and 30-45 ppb for the Trinidad Head, low-elevation site. A similar range was observed for other low-elevation sites. Meteorological evidence exists to support the observation that conditions representative of US background are routinely encountered at the low-elevation monitoring site at Trinidad Head, California. McDonald-Buller et al. (2011) concluded that conditions representative of background O_3 are routinely encountered at Trinidad Head. The site regularly observes measurements under US background conditions for daytime observations (i.e., mid morning to late afternoon). Long-range transport outside of North America and natural processes, such as stratospheric enhancement, contribute to O_3 concentrations measured at this site.

Using data derived from Lefohn et al. (2014a), we characterized the MDA8 EIB O_3 time series for April, May, and June 2006 for Yellowstone NP, Pinedale, Gothic, and Yosemite NP (Fig. 4). As mentioned earlier, the EIB O_3 concentrations represent “titrated” background O_3. For those sites that are influenced by anthropogenic emissions, EIB O_3 concentrations as represented would increase as emissions were reduced. Except for the periods when stratospheric O_3

intrusions influence the peak concentrations, the MDA O_3 values range generally between 40-60 ppb.

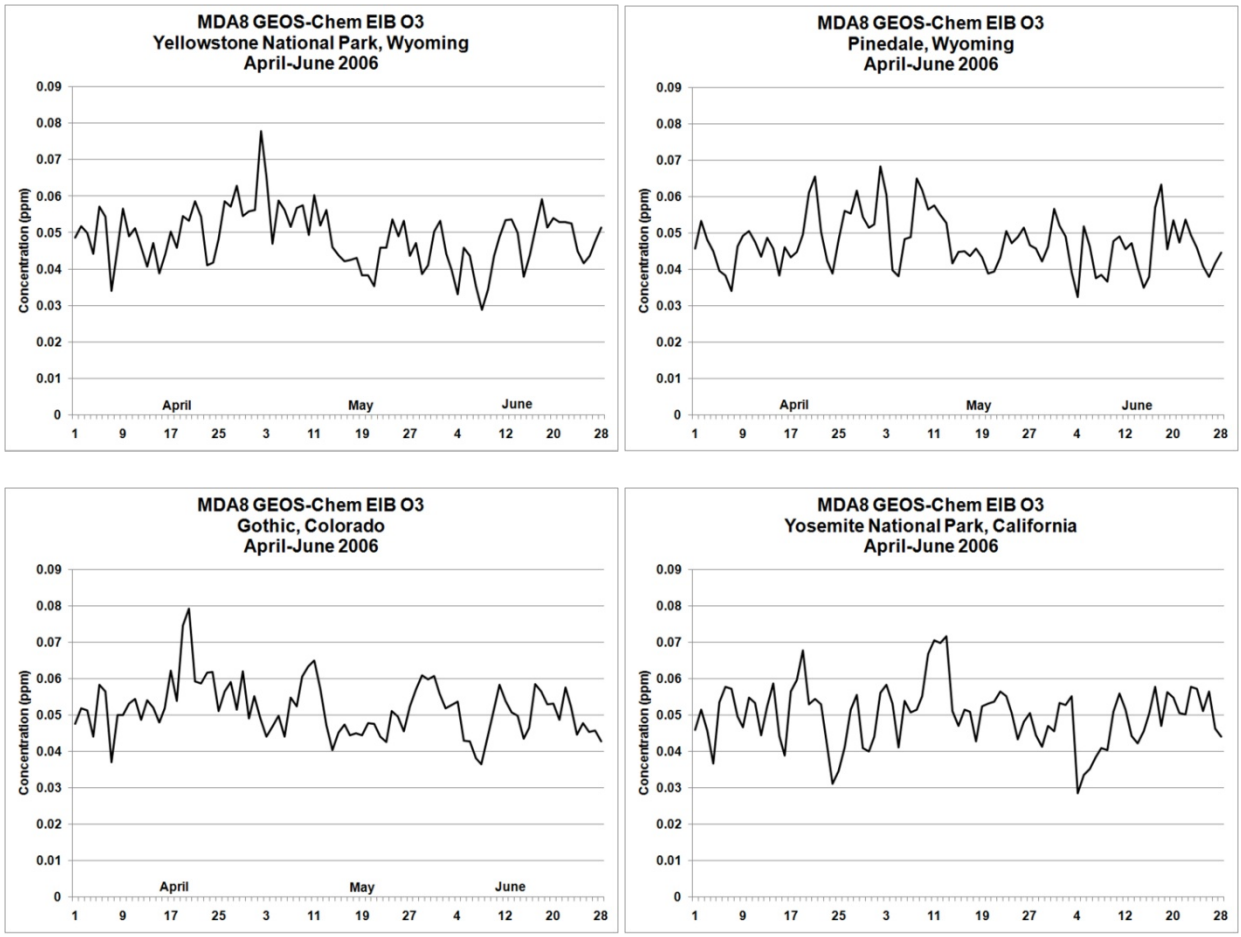


Fig. 4. MDA8 EIB O_3 time series for April-June 2006 for Yellowstone NP, Pinedale, Gothic, and Yosemite NP.

The high-elevation sites are influenced by global tropospheric O_3 (Lin et al., 2012; Lefohn et al., 2014a). Fig. 5 illustrates the MDA8 EIB O_3 time series for Denver and Sacramento. The EIB O_3 time series for the high-elevation site at Denver is similar to the sites in Fig. 4, which showed MDA O_3 values range generally between 40-60 ppb. The range of EIB O_3 concentrations for Sacramento is generally 20-50 ppb, which is a lower range of concentrations

than for the other 5 sites. This reflects the Sacramento site's lower elevation as well as considerably more titration of background O_3 by anthropogenic emissions.

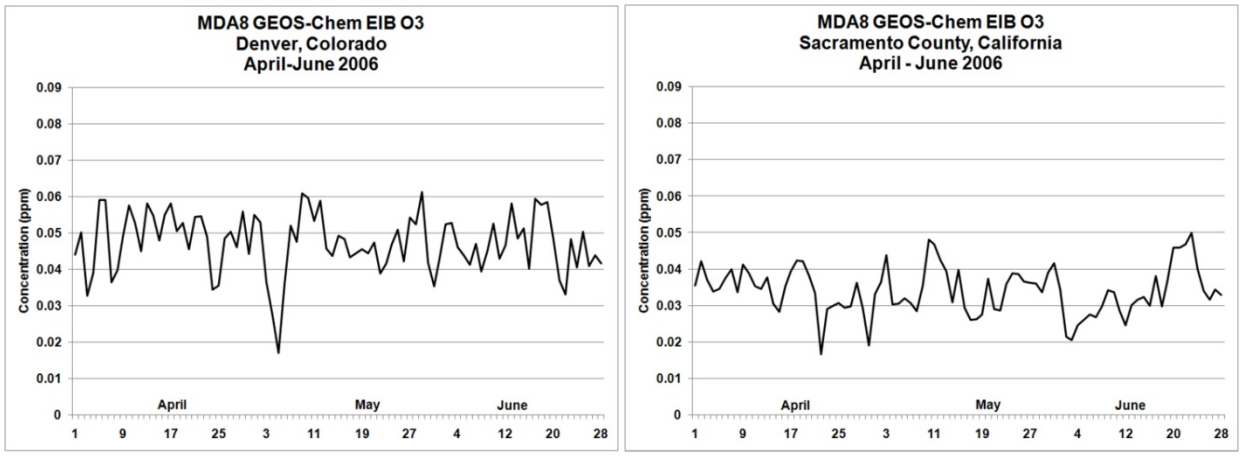


Fig. 5. MDA8 EIB O_3 time series for April-June 2006 for Denver and Sacramento.

In Lin et al. (2012) the contribution to NAB O_3 at 15 high altitude sites in the intermountain west was large for measured O_3 ≥60 ppb. These contributions were bias corrected estimates (Fig. 6). For the time period investigated in Lin et al. (2012), Lefohn et al. (2014b) expanded the analysis for AM3 to 30 sites considered in an earlier analysis of GEOS-Chem/CAMx (Lefohn et al., 2014a).

Using the AM3 model applying an adjustment procedure, we characterized NAB O_3 for 2010 at Trinidad Head (CA), Lassen Volcanic National Park (CA), Sacramento County (CA), Jefferson County (CO), and Pinedale (WY). At Trinidad Head (Fig. 7), the ozonesonde values at 0.5 km an 1.0 km are compared to the measured surface MDA8 O_3 as well as the bias adjusted NAB O_3 and adjusted stratospheric component (O3S). The analysis in Lin et al. (2012) showed that Pt. Reyes was more frequently influenced by stratospheric intrusions that reached closer to the surface than the site at Trinidad Head. In evaluating the contribution of NAB O_3 to the

observed O_3 at Lassen Volcanic National Park and Sacramento a comparison with both ozonesonde locations is shown (Figs. 8 and 9).

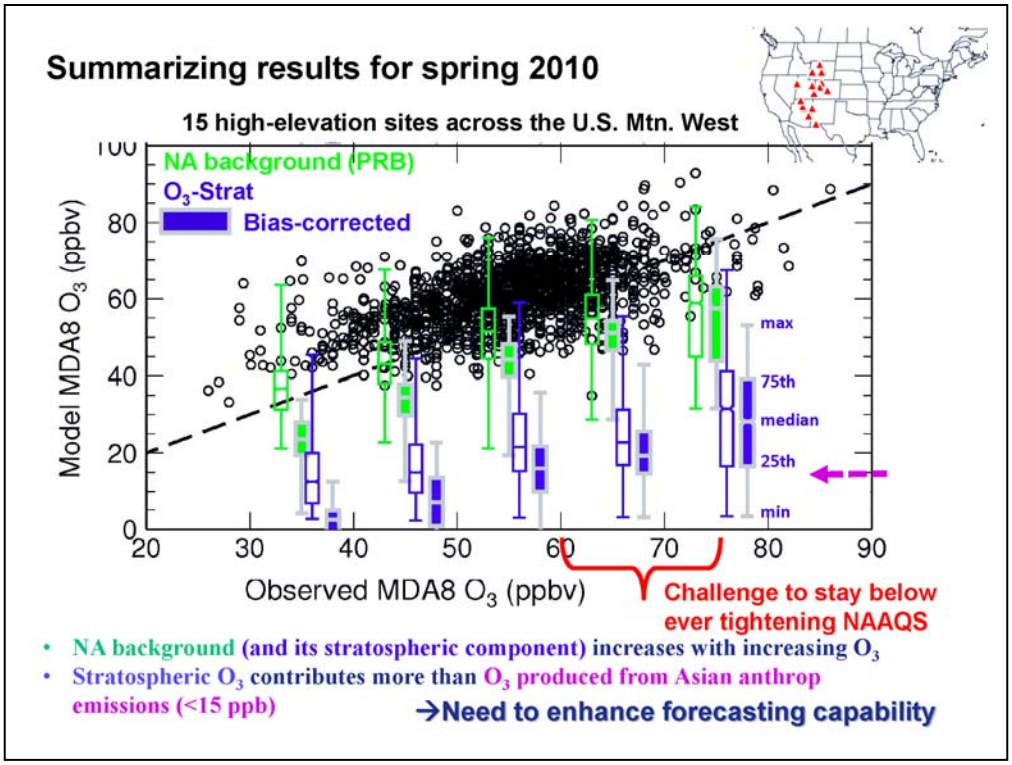


Fig. 6. Model versus observed MDA8 surface O_3 for April–June 2010 at 15 high-elevation sites. Also shown is the 1:1 line. The box-and-whisker plots (minimum, 25th, 50th, 75th percentiles, and maximum) give statistics of the NA background (green) and the stratospheric contribution (blue) for every 10-ppb bin of observed values. Points greater than 80 ppb are merged to the 70–80 ppb range. The filled boxes represent the bias-corrected estimates by assuming that model overestimates of total O_3 are entirely driven by excessive stratospheric influence (adapted from Lin et al., 2012).

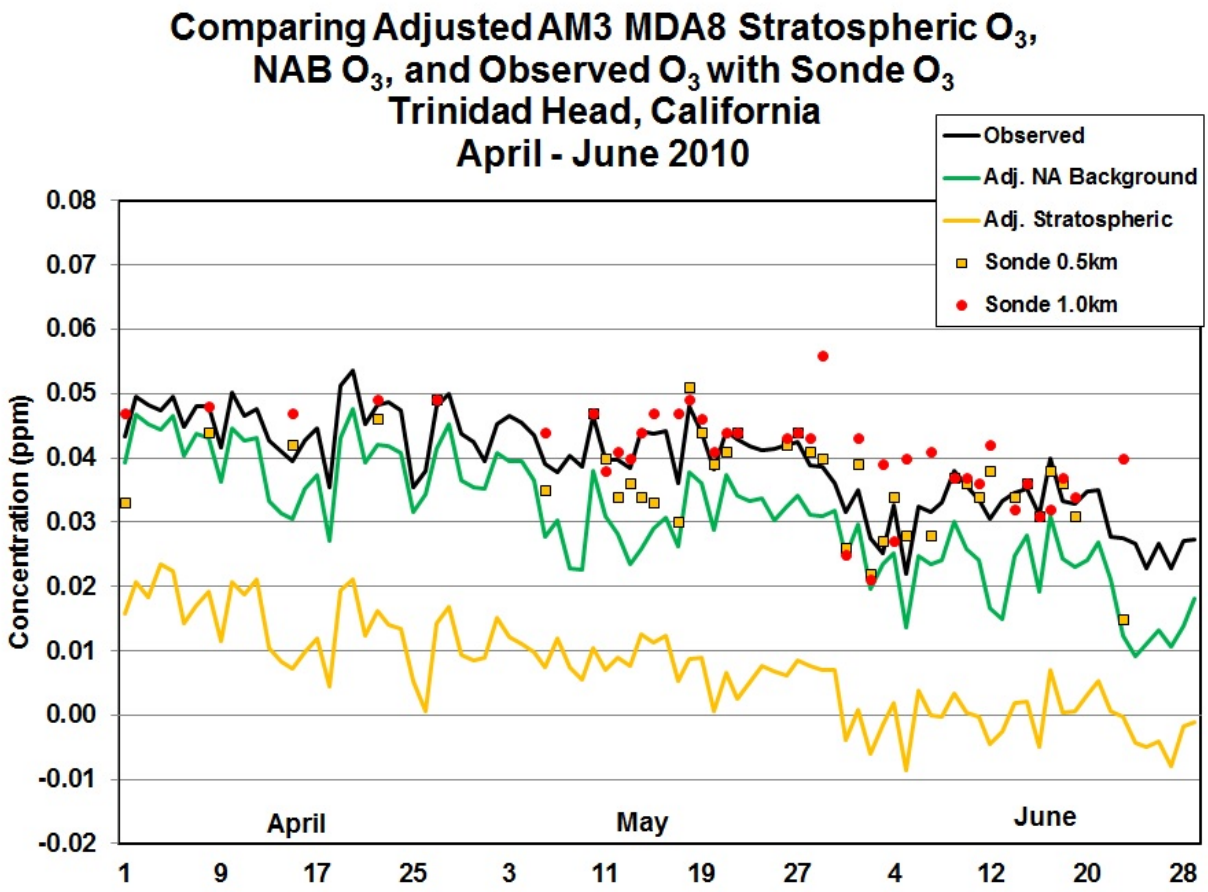


Fig. 7. Comparison of the AM3 model MDA8 stratospheric O_3 and NAB O_3 and the observed MDA8 O_3 at Trinidad Head, CA with ozonesonde measured O_3 0.5 km and 1.0 km at Trinidad Head. Ozonesonde data are 100 m averages centered at the designated altitude. (Source: Lefohn et al., 2014b).

The comparison of the surface MDA8, adjusted NAB, and adjusted O3S O_3 at Trinidad Head with ozonesonde data at 0.5 km (a level in the boundary layer) and 1.0 km (near the top of the boundary layer) indicates that the measured MDA8 surface value is representative of a mixed boundary layer with the surface values closely matching the 0.5 km ozonesonde value and slightly below the 1.0 km value. The adjusted NAB O_3 is the major portion of the observed value. The ozonesonde value at 1.0 km is representative of background air reaching the coast without significant surface O_3 loss. NAB O_3 is always ≤ the 1.0 km value and is often near the 0.5 km or surface value. After the bias adjustment, NAB O_3 is very consistent with expected

values for the measured O_3 value from the ozonesondes that mostly represent air parcels that have been over the Pacific Ocean for at least several days. The NAB O_3 time series for Trinidad Head for April and May showed that MDA8 O_3 values ranged generally between 30-45 ppb. It is noteworthy that though NAB is the primary contributor to measured O_3 at Trinidad Head, O3S is not the major contributor to NAB. This is consistent with the Lin et al. (2012) results that did not find stratospheric intrusions to significantly influence surface values at Trinidad Head in the spring of 2010.

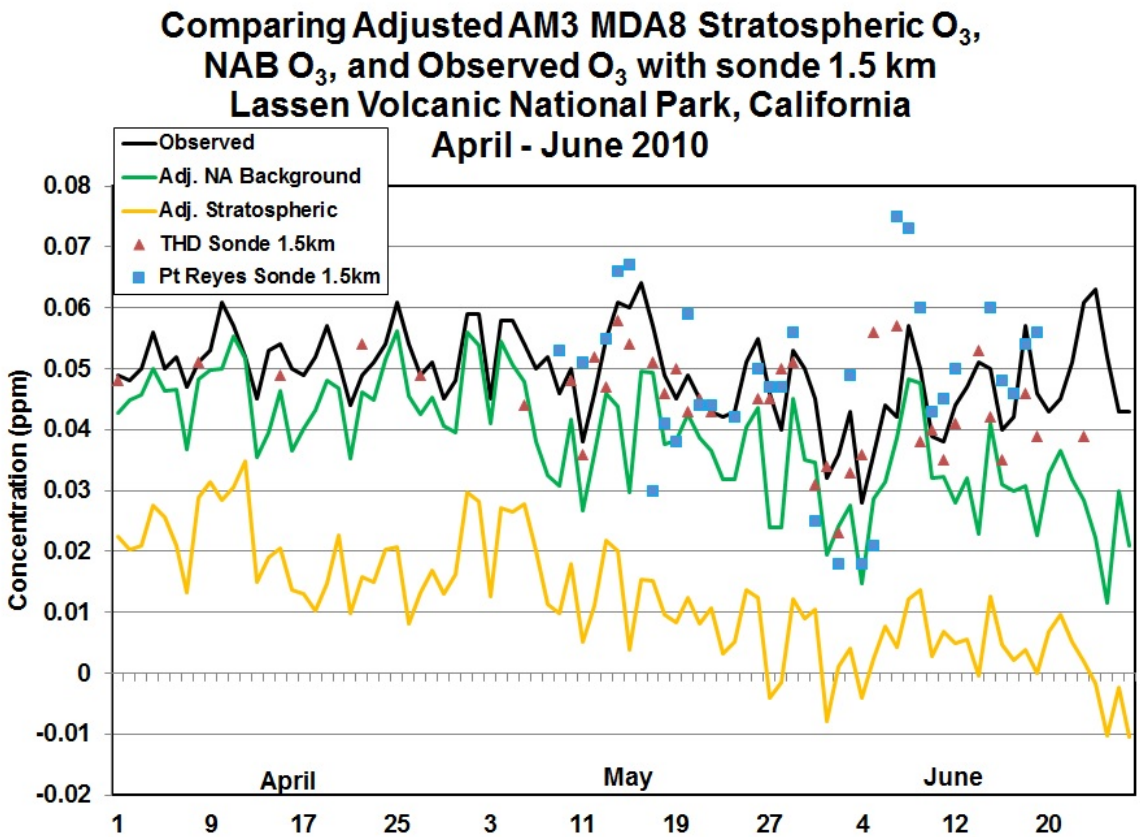


Fig. 8. Comparison of the adjusted AM3 model MDA8 stratospheric O_3 and NAB O_3 and the observed MDA8 O_3 at Lassen Volcanic National Park, CA with ozonesonde measured O_3 1.5 km at Trinidad Head, CA and Pt. Reyes, CA. Ozonesonde data are 100 m averages centered at the designated altitude. (Source: Lefohn et al., 2014b).

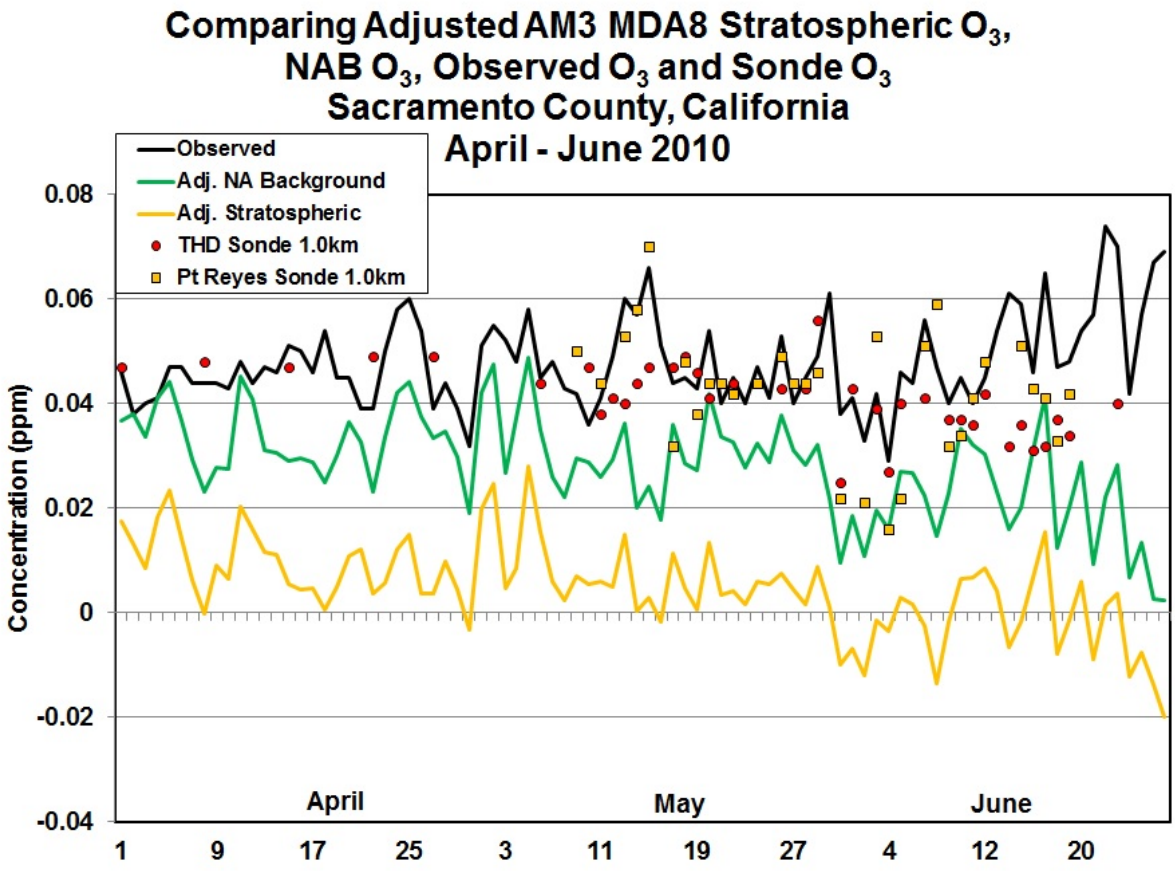


Fig. 9. Comparison of the adjusted AM3 model MDA8 stratospheric O_3 and NAB O_3 and the observed MDA8 O_3 at Sacramento County, CA with ozonesonde measured O_3 1.0 km at Trinidad Head, CA and Pt. Reyes, CA. Ozonesonde data are 100 m averages centered at the designated altitude. (Source: Lefohn et al., 2014b).

Lassen Volcanic National Park, CA is a higher elevation site (~1.5 km) inland from Trinidad Head. During the spring with prevailing westerly flow it is expected that the Lassen location intercepts air flowing inland from the Pacific. This implies that MDA8 surface O_3 at Lassen should be consistent with O_3 measured entering the west coast of the U.S. at the appropriate altitude (~1.5 km). Comparison of the ozonesonde data with Lassen measured and modeled MDA8 O_3 (Fig. 8) is very consistent with this picture. It shows that the adjusted model NAB O_3 for Lassen generally is well represented by the 1.5 km Trinidad Head ozonesonde value. On the other hand, the Pt. Reyes ozonesonde data show several cases with higher 1.5 km

values that are not reflected in the adjusted NAB or O3S O_3. The higher Pt. Reyes values were on days with noted stratospheric influence at Pt. Reyes but not at Trinidad Head. The large adjusted model NAB contribution to the observed values at Lassen is very consistent with the expectation from the ozonesondes. As at Trinidad Head, the NAB at Lassen is not driven by exceptional contributions from O3S, although adjusted O3S is nearly half of the NAB O_3 on several occasions. The NAB O_3 time series for Lassen for April and May showed that MDA8 O_3 values ranged generally between 20-55 ppb.

At Sacramento County, CA the degree to which the coastal ozonesonde values at a particular altitude are related to the surface MDA8 O_3 and adjusted NAB O_3 is not likely to be as large as at the less locally influenced site at Lassen. Comparing the Sacramento data with the 1.0 km ozonesonde data at the two sites does suggest that the model adjusted NAB O_3 does not overestimate the contribution to observed MDA8 O_3 (Fig. 9). The NAB O_3 time series for Sacramento County for April and May showed that MDA8 O_3 values ranged generally between 20-45 ppb.

Jefferson County, Colorado located in the Denver metropolitan area shows a large contribution from NAB O_3 to the measured MDA8 value (Fig. 10). Though there are only limited ozonesonde data from the Boulder, CO location, they are consistent with a rather significant contribution of NAB O_3 as shown by the model. The ozonesonde data from near the surface to well above the surface are near the adjusted NAB O_3 value. The NAB O_3 time series for Jefferson County for April to June showed that MDA8 O_3 values ranged generally between 30-70 ppb.

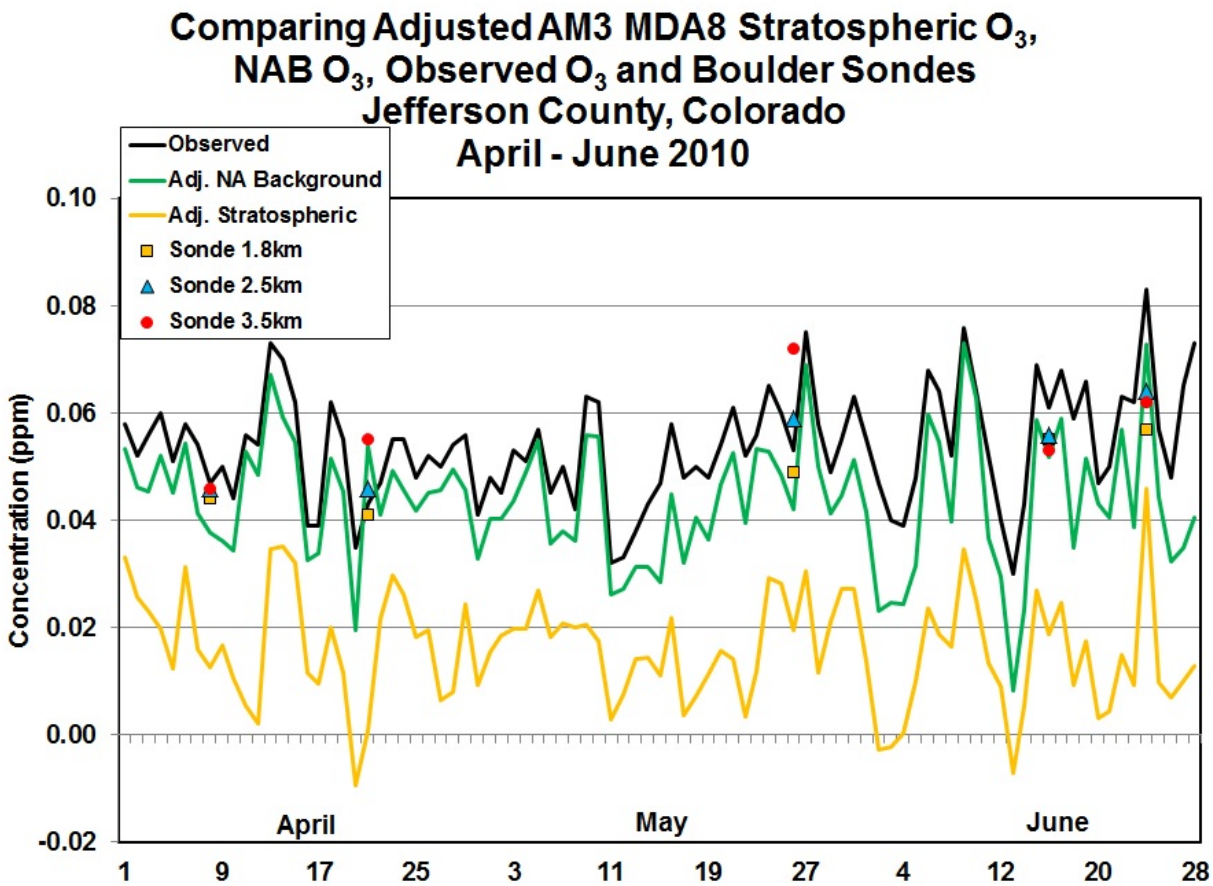


Fig. 10. Comparison of the AM3 model MDA8 stratospheric O_3 and NAB O_3 and the observed MDA8 O_3 at Jefferson County, CO with ozonesonde measured O_3 1.8 km (near surface). 2.5 km, and 3.5 km at nearby Boulder, CO. Ozonesonde data are 100 m averages centered at the designated altitude. (Source: Lefohn et al., 2014b).

The Pinedale, Wyoming site (Fig. 11) does not have a nearby ozonesonde location, but like Jefferson County has a major portion of measured MDA8 O_3 attributed to NAB O_3. On several of the days at Jefferson County and Pinedale, the model shows adjusted O3S to be an important contributor to the adjusted NAB O_3. The NAB O_3 time series for Pinedale for April to June showed that MDA8 O_3 values ranged generally between 30-65 ppb. At Pinedale for the April 9 event with measured MDA8 >70 ppb, the adjusted O3S is ~50 ppb. The LAGRANTO trajectory model (Lefohn et al., 2014a) also found that this event showed significant stratospheric

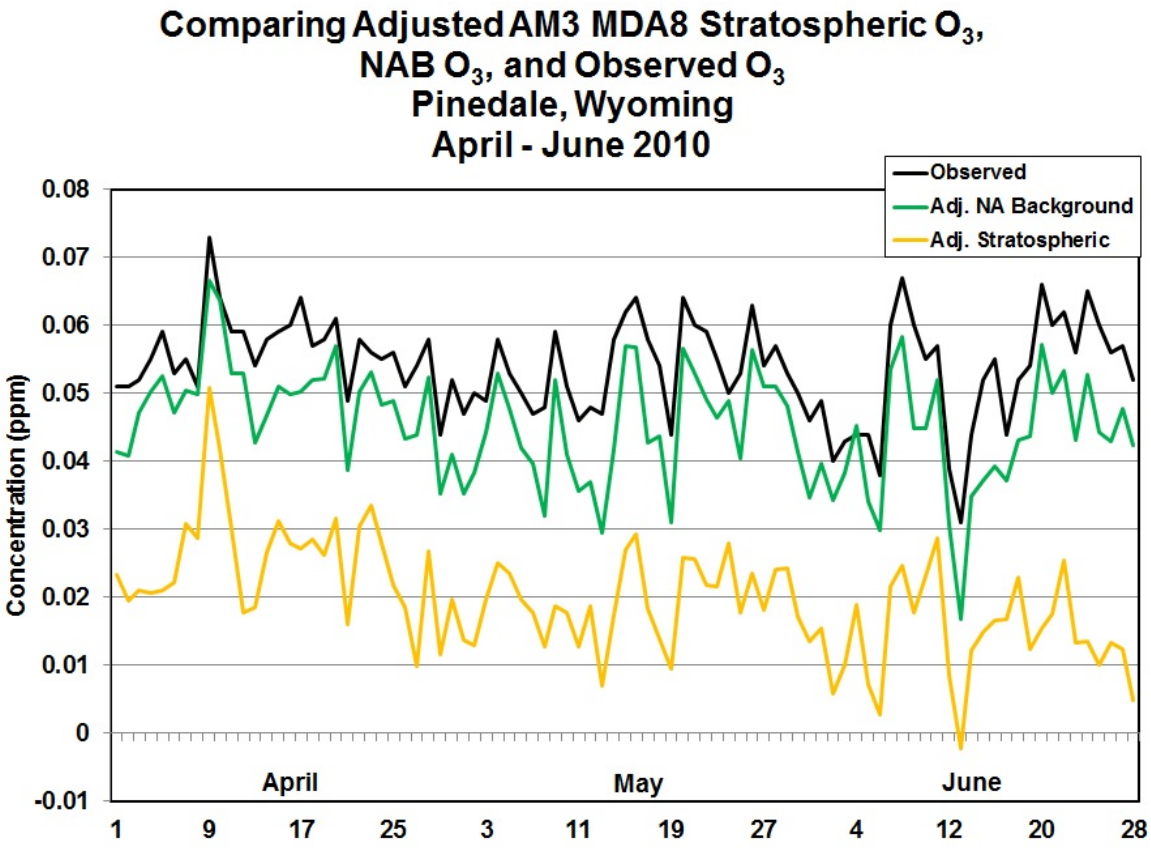


Fig. 11. Comparison of the AM3 model MDA8 stratospheric O_3 and NAB O_3 and the observed MDA8 O_3 at Pinedale, WY. (Source: Lefohn et al., 2014b).

influence (Fig. 12). However, several other days with measured MDA8 O_3 over >60 ppb had much less of an O3S contribution though NAB was a major portion of the observed value. This was the case at Jefferson County as well (Fig. 10).

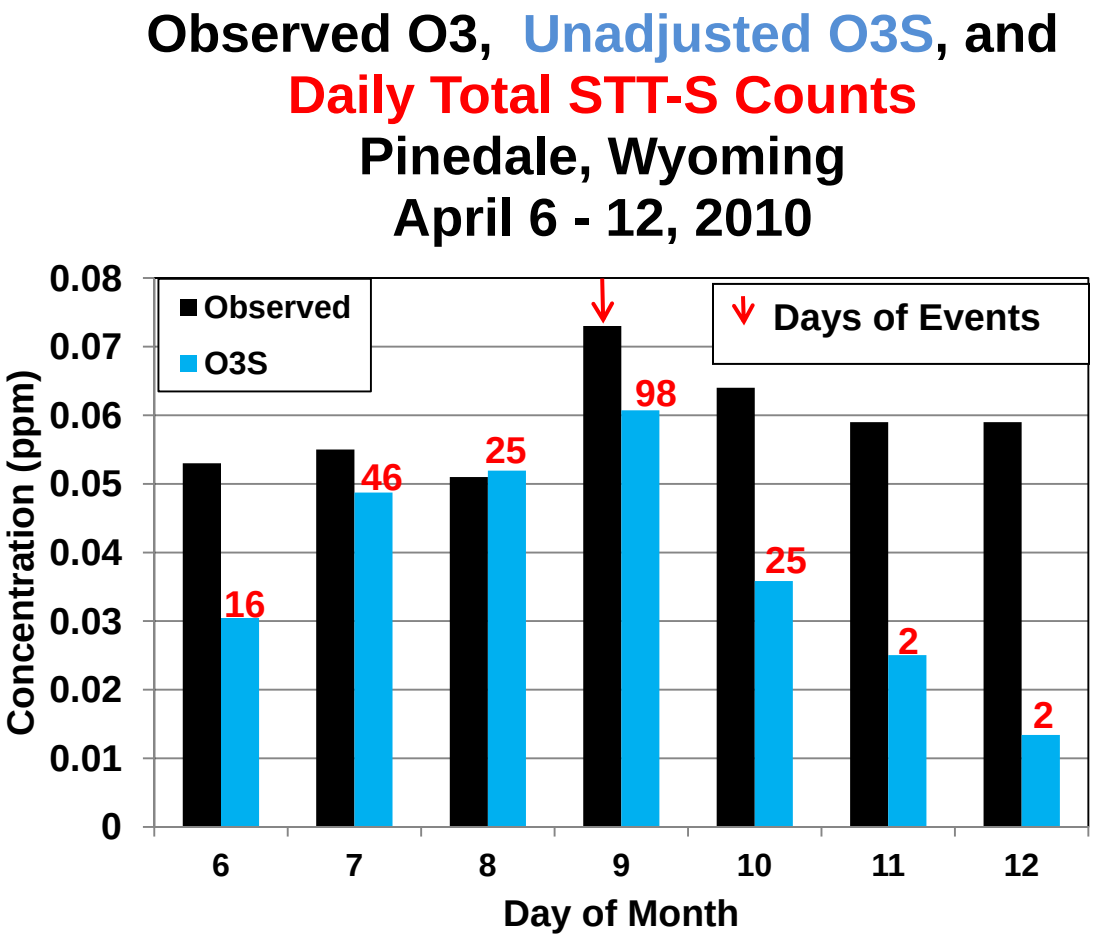


Fig. 12. Event on April 9 at Pinedale, WY, where both the AM3 model and the LAGRANTO trajectory analysis (STT-S counts) show a significant contribution from stratospheric O_3 to NAB O_3. (Note: The O3S O_3 is not adjusted for bias and thus, shows an overly large contribution from the stratosphere. From Fig. 15, the adjusted O3S value for April 9 is ~0.05 ppm). (Source: Lefohn et al., 2014b).

In the analysis of background O_3 we have described in this section, we found that background O_3 was generally in the range of 30-70 ppb for the high-elevation sites and 30-45 ppb for the Trinidad Head, low-elevation site. A similar range was observed for other low-elevation sites. Recent work (Fiore et al., 2014) comparing two models (GEOS-Chem and AM3) that have been used in recent studies to understand the contribution of NAB O_3, confirm that high values of NAB O_3 are associated with the observed MDA8 O_3 ≥60 ppb in the western US in the spring. Both more recent (Zhang et al., 2011; Emery et al., 2012; Lin et al., 2012) and earlier

work (Fiore et al., 2003) are consistent in finding a correlation between NAB O_3 levels and total observed O_3 during the spring. The implication is that NAB O_3 plays a role in raising observed O_3 above the existing NAAQS standard and therefore, above proposed lower O_3 standards. Recent studies have consistently found a larger contribution of NAB O_3 to total O_3 than earlier studies, which has pointed out the particular difficulty in the western US of achieving a standard significantly below the current standard MDA8 threshold of 75 ppb.

As indicated in our comments on the second draft of the REA, we used results from the GEOS-Chem/CAMx model (Lefohn et al., 2014a) and the ozonesonde data from several sites to evaluate the AM3 model performance (Lefohn et al., 2014b) in apportioning background O_3 (i.e., EIB O_3 and NAB O_3) to the total measured MDA8 O_3 at several sites. Overall our evaluation agrees with others that the elevated values of NAB O_3 are a consistent feature of spring measured O_3 in the western US. While several cases could be identified with a relatively large contribution of stratospheric O_3 to NAB O_3 when measured MDA8 was >60 ppb, in the majority of cases no exceptional cause for high measured values was identified. We found that elevated NAB O_3 was seen as the primary contributor to both the high average spring and early summer O_3 in the western US and also to MDA8 amounts >60 ppb.

It is important to note that EPA reported in the PA (page 2-18, 2A-36, and 2A-37) a large percentage (i.e., >50%) of the 8-hour concentrations measured across the US consists of background O_3. In the West, Intermountain West, and the Northeast, the percentage contribution of background O_3 to the seasonal mean 8-hour concentration is 70% or greater (Fig. 13). This is consistent with the findings reported by Lefohn et al. (2014a) as presented in Fig. 3 and in the Appendix of this document.

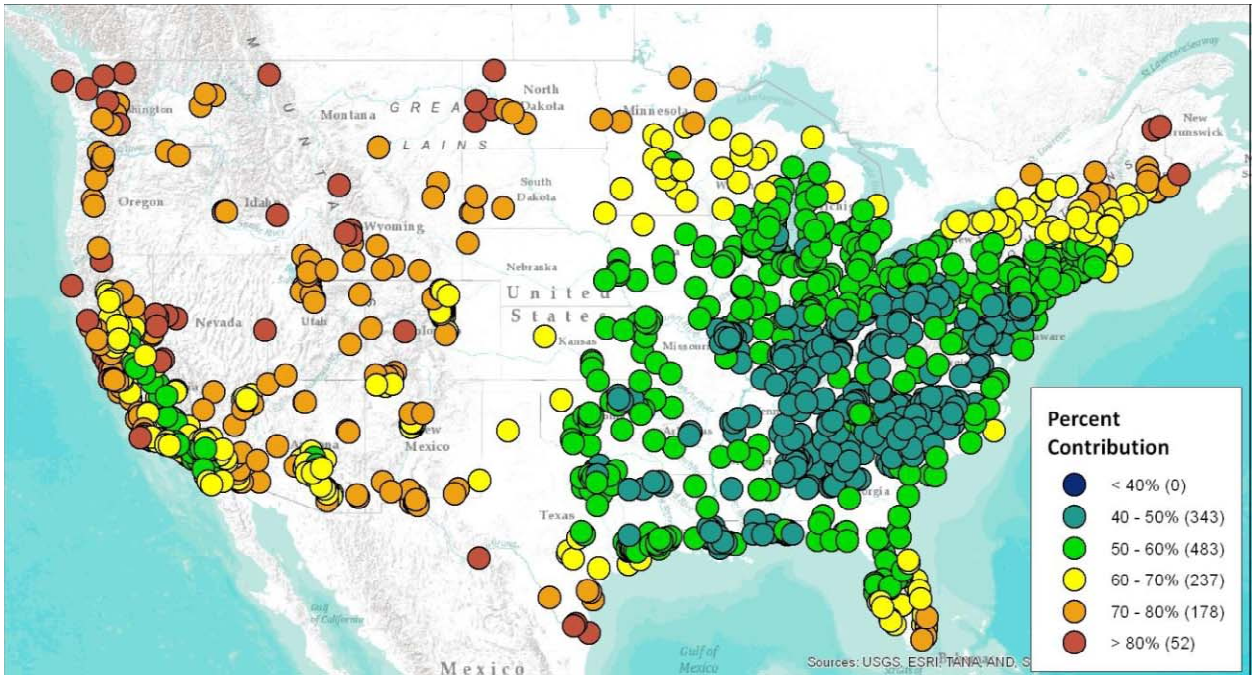


Fig. 13. Map of apportionment-based U.S. background percent contribution to seasonal mean O_3 based on 2007 CAMx source apportionment modeling. (Source: page 2-18 of PA).

4. Evidence to Inform the EPA Administrator on the Appropriate Ozone Standard Level

The cumulative risk estimates are used to advise the EPA Administrator on the level of the O_3 standard. As we indicated in the first section, EPA believes that attainability and technical feasibility are not relevant consideration in the setting of a NAAQS (page 1-6 of the PA). Therefore, we focus on the evidence that the Administrator will use in making a decision on the NAAQS. As EPA discussed in the REA, the lung function and epidemiological risk estimates for attaining the 75, 70, 65 and 60 ppb O_3 standards indicate that a large percentage of the risks are associated with 8-hour average ambient concentrations in the 25-55 ppb range. In addition, background O_3 (either EIB O_3 or NAB O_3) contributes a large percentage of the total O_3 concentration in the 25-55 ppb range. ***Therefore, we conclude that background O_3 is tightly***

linked to the cumulative risk estimated for the current as well as the alternative O_3 standards. Based on these findings, we conclude that background O_3 (i.e., EIB O_3 and NAB O_3) is a major player in the EPA Administrator's decision-making process that evaluates the level of the O_3 standard.

The EPA in the PA has provided clear and concise guidance to the Administrator concerning the relative contribution of (1) anthropogenic (i.e., controllable) O_3 and (2) background O_3 (non controllable) to its human health risk estimates. The lung function and epidemiological risk estimates for attaining the current and alternative standards indicate that background O_3 contributes a large percentage to the cumulative estimates. Background O_3 concentrations are not controllable.

The final PA is to present a transparent evaluation of EPA staff conclusions regarding policy considerations related to reaching judgments about the adequacy of the current standards and what, if any, revisions may be appropriate to consider. When final, the Agency's PA evaluation and associated conclusions on the range of policy options that could be supported by the available scientific evidence and exposure/risk information will inform the Administrator's decisions as to whether the existing primary and/or secondary O_3 standards should be revised and, if so, what revised standard or standards is/are appropriate. It is our opinion that background O_3 deserves to have a place not just at the table, but at the head of the table when the final standard-setting decisions are made.

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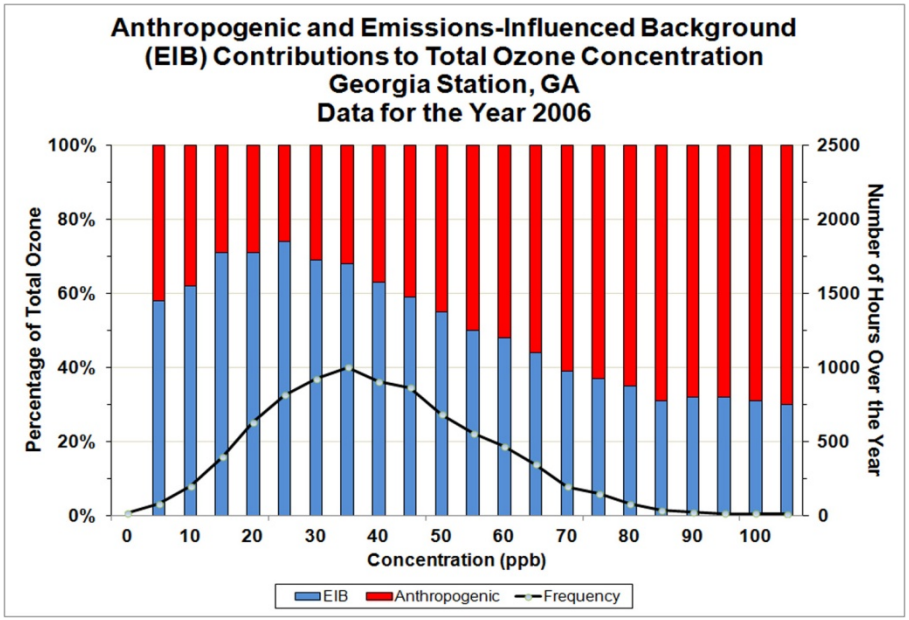
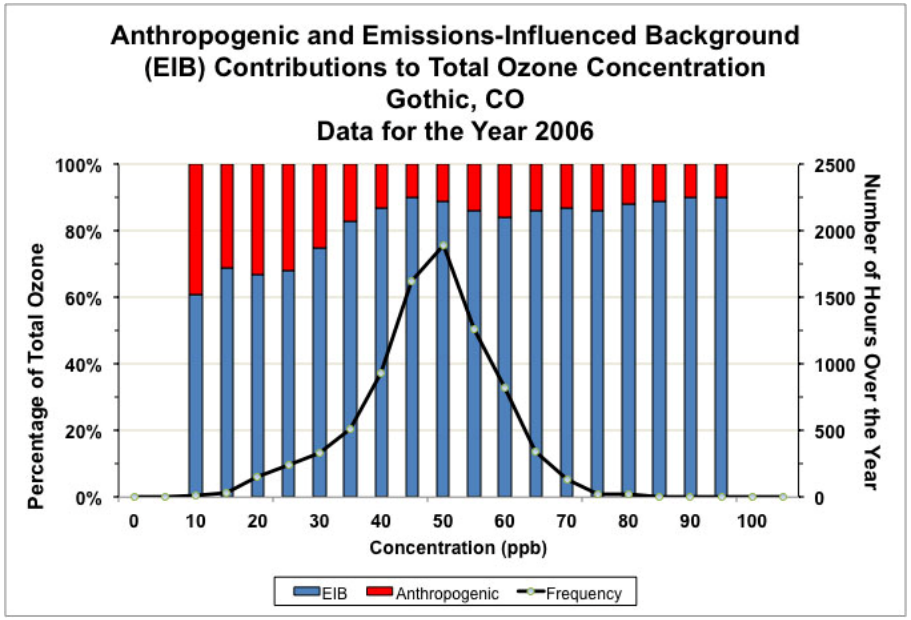
Phys. Discuss., 13, 25871–25909, 2013 www.atmos-chem-phys-discuss.net/13/25871/2013/
doi:10.5194/acpd-13-25871-2013.

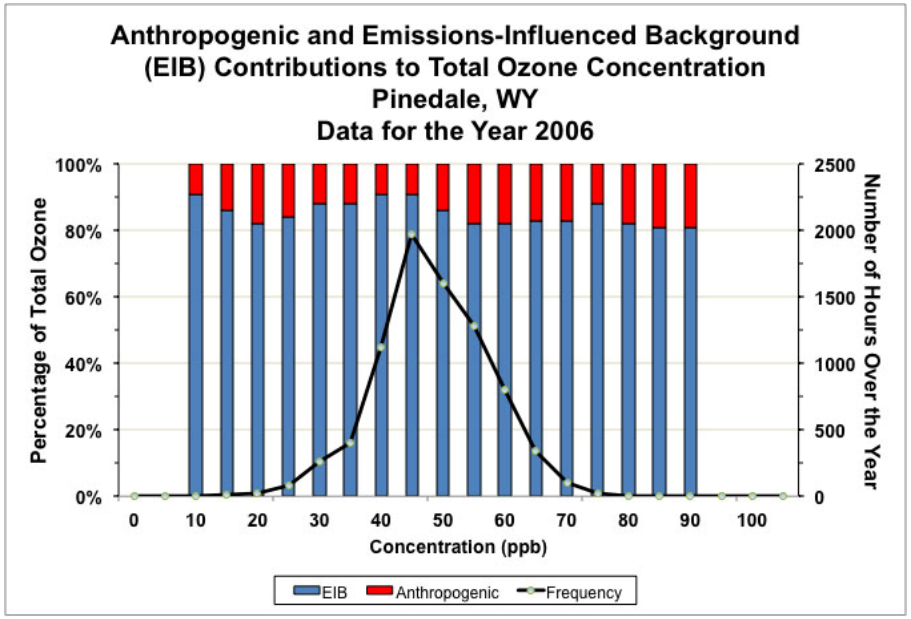
Appendix

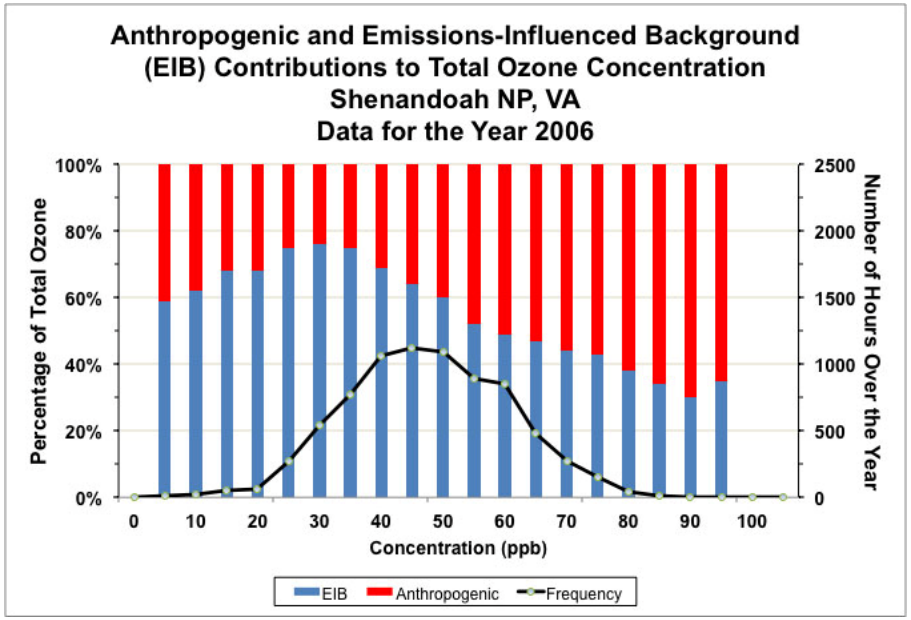
Anthropogenic and Emissions-Influenced Background (EIB) Contributions to Total Ozone Concentrations for 2006

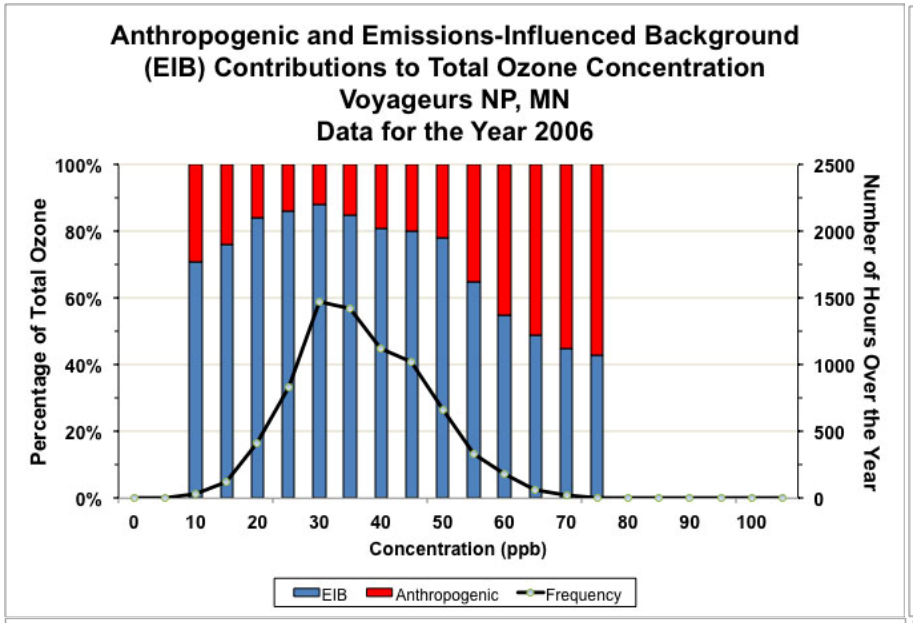
Source: Lefohn et al. (2014a)

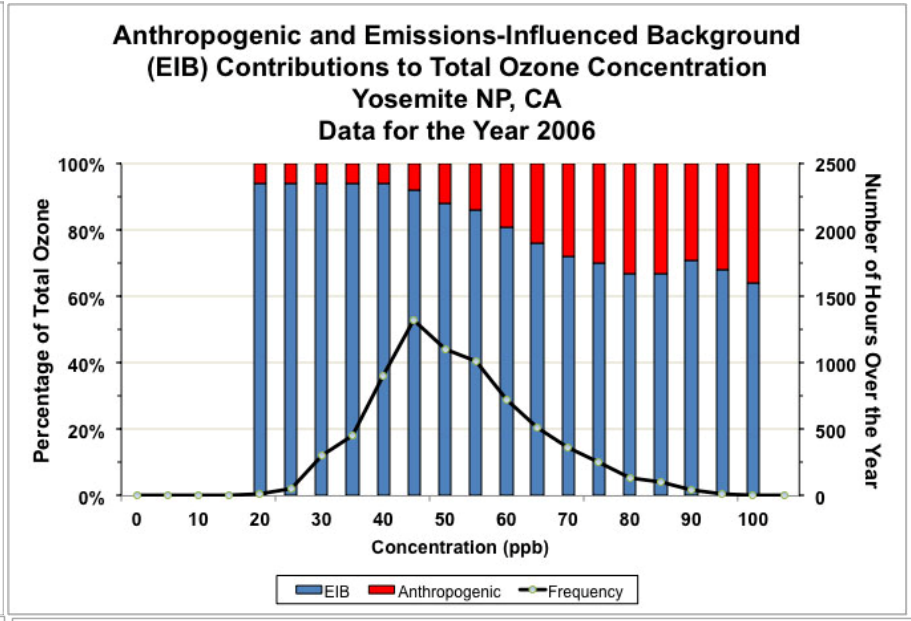

Anthropogenic and Emissions-Influenced Background
(EIB) Contributions to Total Ozone Concentration
Georgia Station, GA
Data for the Year 2006
Percentage of Total Ozone
Number of Hours Over the Year
Concentration (ppb)
EIB
Anthropogenic
Frequency

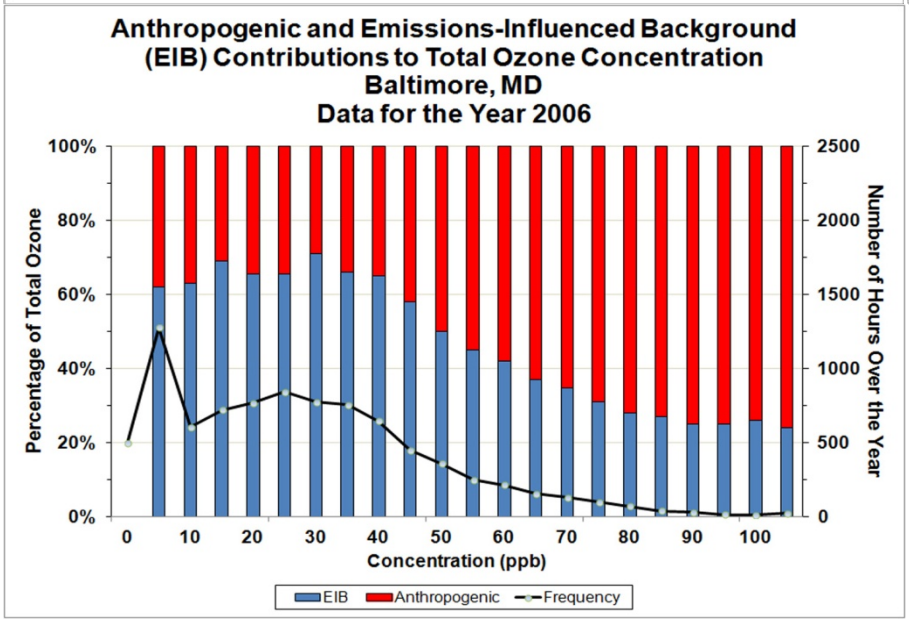

Anthropogenic and Emissions-Influenced Background
(EIB) Contributions to Total Ozone Concentration
Gothic, CO
Data for the Year 2006
Percentage of Total Ozone
Number of Hours Over the Year
Concentration (ppb)
EIB
Anthropogenic
Frequency

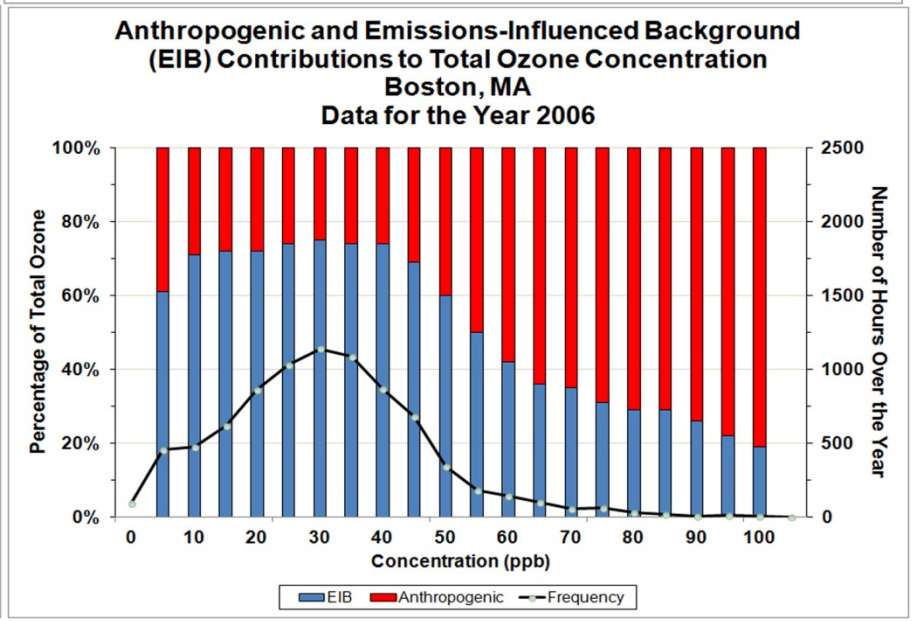

Anthropogenic and Emissions-Influenced Background
(EIB) Contributions to Total Ozone Concentration
Pinedale, WY
Data for the Year 2006
Percentage of Total Ozone
Number of Hours Over the Year
Concentration (ppb)
EIB
Anthropogenic
Frequency

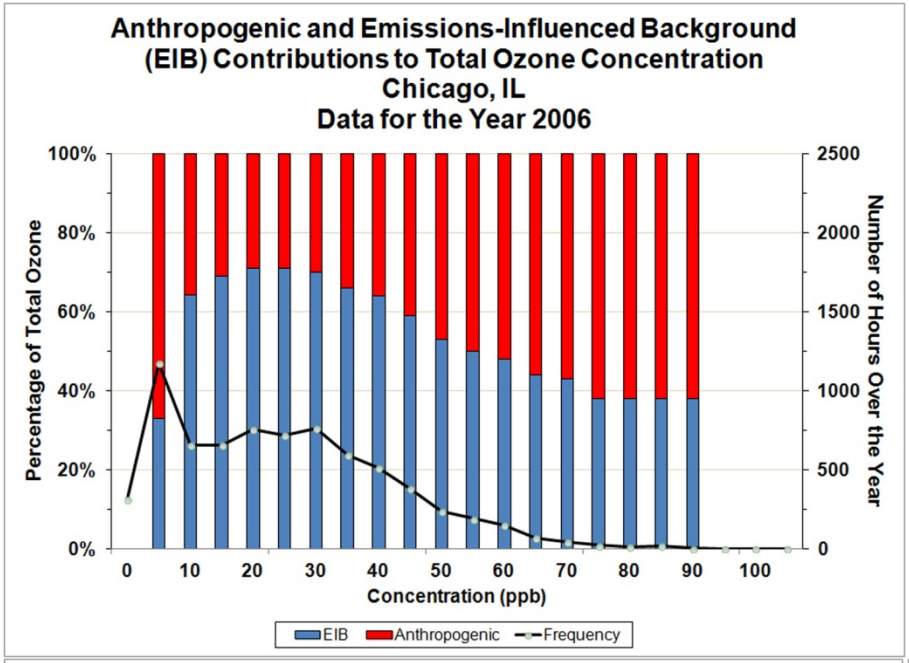

Anthropogenic and Emissions-Influenced Background
(EIB) Contributions to Total Ozone Concentration
Shenandoah NP, VA
Data for the Year 2006
Percentage of Total Ozone
Number of Hours Over the Year
Concentration (ppb)
EIB
Anthropogenic
Frequency

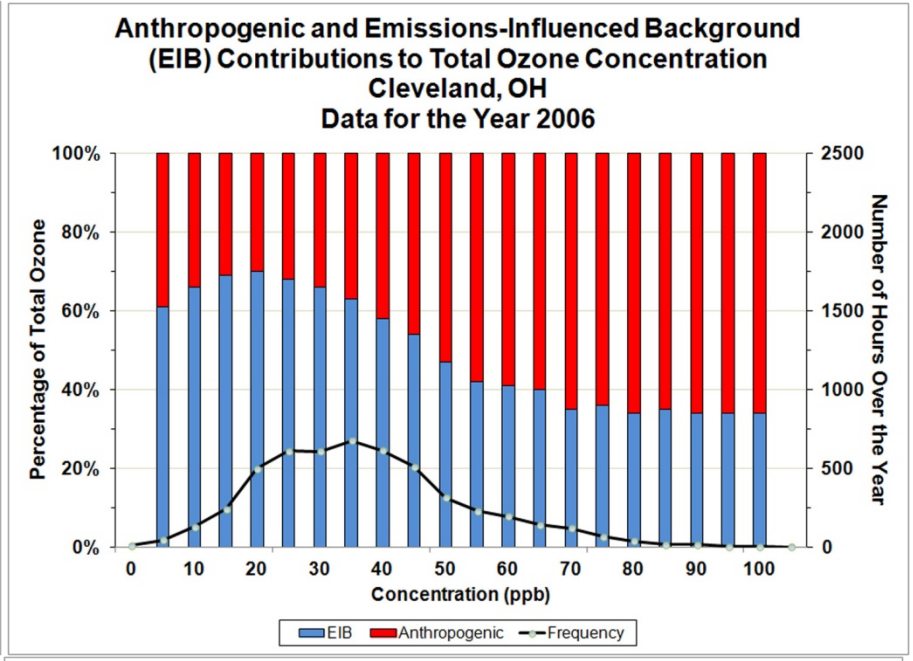

Anthropogenic and Emissions-Influenced Background
(EIB) Contributions to Total Ozone Concentration
Voyageurs NP, MN
Data for the Year 2006
Percentage of Total Ozone
Number of Hours Over the Year
Concentration (ppb)
EIB
Anthropogenic
Frequency

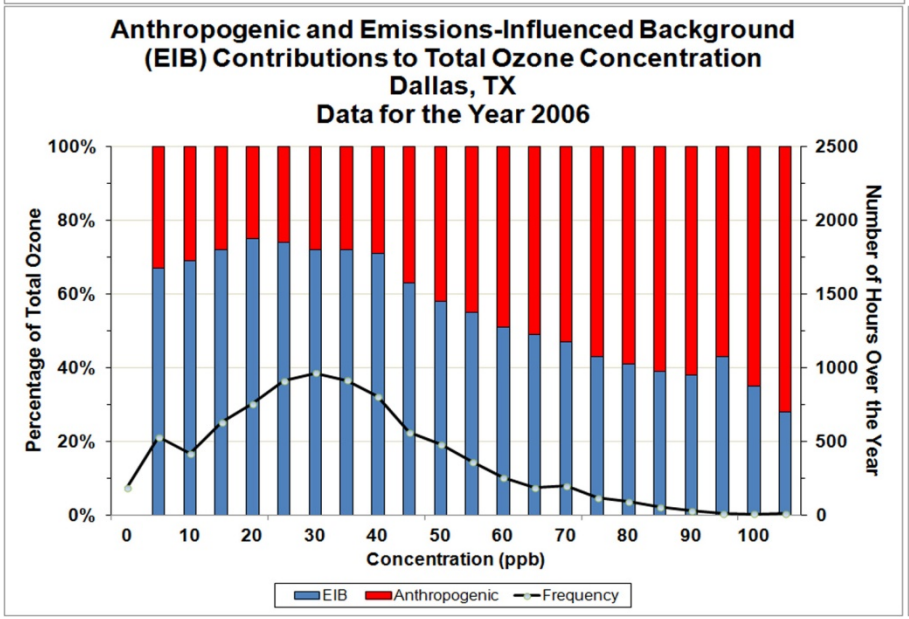

Anthropogenic and Emissions-Influenced Background
(EIB) Contributions to Total Ozone Concentration
Yosemite NP, CA
Data for the Year 2006
Percentage of Total Ozone
Number of Hours Over the Year
Concentration (ppb)
EIB
Anthropogenic
Frequency

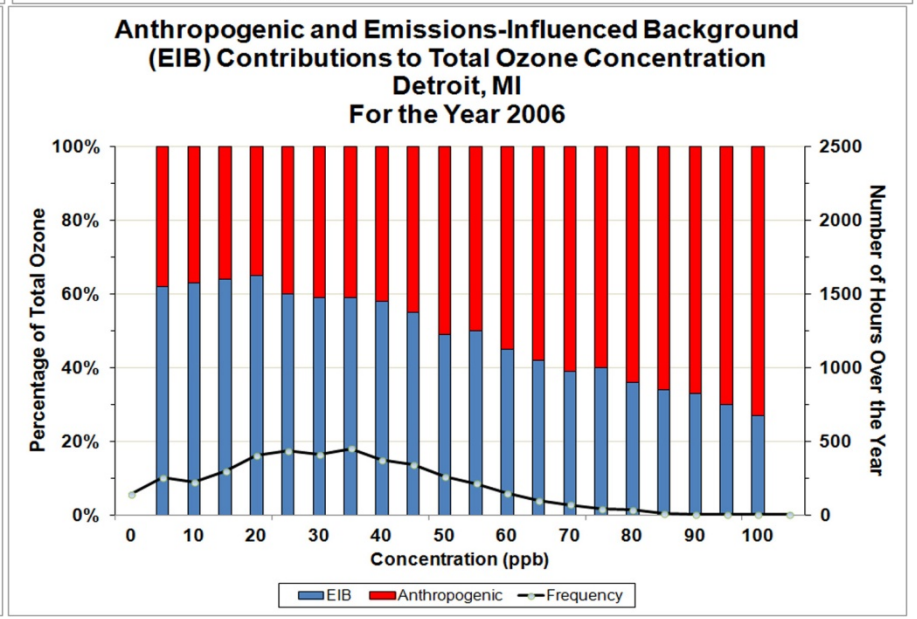

Anthropogenic and Emissions-Influenced Background
(EIB) Contributions to Total Ozone Concentration
Baltimore, MD
Data for the Year 2006
Percentage of Total Ozone
Number of Hours Over the Year
Concentration (ppb)
EIB
Anthropogenic
Frequency

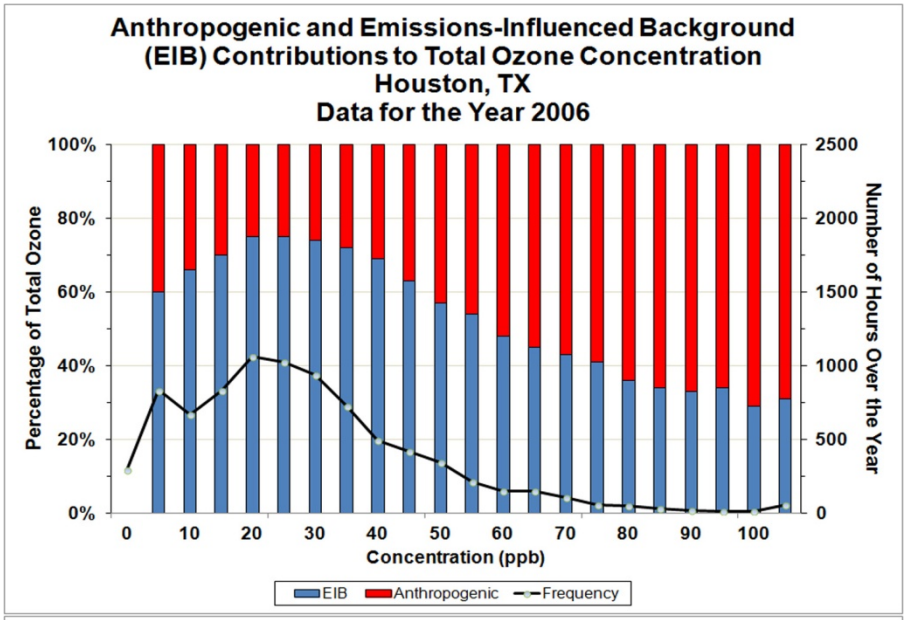

Anthropogenic and Emissions-Influenced Background
(EIB) Contributions to Total Ozone Concentration
Boston, MA
Data for the Year 2006
Percentage of Total Ozone
Number of Hours Over the Year
Concentration (ppb)
EIB
Anthropogenic
Frequency

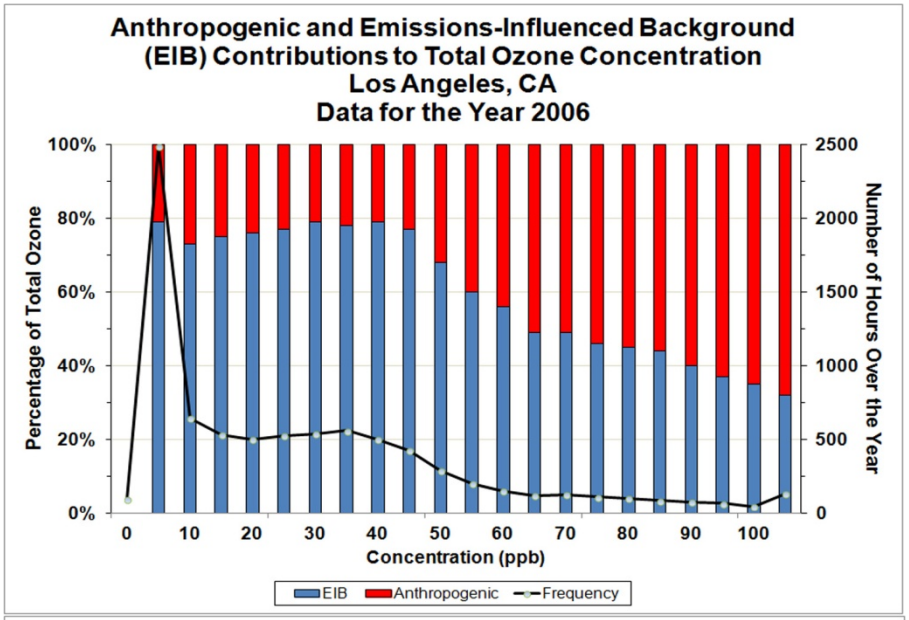

Anthropogenic and Emissions-Influenced Background
(EIB) Contributions to Total Ozone Concentration
Chicago, IL
Data for the Year 2006
Percentage of Total Ozone
Number of Hours Over the Year
Concentration (ppb)
EIB
Anthropogenic
Frequency

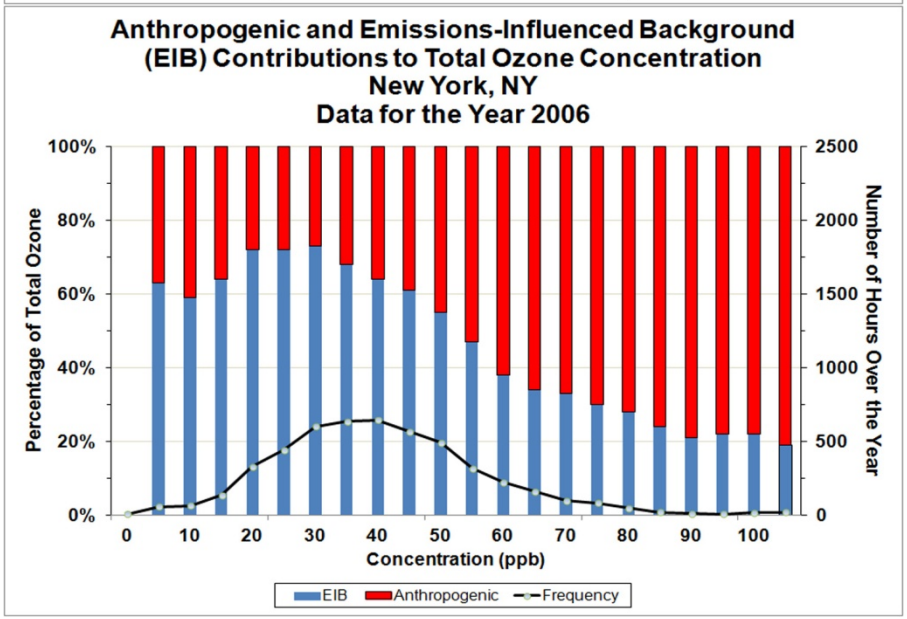

Anthropogenic and Emissions-Influenced Background
(EIB) Contributions to Total Ozone Concentration
Cleveland, OH
Data for the Year 2006
Percentage of Total Ozone
Number of Hours Over the Year
Concentration (ppb)
EIB
Anthropogenic
Frequency

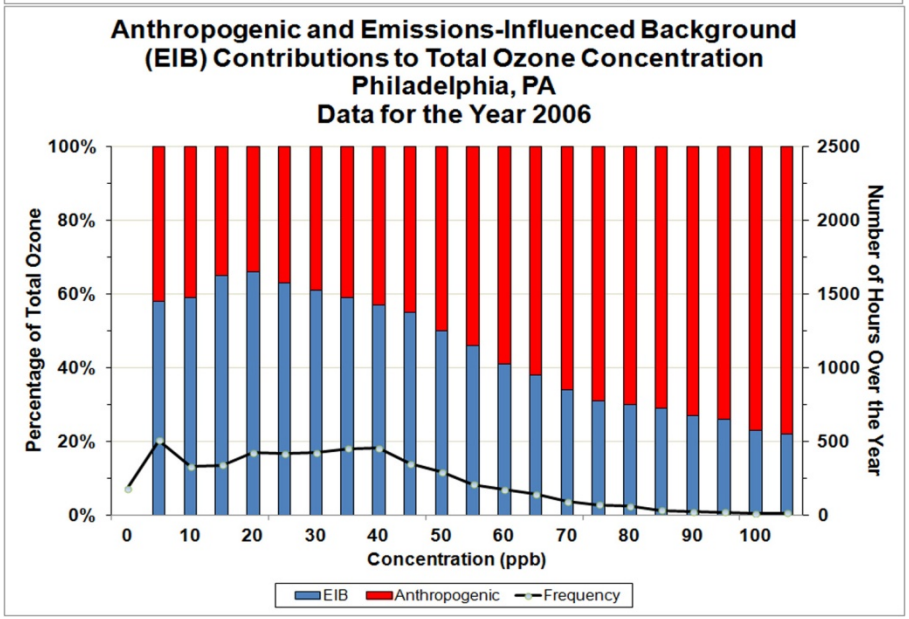

Anthropogenic and Emissions-Influenced Background
(EIB) Contributions to Total Ozone Concentration
Dallas, TX
Data for the Year 2006
Percentage of Total Ozone
Number of Hours Over the Year
Concentration (ppb)
EIB
Anthropogenic
Frequency

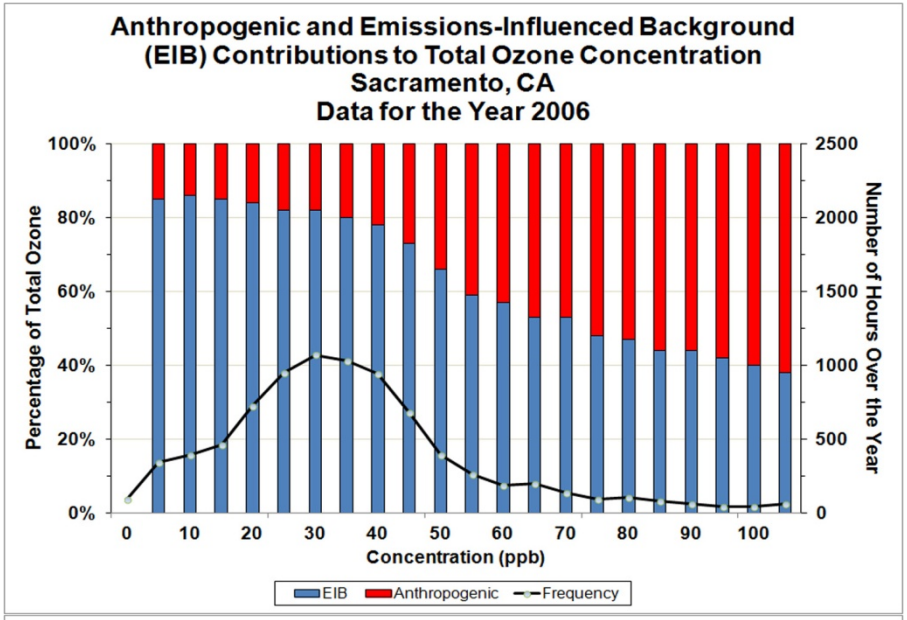

Anthropogenic and Emissions-Influenced Background
(EIB) Contributions to Total Ozone Concentration
Detroit, MI
For the Year 2006
Percentage of Total Ozone
Number of Hours Over the Year
Concentration (ppb)
EIB
Anthropogenic
Frequency

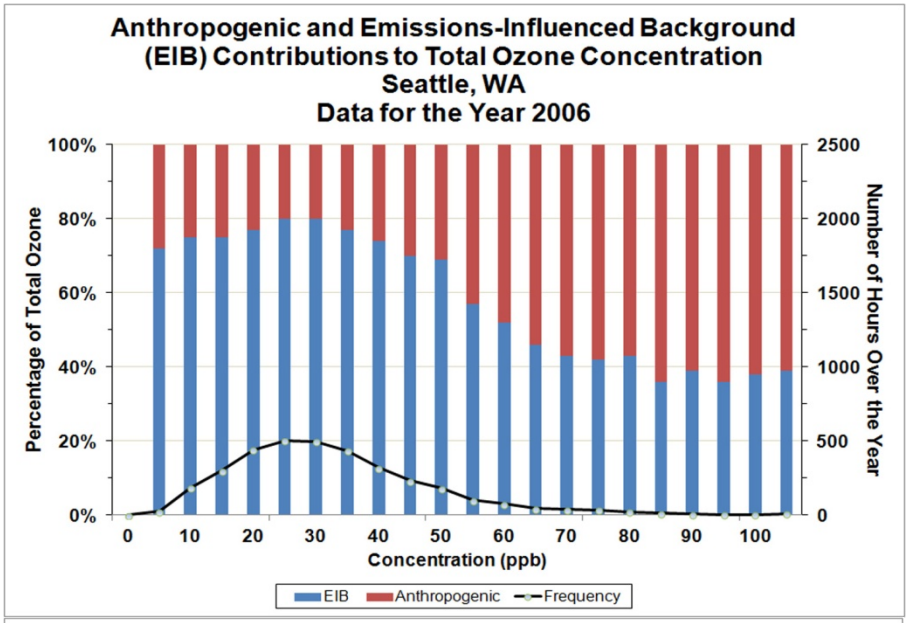

Anthropogenic and Emissions-Influenced Background
(EIB) Contributions to Total Ozone Concentration
Houston, TX
Data for the Year 2006
Percentage of Total Ozone
Number of Hours Over the Year
Concentration (ppb)
EIB
Anthropogenic
Frequency

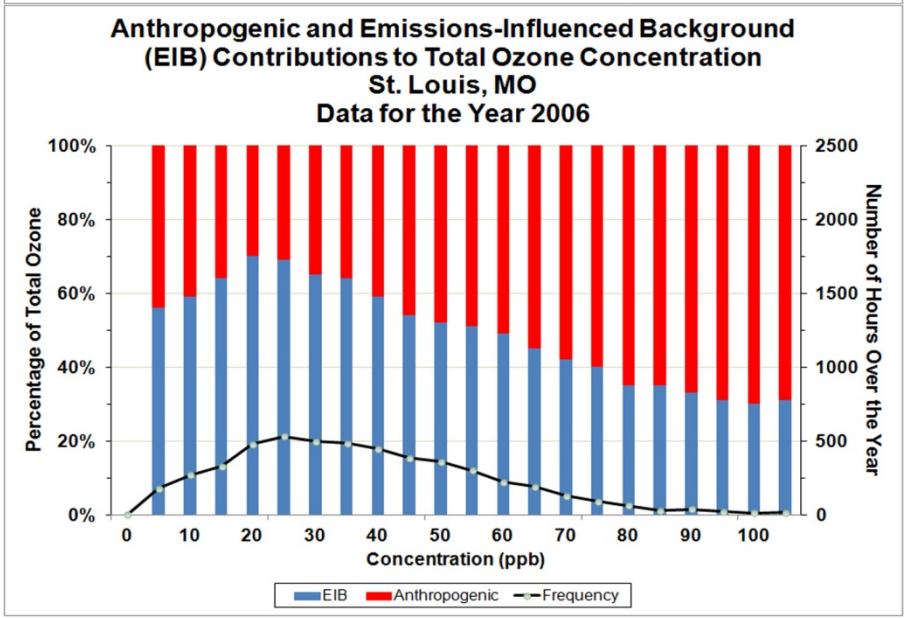

Anthropogenic and Emissions-Influenced Background
(EIB) Contributions to Total Ozone Concentration
Los Angeles, CA
Data for the Year 2006
Percentage of Total Ozone
Number of Hours Over the Year
Concentration (ppb)
EIB
Anthropogenic
Frequency

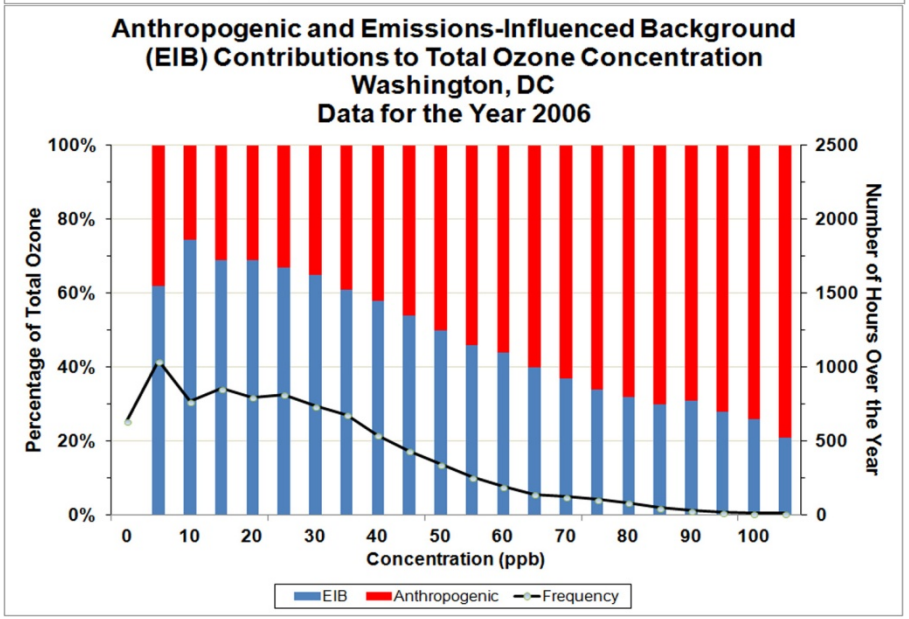

Anthropogenic and Emissions-Influenced Background
(EIB) Contributions to Total Ozone Concentration
New York, NY
Data for the Year 2006
Percentage of Total Ozone
Number of Hours Over the Year
Concentration (ppb)
EIB
Anthropogenic
Frequency

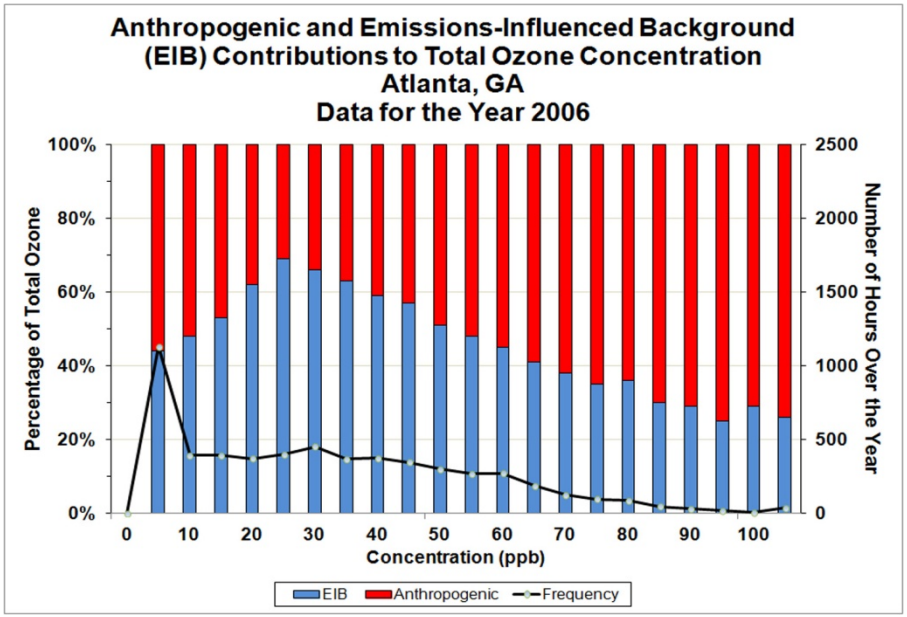

Anthropogenic and Emissions-Influenced Background
(EIB) Contributions to Total Ozone Concentration
Philadelphia, PA
Data for the Year 2006
Percentage of Total Ozone
Number of Hours Over the Year
Concentration (ppb)
EIB
Anthropogenic
Frequency

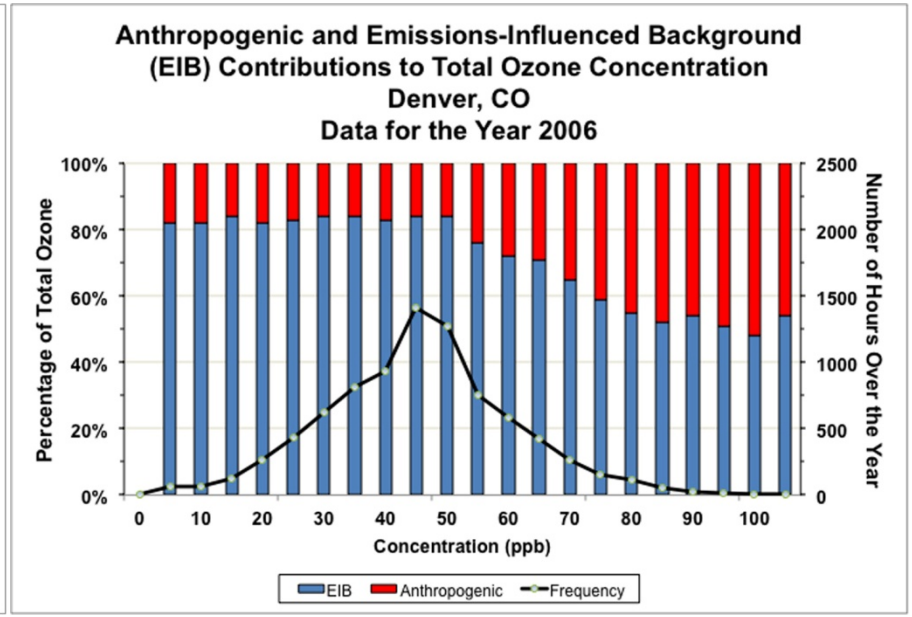

Anthropogenic and Emissions-Influenced Background
(EIB) Contributions to Total Ozone Concentration
Sacramento, CA
Data for the Year 2006
Percentage of Total Ozone
Number of Hours Over the Year
Concentration (ppb)
EIB
Anthropogenic
Frequency


Anthropogenic and Emissions-Influenced Background
(EIB) Contributions to Total Ozone Concentration
Seattle, WA
Data for the Year 2006
Percentage of Total Ozone
Number of Hours Over the Year
Concentration (ppb)
EIB
Anthropogenic
Frequency


Anthropogenic and Emissions-Influenced Background
(EIB) Contributions to Total Ozone Concentration
St. Louis, MO
Data for the Year 2006
Percentage of Total Ozone
Number of Hours Over the Year
Concentration (ppb)
EIB
Anthropogenic
Frequency


Anthropogenic and Emissions-Influenced Background
(EIB) Contributions to Total Ozone Concentration
Washington, DC
Data for the Year 2006
Percentage of Total Ozone
Number of Hours Over the Year
Concentration (ppb)
EIB
Anthropogenic
Frequency





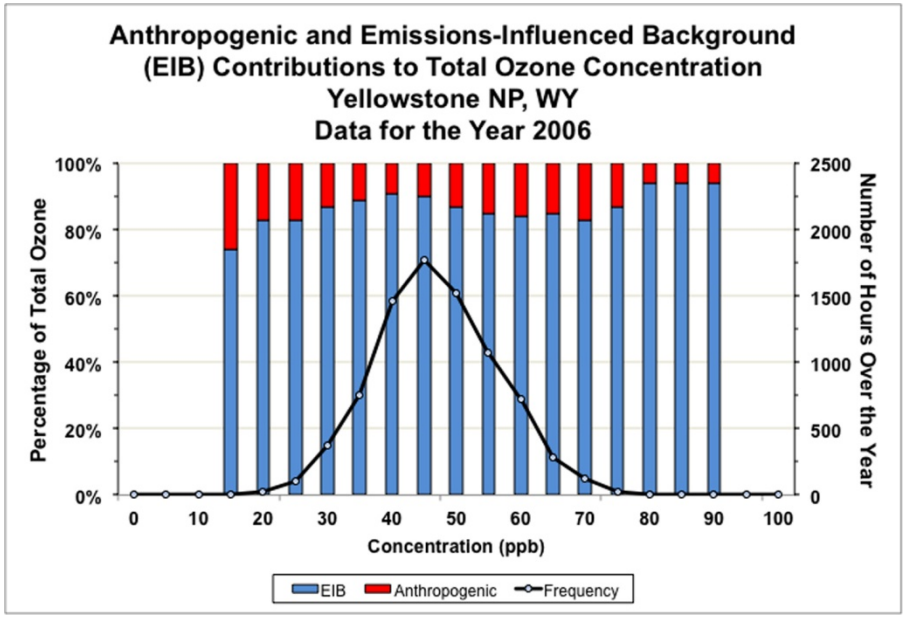


Fig. S1. Binned (5 ppb) frequency distribution of observed hourly total O_3 (black curve; right axis) and average relative binned contributions of hourly maximum EIB and anthropogenic O_3 (bars; left axis) for all other sites analyzed. (Source: Lefohn et al. (2014a).