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OFFICE OF
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MEMORANDUM

SUBJECT: Regional and Seasonal Analysis of North American Background Ozone Estimates from Two Studies

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TO: Ozone NAAQS Review Docket EPA-HQ-OAR-2012-0699

In developing the Policy Assessment document for the Ozone NAAQS review (US EPA, 2012a), EPA is distinguishing between ozone formed from sources that could be controlled through U.S. regulations or through international agreements with neighboring countries and ozone that is not controllable through such a process. The latter is referred to as North American Background ozone (NAB) which is defined as the estimated distribution of ozone concentrations that would be observed in the U.S. in the absence of North American (i.e., U.S., Canada, and Mexico) anthropogenic emissions. Literature estimates of background ozone were extensively reviewed in the ozone Integrated Science Assessment (ISA, US EPA, 2012b). Background ozone, as defined above, cannot be directly measured in the ambient atmosphere. Therefore, the ISA examined simulated ozone from global and regional chemical transport model applications as an appropriate approach for characterizing background ozone concentrations. The most recent simulations of background ozone in the scientific literature (Zhang et al., 2011; Emery et al., 2012) used the zero-out methodology to estimate the contribution of NAB to total ozone concentrations. In this memo, we extend the results of the analyses reported in Zhang et al., 2011 and in Emery et al., 2012 by examining the seasonal and regional characteristics of NAB from their model simulations in relation to total ozone concentrations. The purpose of this analysis is to quantify the distribution of NAB as a function of increasing total ozone concentration and compare these distributions by region for the spring and summer.

For a given region, NAB is predicted to be higher in the spring compared to the summer. In terms of regional differences, NAB is higher in the West than in the North Central, Northeast, Southeast, and California. Of all the regions, the lowest concentrations of NAB are predicted in the Northeast. In general, for both modeling systems NAB increases with increasing total ozone up to maximum daily average 8-hour (MDA8) ozone values of approximately 55 to 60 ppb for all regions. Above this

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concentration level, NAB does not vary significantly with increasing MDA8 ozone concentration. Because of this behavior, the relative “contribution” of NAB to total ozone decreases with increasing concentration.

Attachment

Attachment
Regional and Seasonal Analysis of North American Background Ozone Estimates from Two Studies

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1. Introduction

Ground level ozone is an air quality pollutant that is primarily formed from chemical precursors emitted from anthropogenic and natural sources. An additional fraction of ground level ozone is transported from the stratosphere during certain episodic meteorological events. While it has a relatively short lifetime in the atmosphere compared to some pollutants like methane, ozone formed from anthropogenic and natural sources can be transported on local, regional, and intercontinental spatial scales. As such, national ozone exposure is a function of both local precursor emissions and transported ozone from multiple upwind sources. In developing the Policy Assessment document for the Ozone NAAQS review (US EPA, 2012a), EPA is distinguishing between ozone formed from sources that could be controlled through U.S. regulations or through international agreements with neighboring countries and ozone that is not controllable through such a process. The latter is referred to as North American Background ozone (NAB) which is defined as the estimated distribution of ozone concentrations that would be observed in the U.S. in the absence of North American (i.e., U.S., Canada, and Mexico) anthropogenic emissions. NAB includes ozone formed from anthropogenic sources outside of North America as well as natural ozone both within and outside of North America. In this manner, natural ozone includes ozone formed from emissions from wild fires, lightning, soil, and biogenic sources and ozone from stratospheric intrusions. Literature estimates of background ozone were extensively reviewed in the ozone Integrated Science Assessment (ISA, US EPA, 2012b). Background ozone, as defined above, cannot be directly measured in the ambient atmosphere. Therefore, the ISA examined simulated ozone from global and regional chemical transport model applications as an appropriate approach for characterizing background ozone concentrations.

The most recent simulations of background ozone in the scientific literature (Zhang et al., 2011; Emery et al., 2012) used the zero-out methodology to estimate the contribution of NAB to total ozone concentrations. By modeling ozone concentrations after eliminating North American anthropogenic emissions (NA), the zero-out simulations provide estimates of NAB contributions. Under this methodology, the total ozone concentration is apportioned between ozone produced from North American anthropogenic emissions and NAB. However, because of non-linear chemical interactions between North American anthropogenic emissions and sources of NAB, simulating NAB in isolation, as is the case with the zero-out approach, will not properly capture the contribution of NAB to total ozone under some chemical regimes. For example, in locations near sources of high anthropogenic nitrogen oxide (NOx) emissions, total ozone may, at times, be locally suppressed due to titration of ozone by nitrogen oxides. During these conditions, total ozone would not be the sum of NA and NAB estimated by zero-out modeling.

The analyses by Zhang and by Emery evaluated maximum daily average 8-hour ozone (MDA8) NAB during spring and summer at the location of selected rural monitoring sites in the U.S. We have extended the results of analyses reported in Zhang et al., 2011 and in Emery et al., 2012 by examining the seasonal and regional characteristics of NAB from their model simulations in relation to total ozone concentrations. The purpose of this analysis is to quantify the distribution of NAB as a function of increasing total ozone concentration and compare these distributions by region for the spring and summer.

2. Methods

The methodology for this analysis is presented in three sections. The first section provides a summary of simulations used in this analysis. The second section focuses on the methods used to calculate MDA8 concentrations. The third section defines the regional and temporal categories.

2.1 Simulations

As indicated above, the analyses reported in this memorandum rely upon the underlying data from simulations of total ozone and NAB, as published by Zhang et al. (2011) and Emery et al. (2012). The study by Zhang et al. (2011) used the GEOS-Chem model (Bey et. al., 2001 and Yantosca, 2004) and the study by Emery used the CAMx model (Environ, 2010). Both of these studies employed a coarsely resolved global simulation at 2 by 2.5 degrees (e.g., Zhang et al., 2011) to provide boundary concentrations for more finely resolved "national scale" simulations covering the lower 48 states and adjacent portions of Canada and Mexico. The national scale GEOS-Chem modeling by Zhang et al. (2011) was performed with a grid resolution of 0.5 x 0.667 degrees (~50 km), whereas the grid resolution of the CAMx modeling by Emery et al. (2012) was performed at a resolution of 12 x 12 km. Both studies independently simulated a full year for 2006 and relied upon the 2005 National Emission Inventory grown to 2006 for U.S. anthropogenic emissions. The natural emissions modeled included soil NO_x, biogenic volatile organic compounds (VOCs), lightning NOx, and NOx and VOCs from wild and prescribed fires. As summarized below, important differences between the studies exist for fires and lightning.

Emery et al. (2012) used day-specific fire emission estimates from the SmartFire system (Raffuse et al., 2007), while Zhang et al. (2011) used monthly average estimates. The day-specific emissions were more variable in space and time and produced higher peak ozone concentrations compared to the monthly average estimates. However, the magnitude of ozone predicted from the day-specific fires is likely to be an over-estimate of actual ozone due to certain limitations in the characterization of an important feedback from the impact of smoke from fires on actinic flux in the model. Fires produce smoke which should, therefore, reduce actinic flux available for ozone chemistry. However, this feedback of smoke on actinic flux, which has been found to be important to ozone formation near fires (Real et al., 2007; Mathur et al., 2008), was not included in the CAMx modeling,

Differences in lightning NOx emissions also exist between the GEOS-Chem and CAMx modeling systems, but the impacts of these differences on predicted ozone are unclear. Zhang et al. (2011) and Emery et al. (2012) horizontally distributed annual estimates of lightning NOx based on simulated meteorology. However, the approach for vertically distributing lightning NOx emissions was quite different in the two studies. Zhang et al. (2011) followed the approach by Pickering et al. (1997), which relies upon a concave vertical profile that allocates most of the NOx to the upper troposphere with only a relatively small amount near the surface. Emery et al. (2012) followed Koo et al. (2010), which uses a convex vertical profile that allocates most of the lightning NOx near the surface or just above the planetary boundary layer. The approach in Emery et al. (2012) likely resulted in a greater amount of lightning NOx available for ozone production in the lower portion of the boundary layer near the ground.

2.2 Calculation of Maximum Daily Average 8-Hour Ozone

For regulatory purposes, the MDA8 metric is calculated in two discrete steps. The first step includes creating a running average of ozone mixing ratios (ppm or ppb) for 8 consecutive hours assigning the average concentration to the first hour in the averaging time period. The second step is to determine the maximum 8-hour average value within each day which is, therefore, the value of MDA8. MDA8 values for total ozone and for NAB were calculated in each grid cell from both the GEOS-Chem and CAMx simulations.

The gridded MDA8 values of NAB and total ozone were mapped to the location of the Air Quality System (AQS) and the Clean Air Status and Trends Network (CASTNet) ozone monitoring sites nationwide and the location of four special study monitoring sites operated by the National Oceanic and Atmospheric Administration (NOAA). The model-predicted MDA8 values for the location of AQS, CASTNet and NOAA sites comprise the data set of NAB and total ozone used for this analysis.

2.3 Regional and Seasonal Aggregations

The conceptual model for the sources and processes affecting ozone levels varies by region and season. Ozone formation efficiency decreases in winter compared to summer because of lower temperatures and actinic fluxes. Ozone produced from lighting emissions and stratospheric intrusion events (STE) vary by region. Lightning NO_x emissions are known to be more active in the Southeast where convection is active, biogenic organics are plentiful, and anthropogenic NO_x is relatively scarce (e.g., Hagerman et al., 1997). Stratospheric intrusions are known to be more active at high elevation that is more commonly found in the West (e.g., Fiore, 2003). These are a few of the processes that lead to regional and seasonal differences in background ozone and total ozone.

To examine the extent of regional differences in NAB we have divided the county into five distinct regions. The five regions, shown in **Figure 2-1**, are based on previous definitions (e.g., ISA 2012) that segment the country into California, West (except for California), North Central, Northeast, and Southeast. An extra set of categories was created for the West, which includes low (i.e., <1500 m) and high elevation sites. The gridded data paired to the location of ozone monitoring sites, as described above (i.e., >1500 m), were aggregated by region based on the location of the grid cell center. For each region we aggregated the data temporally by season. Because both total ozone and NAB are higher in the spring and summer, compared to the fall and winter, our analysis focuses on NAB predictions during the spring and summer seasons only. The spring/summer divide is generally based on traditional definitions with a small change. The traditional definitions use March-April-May for spring and June-July-August for summer. Visual inspection of the modeled data reveals, however, that the last 5 days of May have variability in NAB and total ozone more characteristic of summer. In order to avoid any influence of predictions on these five more summer-like days on the distribution of ozone for the spring we did not include the data for these days in this analysis.

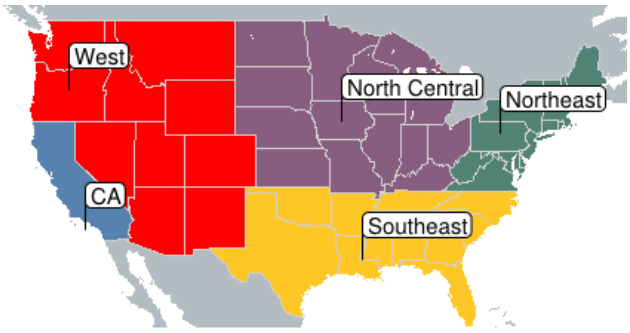

Figure 2-1. Regions used in this analysis: California (blue), West (red), Southeast (yellow), North Central (purple), Northeast (green).

3. Characterization of North American Background

In this section we characterize NAB concentrations relative to total ozone. As described above in section 2, MDA8 NAB and MDA8 total ozone were estimated independently for the location of monitoring sites in each region from both the GEOS-Chem and CAMx modeling systems. To reveal the relationships between NAB and total ozone, NAB was plotted as a function of total ozone for each of the region/season[1]. In addition, for the West region, we also compare NAB to total ozone for the location of low elevation versus high elevation monitoring sites. Total ozone is grouped into 5 ppb bins and the distribution of NAB for each total ozone bin is shown as a boxplot. Boxplots for each region/season are provided in section 6 as **Figure 6-1**, **Figure 6-2**, **Figure 6-3**, **Figure 6-4**, **Figure 6-5**, and **Figure 6-6**. Note that the median values for each bin along with the values for the minimum, maximum, 5th, 25th, 75th, and 95th percentiles are provided in Table 6-1 for each region/season and for each modeling system. **Table 6-1** also provides the distribution of NAB above several cut-points: 55, 60, 65, 70, and 75 ppb. In the figures and tables "MAMC" is used to denote March, April, May (i.e., spring, excluding the last 5 days in May) and "JJA" is used to denote June, July, August (i.e., summer).

For this analysis we focus on the characteristics of NAB using median values, but present data for other parts of the distribution as contextual information. The median provides a more robust indicator than the extremes of the distribution for the purpose of examining and comparing the regional and seasonal variability in NAB. The NAB predictions at the higher and lower ends of the distribution are more reflective of infrequent or perhaps atypical events. In addition, due to the overall uncertainties and assumptions in the inputs to the two modeling systems, the more extreme NAB predictions are likely to have a greater degree of uncertainty than the median values.

In the remainder of this section we describe the general regional and seasonal patterns of NAB based on the median values. We then compare the median NAB concentrations to the corresponding 75th and 95th percentile values in each region for spring and for summer days with predicted MDA8 total ozone

[1] Initially, NAB was separated into "urban" and "non-urban" categories depending on the location of the corresponding monitoring site. Sites within a Combined Statistical Area (CSAs) were considered as "urban" and sites outside of a CSA were considered as "non-urban Sites". However, we found that there is relatively little overall difference in the relationship between NAB and total ozone at "urban" versus "non-urban" locations within a given region/season. The within region differences are more subtle than the variability between regions. Thus, we have combined the data at "urban" and "non-urban" locations and examine NAB by region/season in this analysis.

above 55 ppb. This is discussion is followed by an examination of similarities and differences in NAB predicted by the GEOS-Chem and CAMx modeling systems.

3.1 General Regional and Seasonal Patterns of NAB

Figure 3-1, **Figure 3-2**, and **Figure 3-3** (provided at the end of this section) show the median NAB concentration for each region and season within each 5 ppb total ozone bin from each model. These plots show that, in general for both modeling systems, NAB increases with increasing total ozone up to MDA8 values of approximately 55 to 60 ppb for all regions. Above this concentration level, NAB does not vary significantly across the 5 ppb bins between 55-135 ppb during both the spring and summer. Because of this behavior, the relative "contribution" of NAB to total ozone decreases with increasing concentration, as illustrated in **Figure 3-4**for example.

For each region, median NAB is higher in the spring compared to the summer. Within a given region, the largest variations between seasons in NAB appear to be predicted when total ozone concentrations are below 55 to 60 ppb. In terms of regional differences, NAB is higher in the West than in the North Central, Northeast, Southeast, and California. Of all the regions, the lowest concentrations of NAB are predicted in the Northeast.

Table 3-1 presents the modeled median, 75th percentile, and 95th percentile NAB concentrations based on the GEOS-Chem and CAMx modeling systems for days with predicted total ozone greater than or equal to 55 ppb. These data indicate that NAB concentrations are similar in the North Central region and in the Southeast. On days with predicted total ozone above 55 ppb in the spring, median NAB concentrations from GEOS-Chem and CAMx were 28 ppb and 33 ppb for the North Central region and 30 ppb and 34 ppb for the Southeast, respectively. The 75th percentile MDA8 NAB concentrations were about 4 to 5 ppb higher than the median values for the North Central region and Southeast with both models. The 95th percentile spring NAB concentrations were estimated to be 40 ppb and 42 ppb for North Central, and 41 ppb and 45 ppb for the Southeast. As noted above, NAB concentrations were lower in the summer compared to the spring. Specifically, median NAB concentrations in summer for the two models were 24 ppb and 33 ppb for the North Central region, and 29 ppb and 31 ppb for the Southeast. The corresponding 75th percentile NAB concentrations were 28 ppb and 36 ppb for the North Central region and 36 ppb and 34 ppb for the Southeast. The 95th percentile NAB concentrations were estimated to be 39 ppb and 41 ppb for North Central and 44 ppb and 41 ppb for the Southeast.

Among all the regions, the Northeast had the lowest spring and summer NAB concentrations for days when predicted total ozone was above 55 ppb. In the spring, median NAB concentrations in this region were 23 ppb and 31 ppb for CAMx and GEOS-Chem, respectively. The 75th percentile NAB concentrations were 3 ppb higher than the corresponding median values. In the spring, 95th percentile NAB concentrations were estimated to be 33 ppb and 38 ppb in this region. Summer NAB values from both GEOS-Chem and CAMx were lower than in spring with summer values of 18 ppb and 29 ppb, respectively. The summer 75th percentile NAB concentrations were 23 ppb and 32 ppb and the 95th percentile NAB concentrations were estimated to be 34 ppb and 36 ppb on days with total ozone above 55 ppb.

Table 3-1. Modeled median, 75th and 95th percentile North American Background concentrations at monitoring site locations based on GEOS-Chem and CAMx for days with total ozone >= 55 ppb.

Region		Spring (GEOS-Chem/CAMx)			Summer (GEOS-Chem/CAMx)		
		Median (ppb)	**75th percentile (ppb)**	**95th percentile (ppb)**	**Median (ppb)**	**75th percentile (ppb)**	**95th percentile (ppb)**
California		34/35	40/40	48/48	30/36	36/40	45/47
North Central		28/33	33/37	40/42	24/33	28/36	39/41
Northeast		23/31	26/34	33/38	18/29	23/32	34/36
Southeast		30/34	34/38	41/45	29/31	36/34	44/41
West*	*All sites*	44/43	47/48	52/55	41/41	46/46	54/52
	Low-elevation sites	43/41	46/44	51/51	40/39	45/44	52/52
	High-elevation sites	45/48	48/52	53/57	42/43	47/48	54/53

*Excludes sites in California.

Spring and summer median and 75th percentile NAB concentrations in California were higher than the corresponding values for the regions in the East. Median NAB for GEOS-Chem and CAMx were 34 ppb and 35 ppb in the spring, and 30 ppb and 36 ppb in the summer, respectively. The 75th percentile NAB estimates were 40 ppb in the spring, and 36 ppb and 40 ppb in the summer for the two modeling systems. The 95th percentile NAB concentrations in California were estimated to be 48 ppb in the spring and 45 ppb and 47 ppb in the summer.

In the remainder of the West, where NAB levels are greater than in California, the median predicted spring NAB estimates are 44 ppb and 43 ppb and the 75th percentile NAB estimates are of 47 ppb and 48 ppb for the two models, respectively. The spring 95th percentile NAB concentrations are 52 ppb and 55 ppb. On summer days with total ozone above 55 ppb median NAB was 41 ppb and the 75th percentile NAB concentration was 46 ppb for both models in portions of the West outside of California. For the 95th percentile, NAB concentrations were estimated to be 54 ppb and 52 ppb, from GEOS-Chem and CAMx, respectively.

As an additional analysis for the West, we examined the NAB concentrations predicted for high elevation monitoring sites (> 1500 m) versus NAB at low elevation sites (< 1500 m). Consistent with the results reported by Zhang et al., 2011 and Emery et al., 2012, NAB was higher at higher elevations, compared to NAB low-elevation locations. On days in the spring when total ozone was predicted to be above 55 ppb, median NAB from GEOS-Chem and CAMx at high-elevation locations were 45 ppb and 48 ppb, compared to 43 ppb and 41 ppb at low-elevation locations. The 75th percentile spring NAB concentrations at high-elevation and low elevation locations were 3 to 4 ppb higher than the corresponding median values. The 95th percentile spring NAB concentrations at high elevation locations were estimated to be 53 ppb and 57 ppb, compared to low elevation sites with a 95th percentile NAB

concentrations of 51 ppb. In the summer, NAB was also higher at high-elevation locations compared to NAB at low-elevations.

3.2 Comparison of NAB Predictions from CAMx and GEOS-Chem

With a few exceptions, the CAMx simulation tends to predict the same or higher NAB ozone as GEOS-Chem. In all regions, the GEOS-Chem over predictions of low total ozone coincide with lower predicted NAB concentrations and fractions. In the rest of the distribution, results are more regionally specific.

In the West, NAB predicted by the two modeling systems agrees within 3 ppb, except on the summer days with the highest predicted total ozone (see **Figure 3-1**a,b). On high total ozone days, CAMx and GEOS-Chem summer NAB concentrations diverge similar to their total concentrations. While total ozone from CAMx is higher than GEOS-Chem, the GEOS-Chem predicts higher NAB. In the 80 to 85 ppb total ozone bin, GEOS-Chem NAB is 5 ppb higher than CAMx. **Figure 3-1**c,d show that at lower total concentrations there are larger differences in NAB at high elevation than at low elevation.

In California, the largest differences in NAB between the two modeling systems occurs in the summer (see **Figure 3-2**a,b). In the summer, CAMx NAB concentrations are 4 to 9 ppb higher than those from GEOS-Chem when total ozone is at or above 50 ppb. In contrast total ozone is higher in GEOS-Chem compared to CAMx, as seen in Error! Reference source not found.**3**b. However, in the pring, the greatest difference between the two modeling systems occurs between 30 and 35 ppb total ozone and is only 3 ppb.

In the Southeast, the GEOS-Chem and CAMx NAB predictions are more similar in summer than in spring for most total ozone bins (see Figure c,d). In spring, CAMx predicts higher NAB by 3 to 6 ppb for total ozone in the range of 50 to 75 ppb. In summer, the largest model to model differences in NAB are predicted to occur between 45 and 75 ppb total ozone where GEOS-Chem is higher than CAMx by 2.5 to 3.5 ppb.

In the Northeast and North Central regions, NAB predictions are consistently higher from CAMx than from GEOS-Chem (see Figure 3-3). In the spring, CAMx NAB is 3 to 5 ppb higher in the North Central region and 5 to 8 ppb higher in the Northeast. The exception is when total ozone concentrations are between 35 and 50 ppb. In the summer, differences between the two modeling systems are larger than in the spring. Specifically, in the North Central region, CAMx NAB is 5 to 10 ppb higher than GEOS-Chem. Similarly, CAMx NAB is 4 to 12 ppb higher than GEOS-Chem in the Northeast. In the North Central region and the Northeast, the summer difference in NAB is highly correlated with model bias for total ozone.

In summary, the two models largely agree on the magnitude of NAB concentrations. In spring, only NAB concentrations in the North Central and Northeast regions differed by more than 5 ppb. In the summer, California, North Central, and the Northeast regions all had discrepancies of more than 5 ppb. In general, the CAMx model tended to produce higher North American Background values.

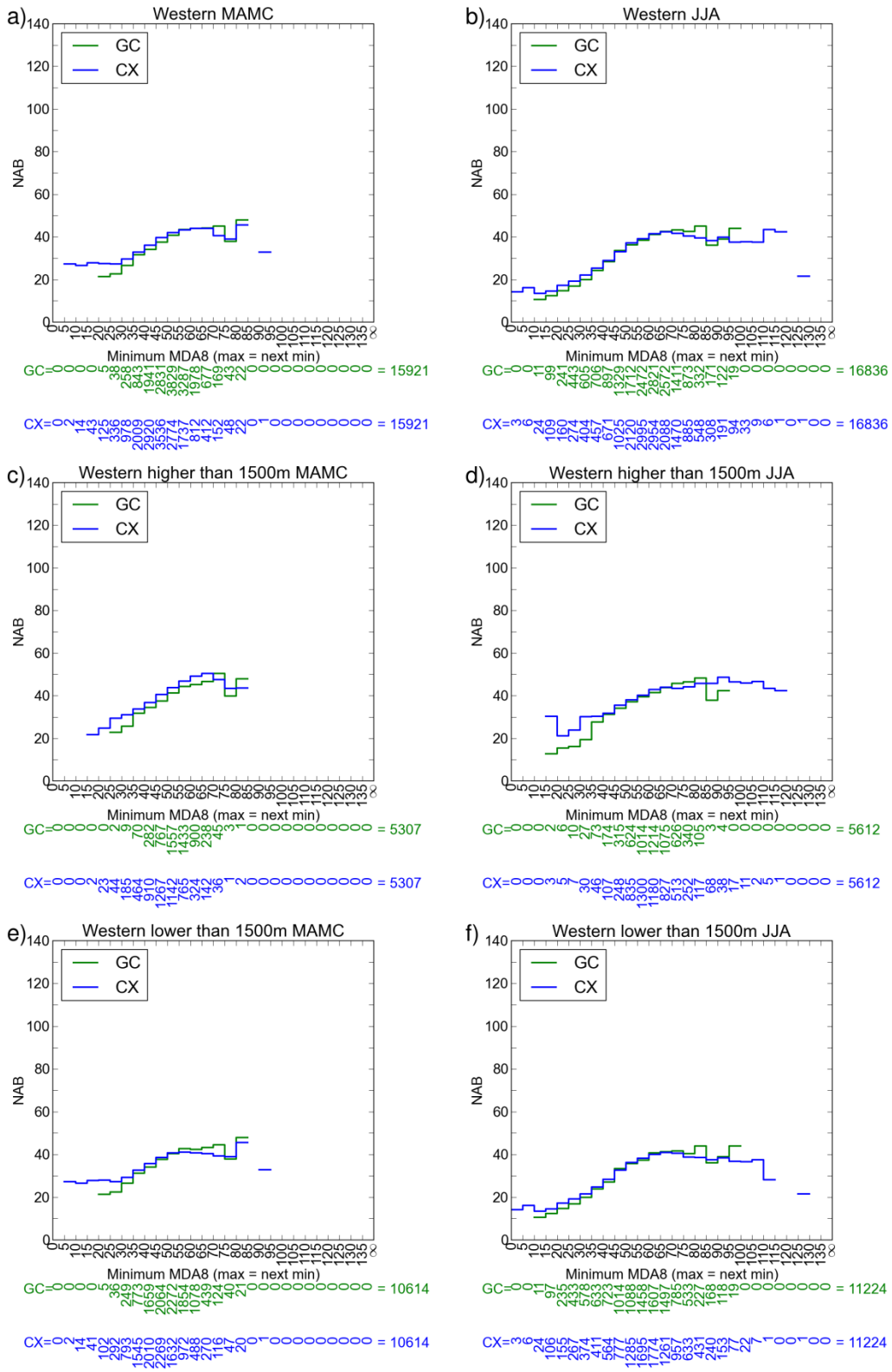

Figure 3-1. North American Background ozone plotted as a function of total simulated ozone for the West region. Median NAB for each 5 ppb bin is shown for GEOS-Chem (green) and CAMx (blue). Below the x-axis is a count of values in each bin for GEOS-Chem (top) and CAMx (bottom).

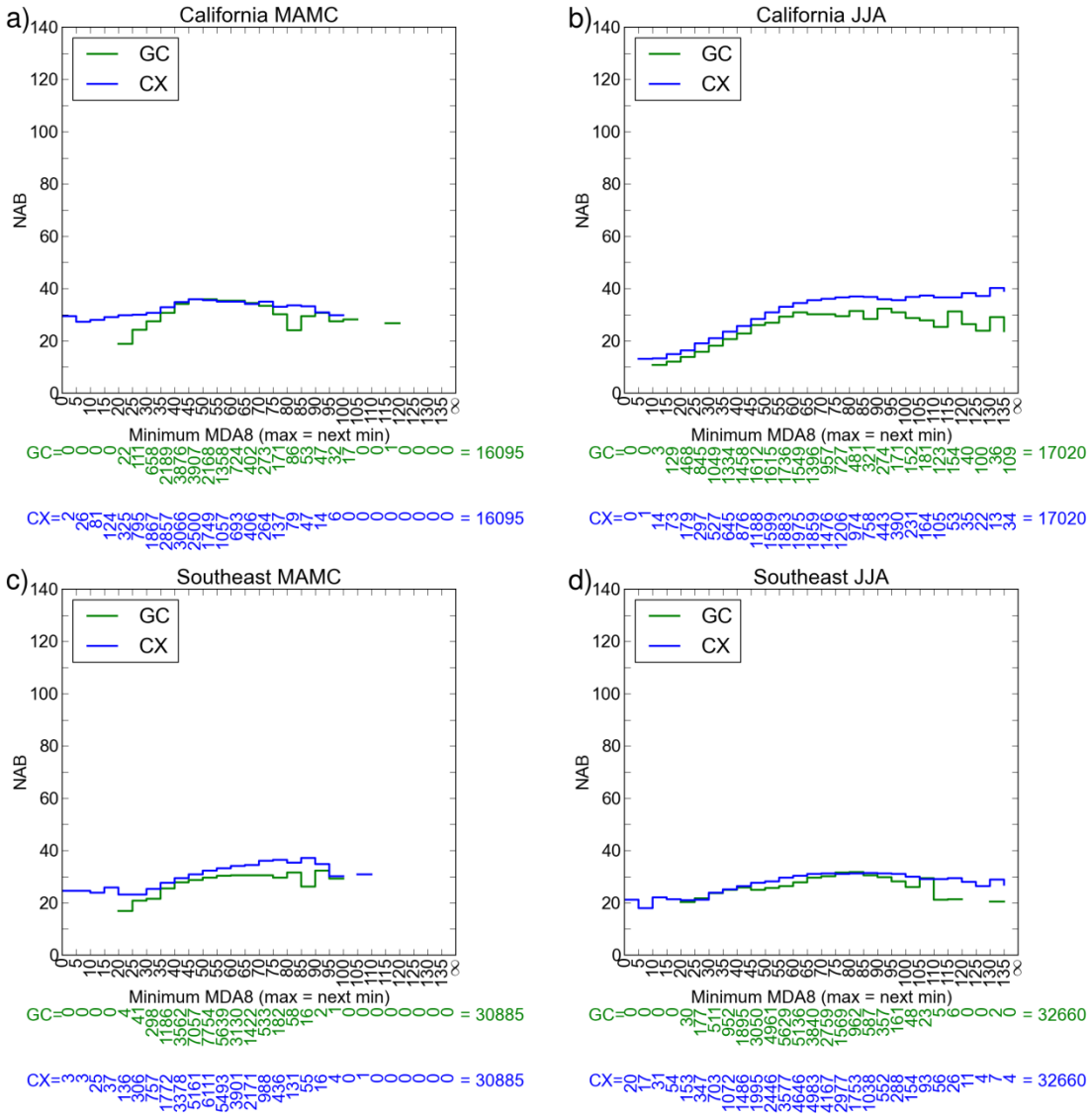

Figure 3-2. North American Background ozone plotted as a function of total simulated ozone in the Southeast and California regions. Median NAB for each 5 ppb bin is shown for GEOS-Chem (green) and CAMx (blue). Below the x-axis is a count of values in each bin for GEOS-Chem (top) and CAMx (bottom).

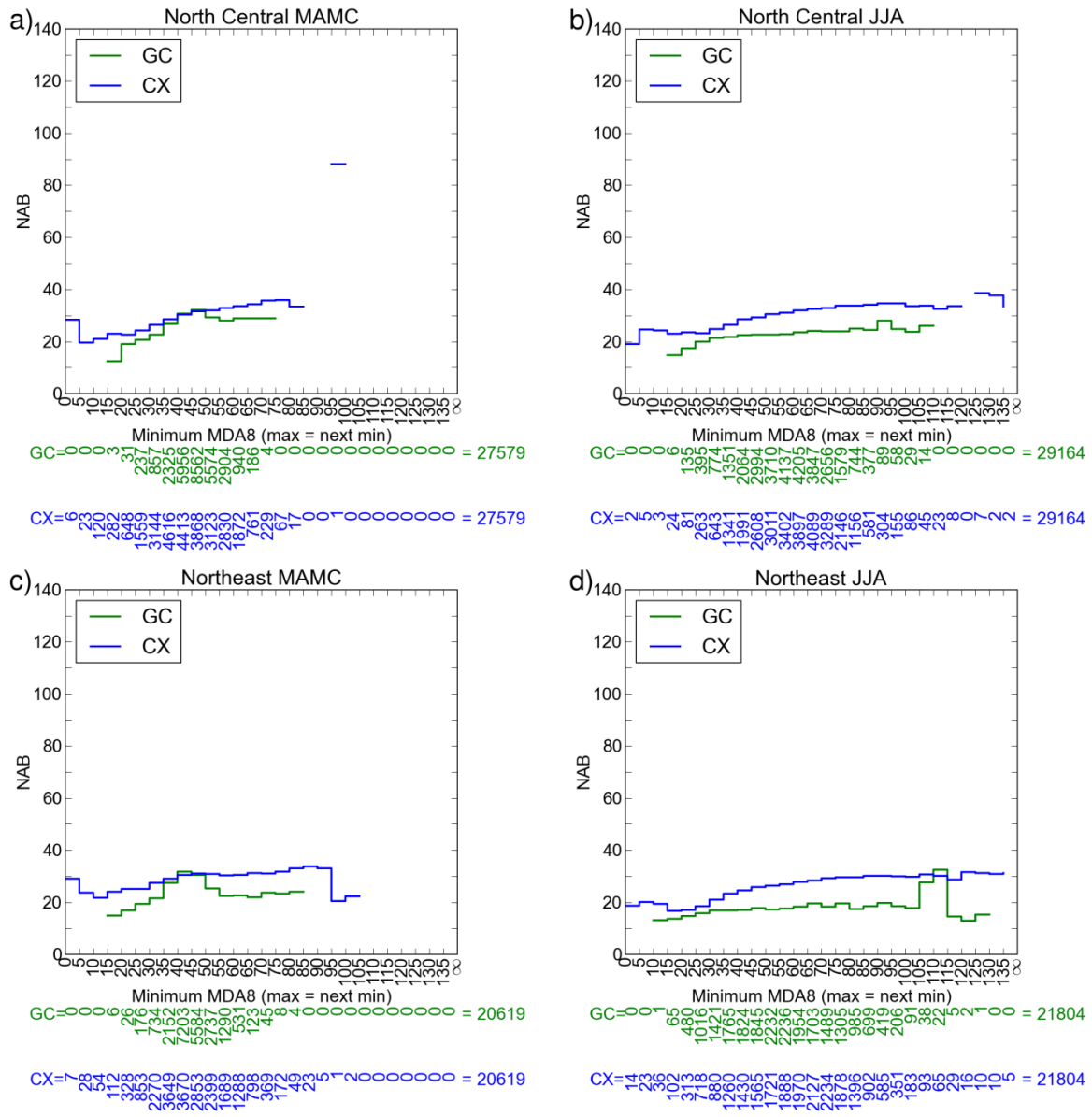

Figure 3-3. North American Background ozone plotted as a function of total simulated ozone for the North Central and Northeast regions. Median NAB for each 5 ppb bin is shown for GEOS-Chem (green) and CAMx (blue). Below the x-axis is a count of values in each bin for GEOS-Chem (top) and CAMx (bottom).

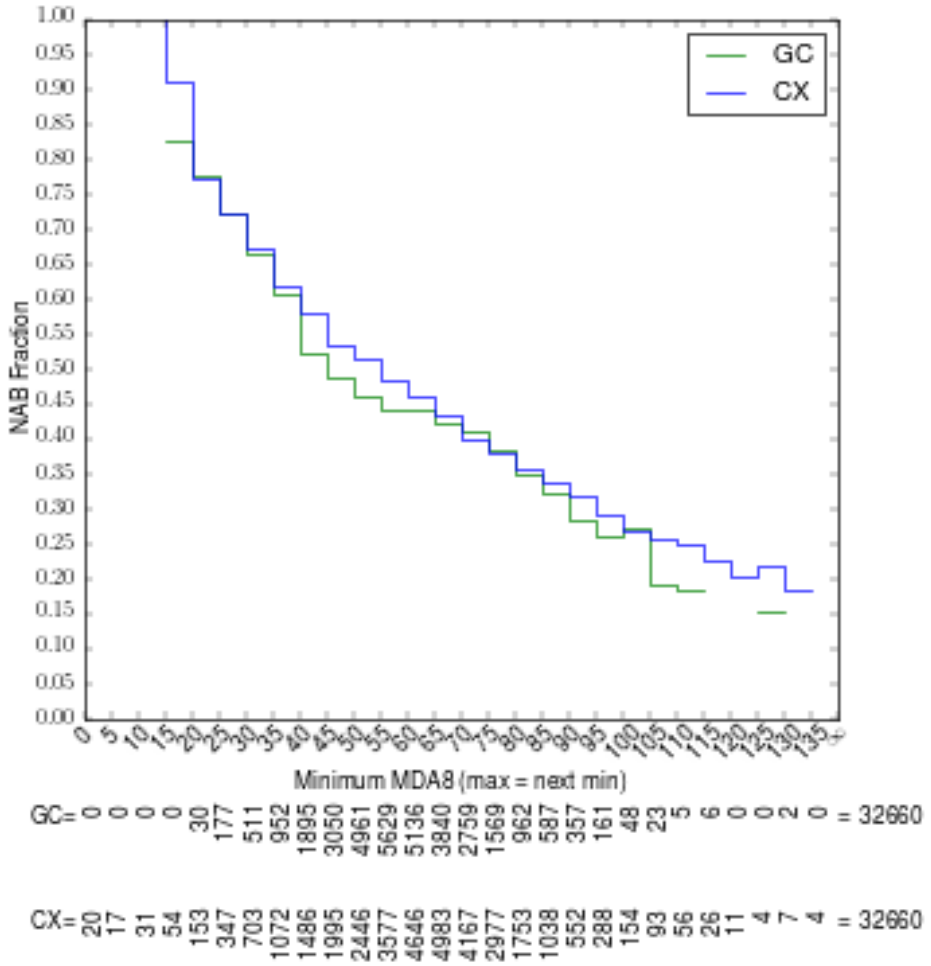

Figure 3-4. North American Background ozone plotted as a fraction of the corresponding total ozone for the Southeast region in summer. Median NAB fraction for each 5 ppb total ozone bin is shown for GEOS-Chem (green) and CAMx (blue). Below the x-axis is a count of values in each bin for GEOS-Chem (top) and CAMx (bottom).

4. Model Evaluation

This study expands upon previous evaluations in the original studies by including measured data from CASTNet and AQS monitors in each region with a break-out of performance for the spring and summer seasons. For each region and season, the evaluation is performed using time-unpaired parametric visual and statistical metrics. The visual metric shown is the quantile-quantile (QQ) plot. The QQ plot shows predicted quantile (rank ordered values) as a function of observed quantiles. The quantiles are selected based on the number of valid observations (n_o) for both observations and predictions (i.e. $q = 1/n_o, \ldots, n_o/n_o$).

The QQ plots for each region/season for each model are shown in **Figure 4-1**, **Figure 4-2**, and **Figure 4-3**. These figures indicate that both models tend to perform best in the West followed by California and the Southeast. The CAMx modeling system also performed well compared to the performance of GEOS-Chem in the North Central and Northeast regions in spring. Both models over predicted the distribution of the observed ozone in the North Central and Northeast regions in summer. In general the two models appear to agree in the middle of the distribution, but often disagree at the lower and upper-ends of the distribution. **Figure 4-1** (a,c,e), **Figure 4-2** (a,c), and **Figure 4-3** (a,c) show that there is a consistent pattern at the low end of observed distribution in the spring where GEOS-Chem predictions are consistently higher than CAMx and are high-biased compared to observations. At the high-end of the distribution, **Figure 4-1** (b,d,f), **Figure 4-2** (b), and **Figure 4-3** (b,c) show that CAMx predictions are consistently higher than GEOS-Chem and are high-biased compared to observations in summer for all regions.

There are two major exceptions to these results. The first is shown in **Figure 4-3** (a,c) where CAMx predictions in spring are closer to the distribution of observations than GEOS-Chem. The second exception is shown in **Figure 4-2** (b) for California in summer when CAMx is higher than GEOS-Chem and high-biased throughout most of the distribution, except at the high-end of the distribution where GEOS-Chem has higher total ozone than CAMx, even though CAMx is still high-biased.

In summary we found that the models agree relatively well between 30 and 90 ppb in most region/season combinations. In the spring, the performance of the two models for the North Central and Northeast regions diverges with CAMx out performing GEOS-Chem. This is an expected outcome that is likely the result of comparing larger horizontal grid cells to point observations. Similar results can be seen in the difference between the models below 30 ppb. At higher than 90 ppb, performance results were mixed depending on the season and region.

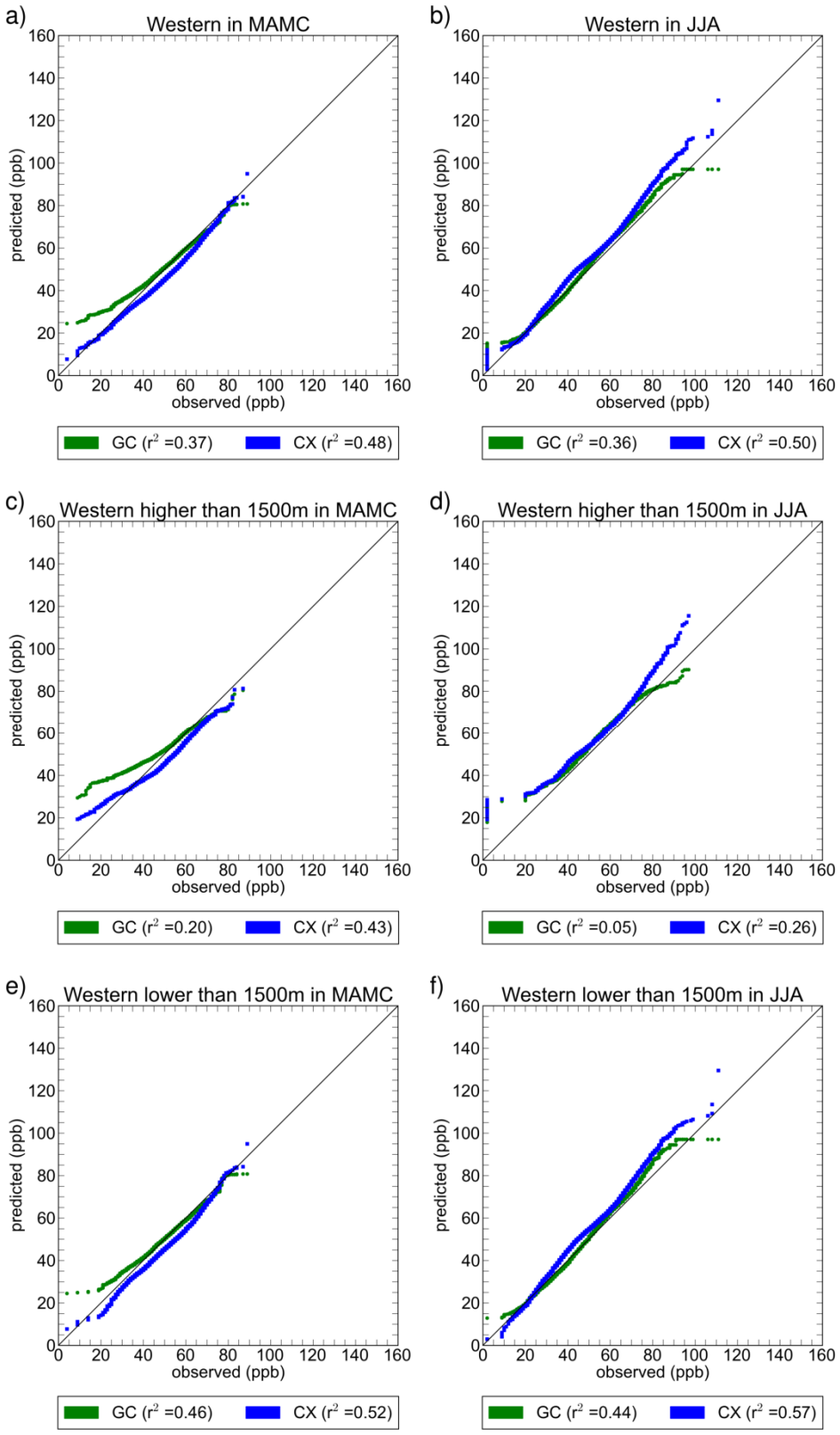

Figure 4-1. Predicted quantiles plotted as a function of the observed quantile for the West region. Each plot shows GEOS-Chem (green) and CAMx (blue) predictions and Pearson r-squared values.

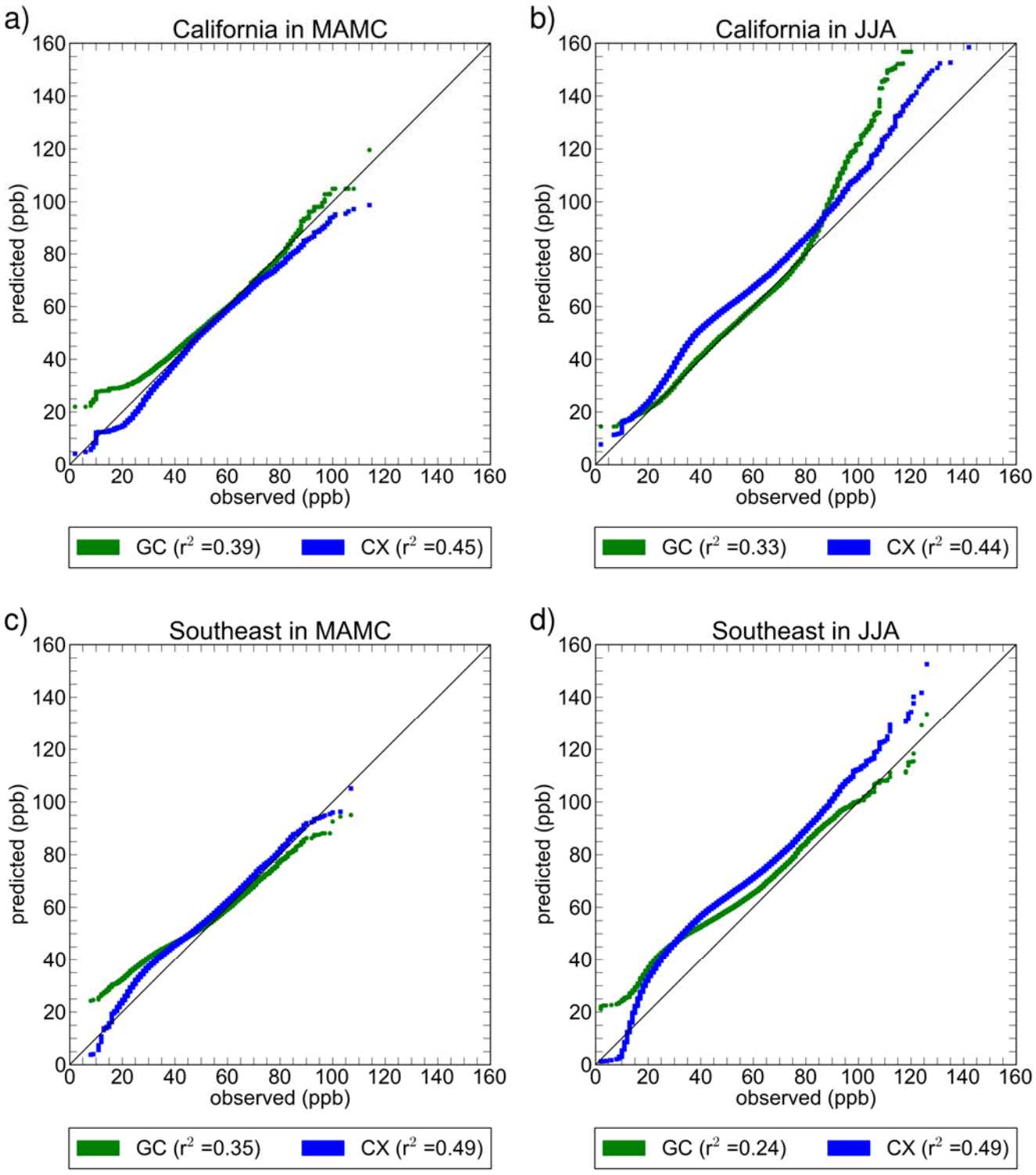

Figure 4-2. Predicted quantiles plotted as a function of the observed quantile for the California and Southeast regions. Each plot shows GEOS-Chem (green) and CAMx (blue) predictions and Pearson r-squared values.

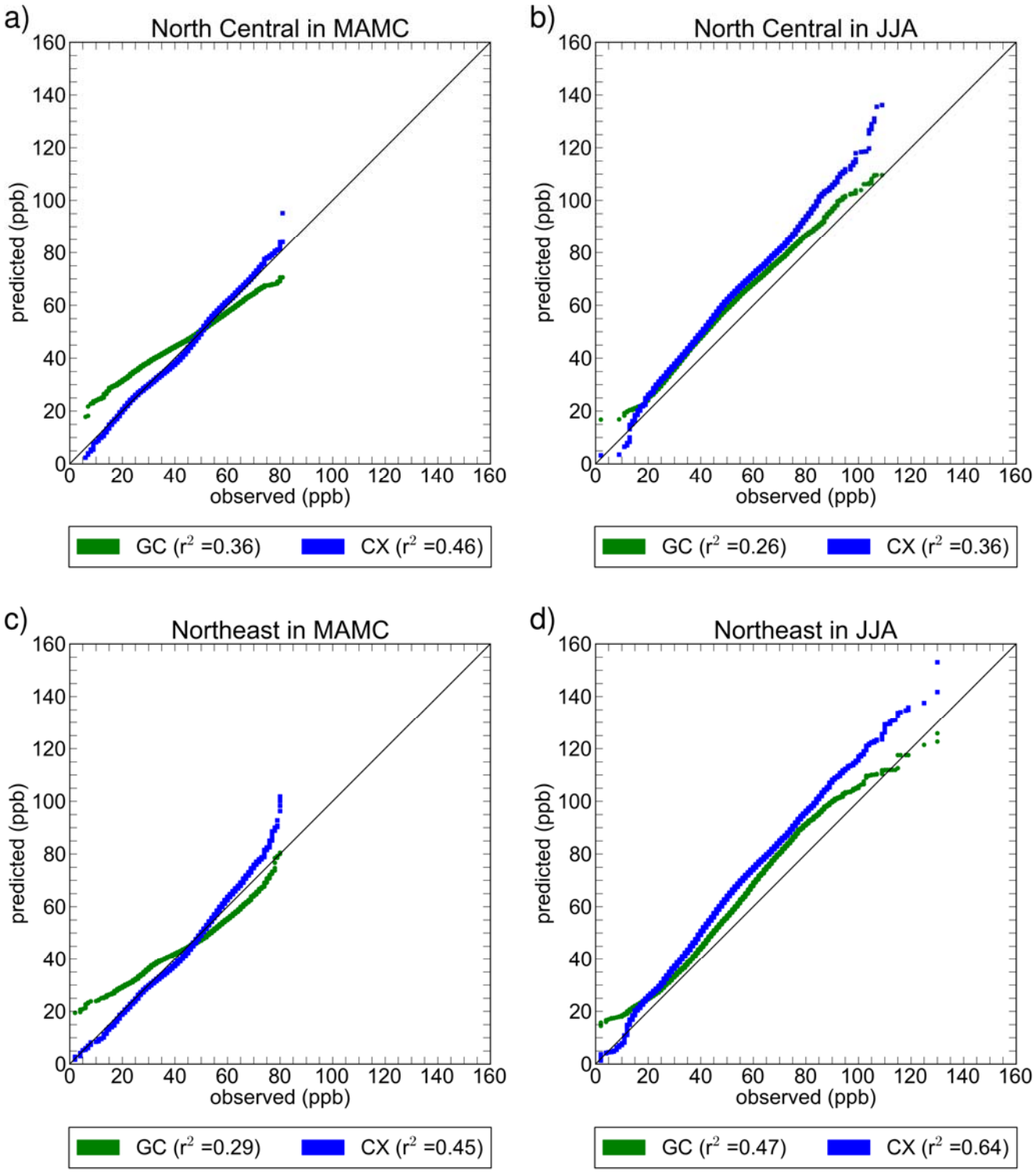

Figure 4-3. Predicted quantiles plotted as a function of the observed quantile for North Central and Northeast regions. Each plot shows GEOS-Chem (green) and CAMx (blue) predictions and Pearson r-squared values.

Acknowledgements

We would like to recognize the authors of the studies reviewed here, Lin Zhang of Harvard University and Christopher Emery of the ENVIRON International Corporation, for providing their modeled datasets for our analysis. Both studies were originally funded by the American Petroleum Institute. We also thank EPA staff members, Susan Anenberg, Joseph Pinto, Karen Wesson, and Scott Jenkins for providing their valuable insights on this work.

5. References

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6. Supplemental

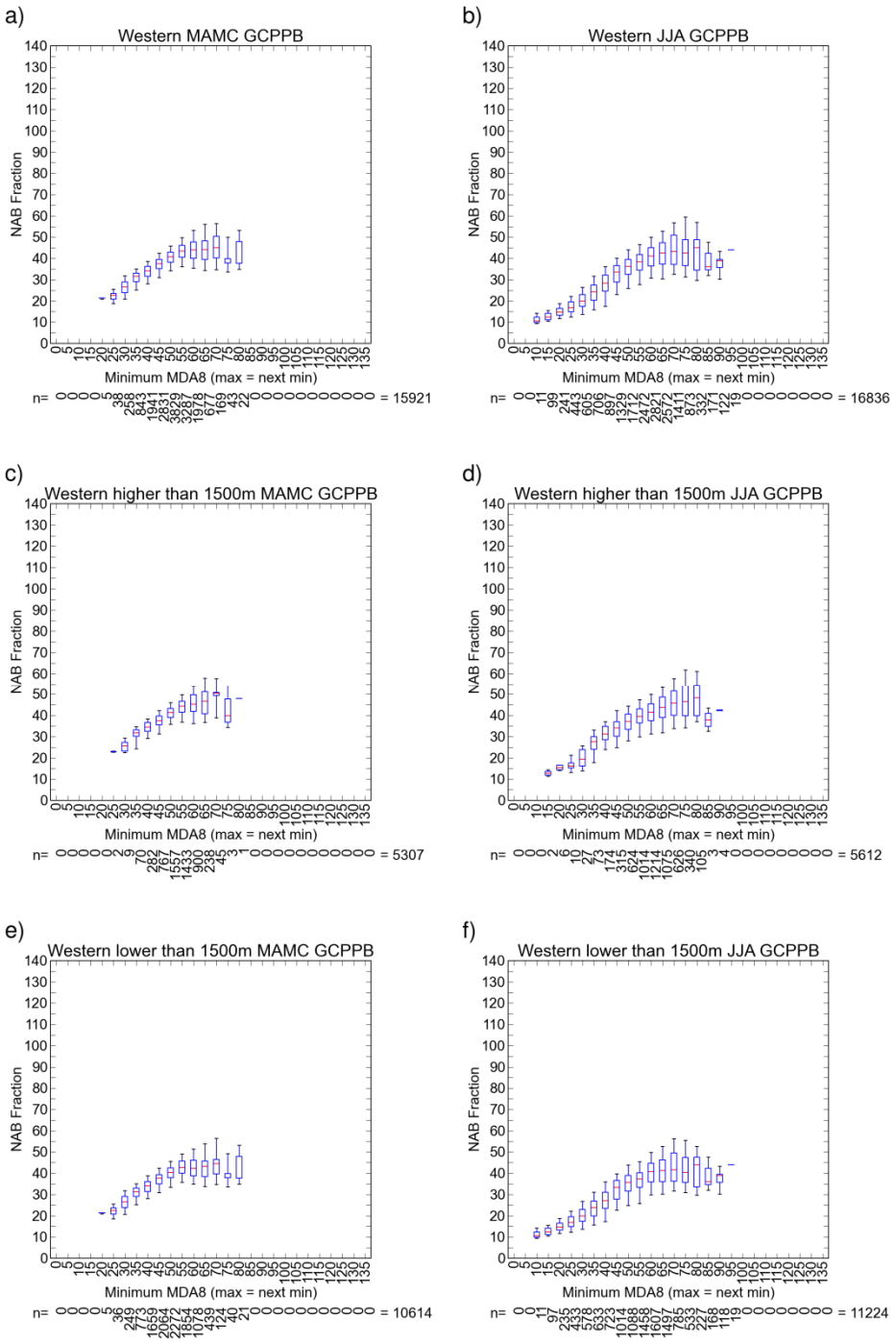

Figure 6-1. Ozone from North American Background plotted as a function of GEOS-Chem simulated total ozone in the West region. Upper and lower caps show the 5th and 95th percentiles, the box bottom and tow show the 25th and 75th percentiles, and the center line shows the median value. Below the x-axis, is a count of values in each 5 ppb bin.

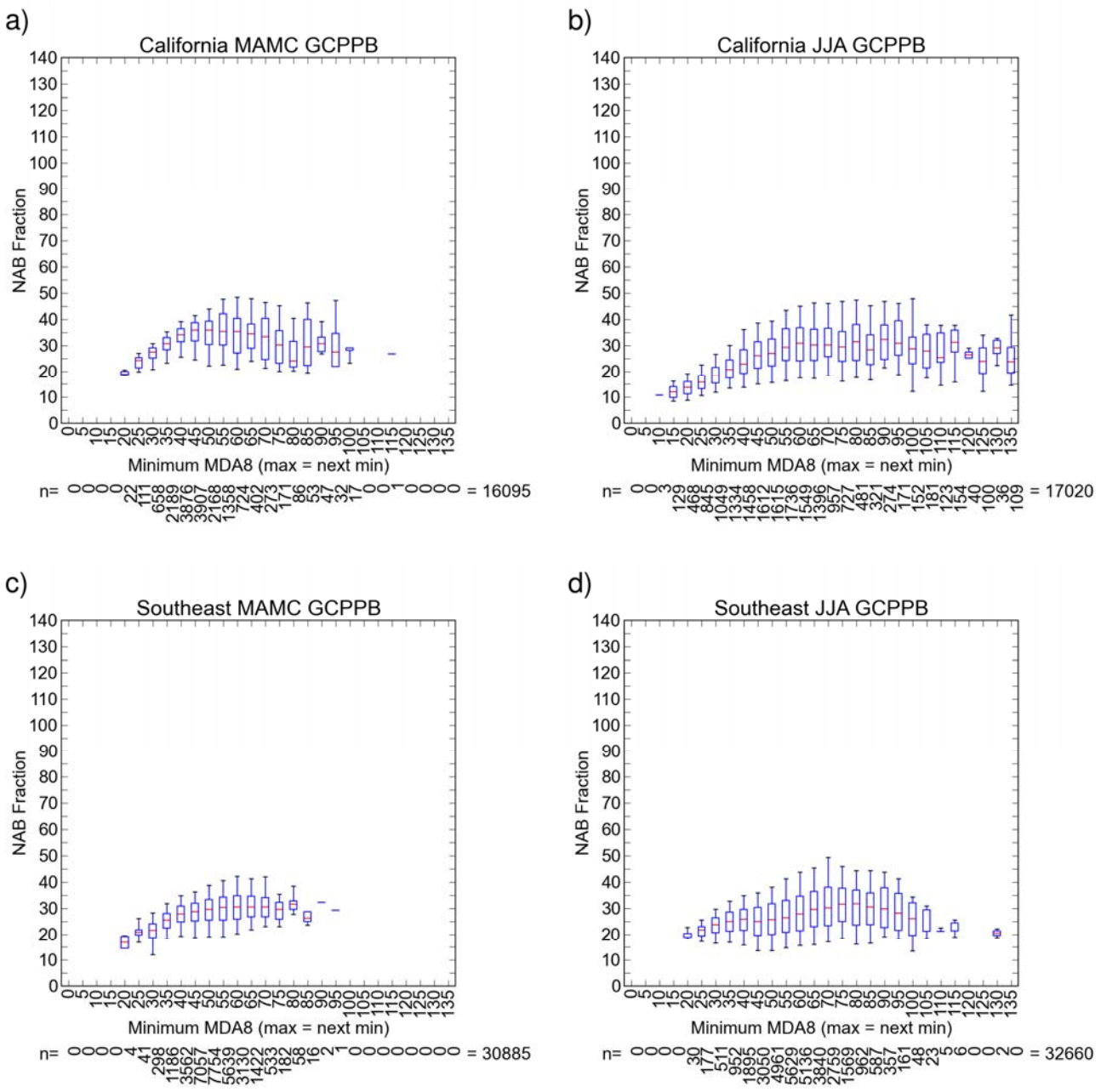

Figure 6-2. Ozone from North American Background plotted as a function of GEOS-Chem simulated total ozone in the Southeast and California regions. Upper and lower caps show the 5th and 95th percentiles, the box bottom and tow show the 25th and 75th percentiles, and the center line shows the median value. Below the x-axis, is a count of values in each 5 ppb bin.

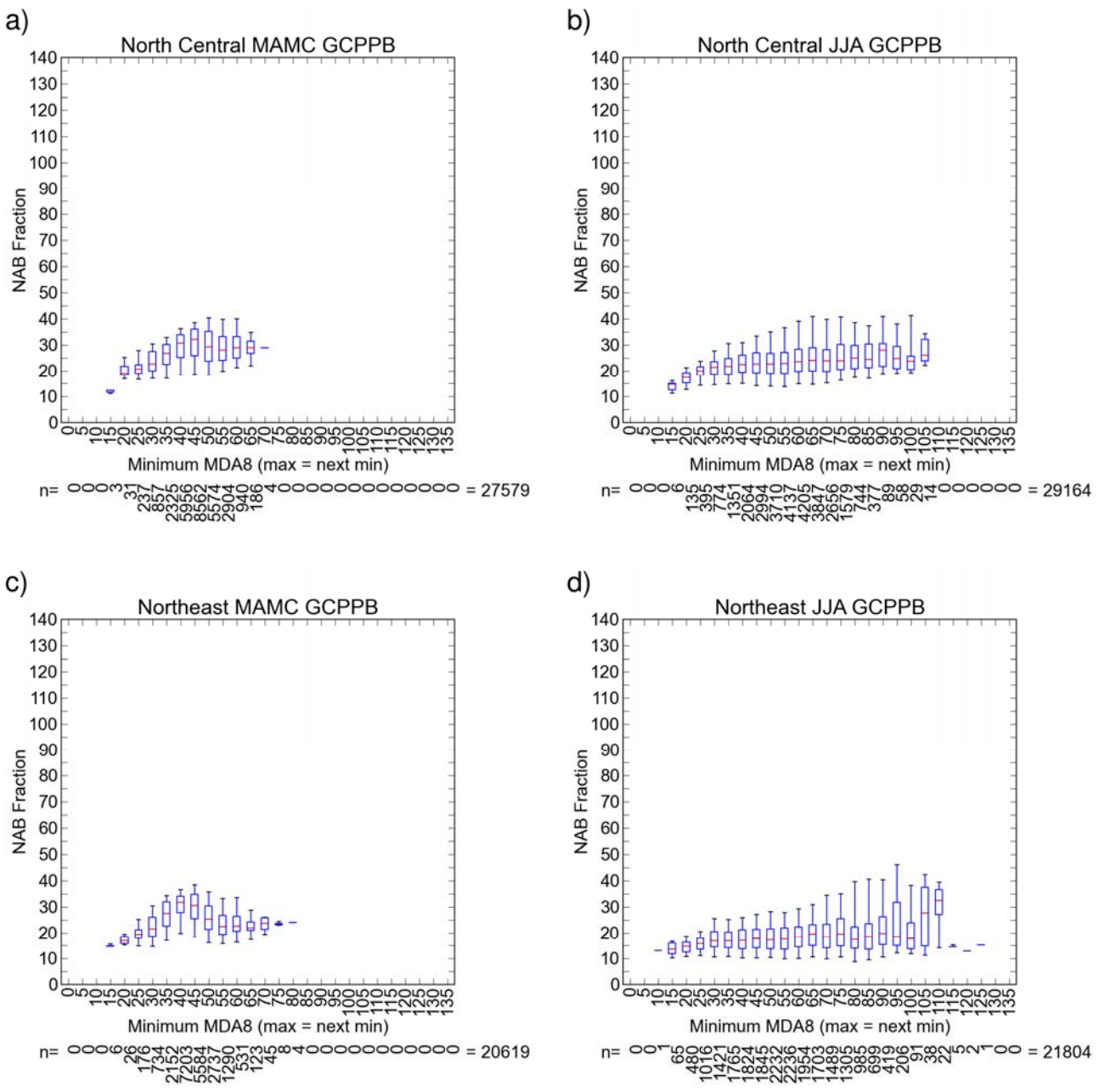

Figure 6-3. Ozone from North American Background plotted as a function of GEOS-Chem simulated total ozone in the North Central and Northeast regions. Upper and lower caps show the 5th and 95th percentiles, the box bottom and tow show the 25th and 75th percentiles, and the center line shows the median value. Below the x-axis, is a count of values in each 5 ppb bin.

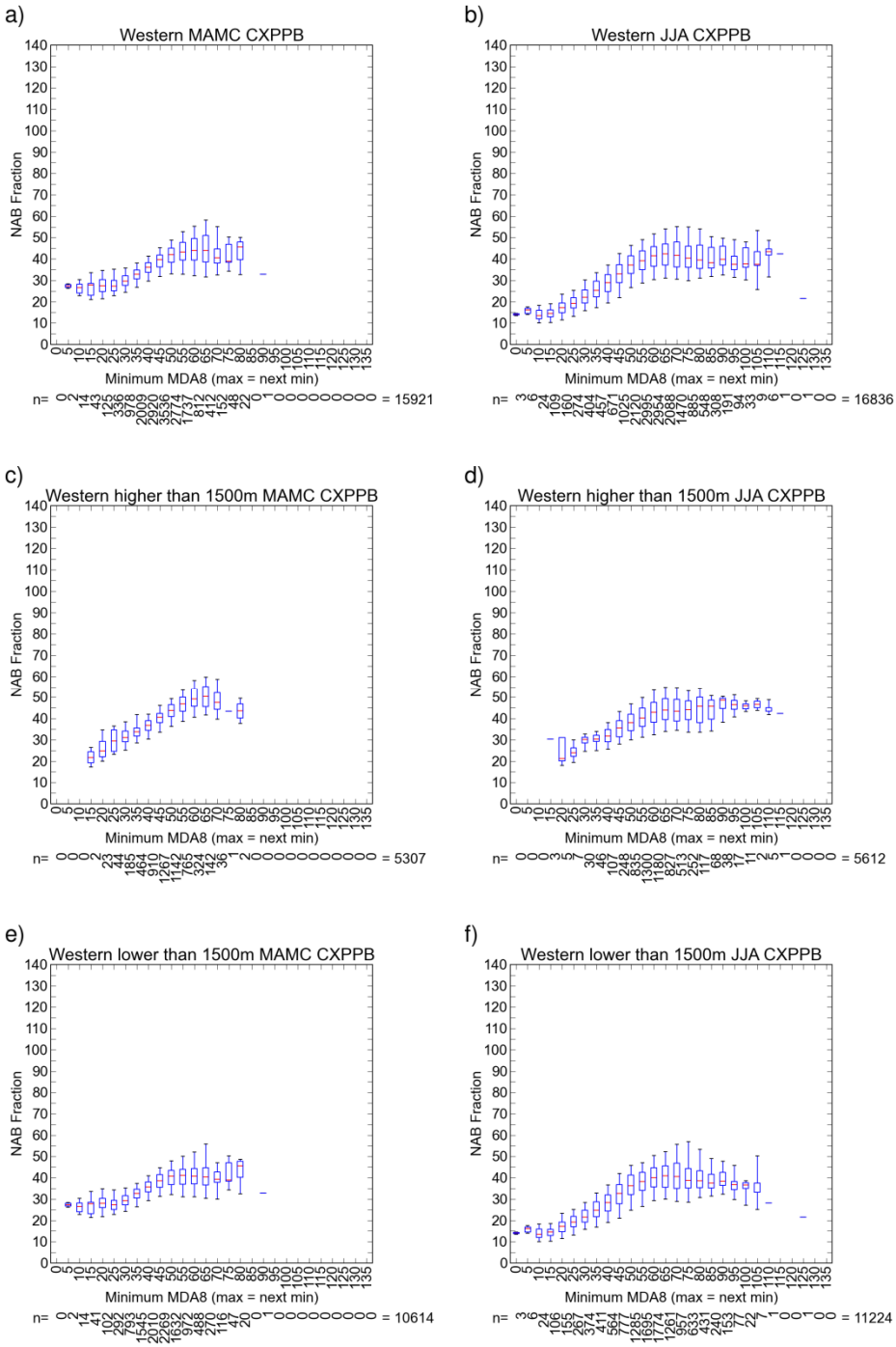

Figure 6-4. Ozone from North American Background plotted as a function of CAMx simulated total ozone in the West region. Upper and lower caps show the 5th and 95th percentiles, the box bottom and tow show the 25th and 75th percentiles, and the center line shows the median value. Below the x-axis, is a count of values in each 5 ppb bin.

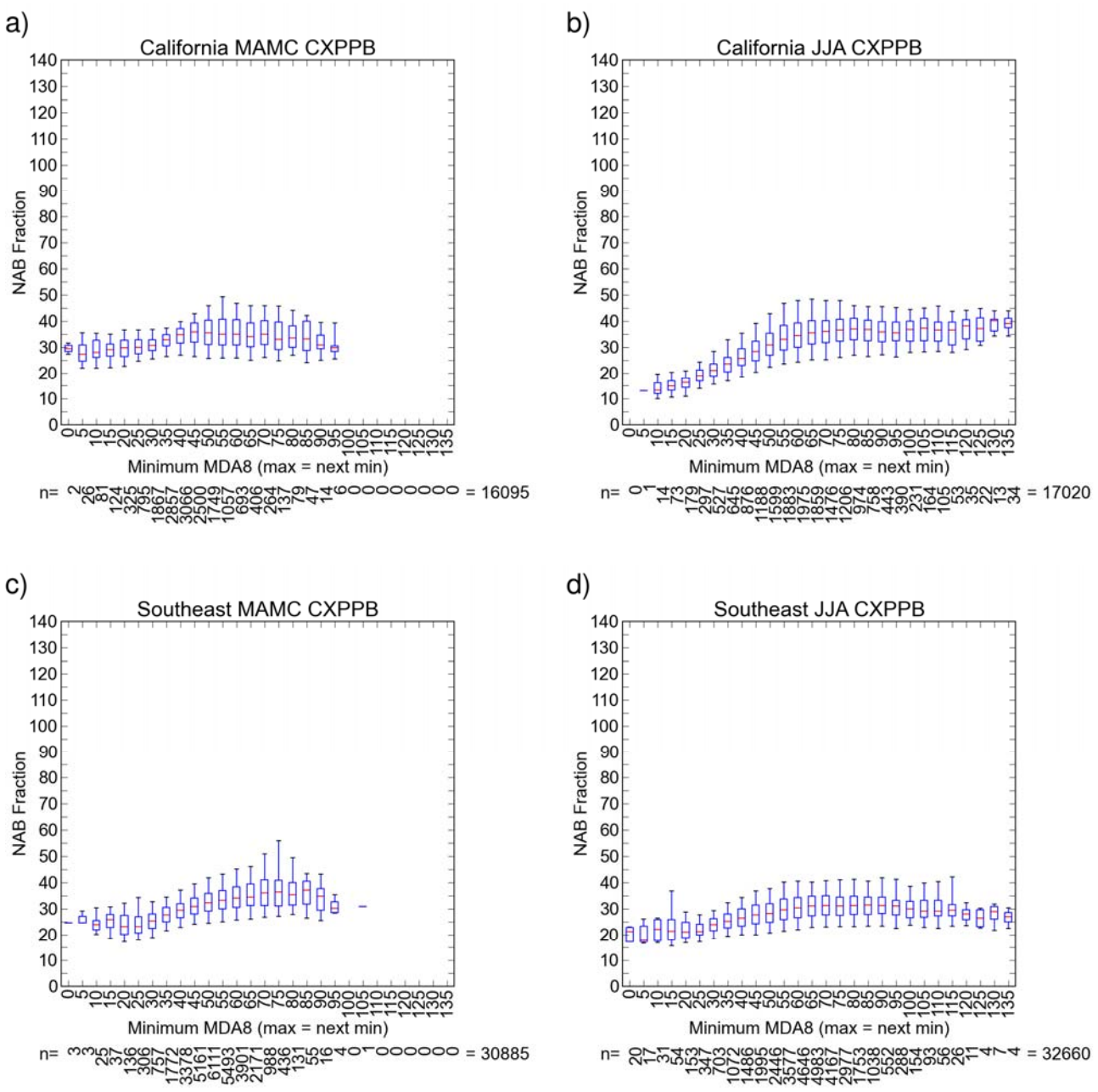

Figure 6-5. Ozone from North American Background plotted as a function of CAMx simulated total ozone in the California and Southeast regions. Upper and lower caps show the 5th and 95th percentiles, the box bottom and tow show the 25th and 75th percentiles, and the center line shows the median value. Below the x-axis, is a count of values in each 5 ppb bin.

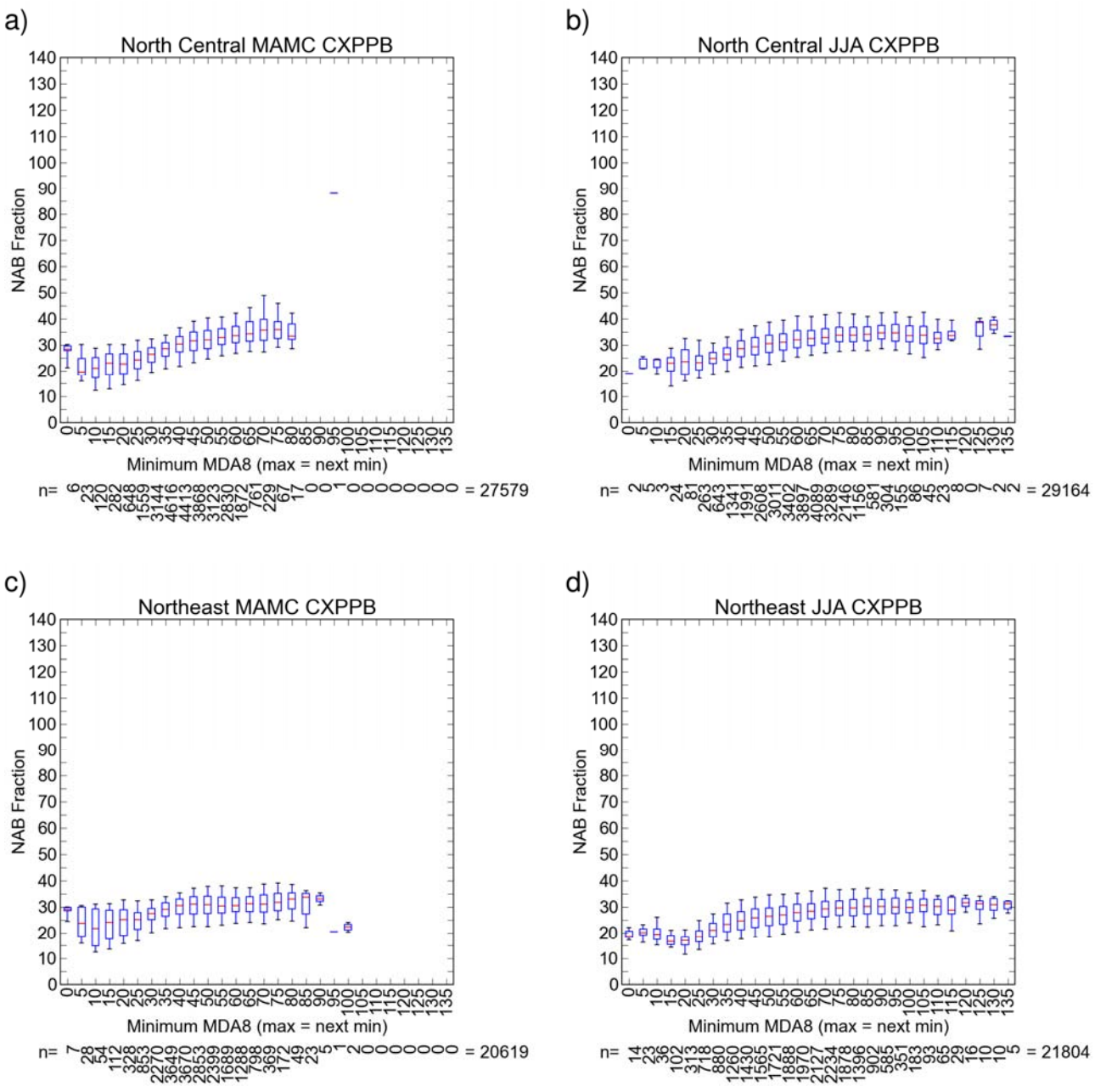

Figure 6-6. Ozone from North American Background plotted as a function of CAMx simulated total ozone the North Central and Northeast regions. Upper and lower caps show the 5th and 95th percentiles, the box bottom and tow show the 25th and 75th percentiles, and the center line shows the median value. Below the x-axis, is a count of values in each 5 ppb bin.

Table 6-1a. Distribution of North American Background concentrations by total ozone bin for the West region in the spring from GEOS-Chem.

Region: West				Season: MAMC		Model: GEOS-Chem			
Number of Values	Total Ozone Bin Range		Min	5%	25%	50%	75%	95%	Max
0	0	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	5	10	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	10	15	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	15	20	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5	20	25	21	21	21	21	21	21	21
38	25	30	17	19	21	23	23	25	26
258	30	35	19	21	24	27	29	32	32
843	35	40	19	25	29	32	33	35	37
1941	40	45	21	28	32	34	36	39	43
2831	45	50	22	31	35	38	40	42	49
3829	50	55	21	34	38	41	43	46	50
3287	55	60	25	36	41	43	46	50	54
1978	60	65	31	35	40	44	48	53	59
677	65	70	29	34	40	44	48	56	59
169	70	75	33	35	40	45	50	56	58
43	75	80	34	34	38	38	40	50	56
22	80	85	35	35	38	48	48	53	53
0	85	90	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	90	95	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	95	100	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	100	105	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	105	110	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	110	115	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	115	120	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	120	125	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	125	130	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	130	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
9745	0	55	17	28	34	37	41	44	50
6176	>= 55		25	35	40	44	47	52	59
2889	>= 60		29	35	40	44	48	54	59
911	>= 65		29	34	40	44	48	56	59
234	>= 70		33	34	40	45	49	56	58
65	>= 75		34	34	38	38	48	53	56

Table 6-1b. Distribution of North American Background concentrations by total ozone bin for the West region in the spring from CAMx.

Region: West				Season: MAMC		Model: CAMx			
Number of Values	Total Ozone Bin Range		Min	5%	25%	50%	75%	95%	Max
0	0	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2	5	10	26	26	27	27	28	28	29
14	10	15	22	23	24	27	28	30	32
43	15	20	17	21	23	28	29	34	36
125	20	25	16	21	25	27	30	35	39
336	25	30	20	23	25	27	30	35	40
978	30	35	21	24	28	30	32	36	44
2009	35	40	20	27	31	33	35	38	48
2920	40	45	21	30	34	36	38	41	48
3536	45	50	20	32	36	40	42	45	53
2774	50	55	21	33	38	42	45	49	55
1737	55	60	23	33	39	43	48	53	60
812	60	65	22	32	39	44	50	55	60
412	65	70	22	32	39	44	51	58	63
152	70	75	25	32	38	41	45	55	60
48	75	80	27	34	38	39	47	50	50
22	80	85	29	33	40	46	48	50	50
0	85	90	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1	90	95	33	33	33	33	33	33	33
0	95	100	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	100	105	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	105	110	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	110	115	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	115	120	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	120	125	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	125	130	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	130	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12737	0	55	16	27	33	37	41	46	55
3184	>= 55		22	32	39	43	48	55	63
1447	>= 60		22	32	39	44	49	57	63
635	>= 65		22	32	38	43	49	57	63
223	>= 70		25	33	38	41	46	52	60
71	>= 75		27	33	38	40	47	50	50

Table 6-1c. Distribution of North American Background concentrations by total ozone bin for the West region in the summer from GEOS-Chem.

Region: West				Season: JJA		Model: GEOS-Chem			
Number of Values	Total Ozone Bin Range		Min	5%	25%	50%	75%	95%	Max
0	0	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	5	10	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11	10	15	9	9	10	11	12	14	14
99	15	20	10	10	11	12	14	15	17
241	20	25	10	12	13	15	17	19	21
443	25	30	9	12	15	17	20	22	26
605	30	35	11	14	17	20	23	26	31
706	35	40	11	16	20	24	27	32	35
897	40	45	11	17	25	28	32	36	39
1329	45	50	12	23	29	34	37	40	46
1712	50	55	17	26	33	36	40	44	47
2472	55	60	15	28	35	38	42	46	53
2821	60	65	17	31	37	41	45	50	56
2572	65	70	17	30	37	43	47	53	59
1411	70	75	19	33	37	43	51	57	61
873	75	80	21	31	37	43	49	59	63
332	80	85	30	30	34	45	49	57	63
171	85	90	30	32	35	36	42	47	47
122	90	95	30	30	36	39	39	43	47
19	95	100	44	44	44	44	44	44	44
0	100	105	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	105	110	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	110	115	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	115	120	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	120	125	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	125	130	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	130	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6043	0	55	9	14	21	29	35	41	47
10793	>= 55		15	30	36	41	46	54	63
8321	>= 60		17	31	37	42	47	54	63
5500	>= 65		17	31	37	42	48	55	63
2928	>= 70		19	32	37	42	49	57	63
1517	>= 75		21	31	36	42	48	57	63

Table 6-1d. Distribution of North American Background concentrations by total ozone bin for the West region in the summer from CAMx.

Region: West				Season: JJA		Model: CAMx			
Number of Values	Total Ozone Bin Range		Min	5%	25%	50%	75%	95%	Max
3	0	5	13.49	13.55	13.8	14.12	14.31	14.46	14.5
6	5	10	14	14	14	16	17	18	18
24	10	15	10	10	12	14	16	18	19
109	15	20	9	10	13	15	16	19	30
160	20	25	10	12	15	17	19	24	31
274	25	30	11	13	17	19	22	25	31
404	30	35	12	16	19	22	25	30	40
457	35	40	14	17	22	25	30	34	38
671	40	45	13	19	25	29	33	37	41
1025	45	50	12	22	29	33	37	43	46
2120	50	55	16	27	33	37	42	46	52
2995	55	60	17	29	35	39	44	49	57
2954	60	65	12	30	37	42	46	52	60
2088	65	70	14	31	37	42	47	54	64
1470	70	75	11	31	36	42	48	55	67
885	75	80	15	30	36	40	46	55	68
548	80	85	23	31	36	40	47	54	69
308	85	90	19	32	36	38	45	50	77
191	90	95	30	33	37	40	46	50	57
94	95	100	25	31	35	38	41	49	55
33	100	105	27	30	36	38	45	48	49
9	105	110	23	26	37	38	43	53	56
6	110	115	28	32	42	43	45	49	50
1	115	120	42	42	42	42	42	42	42
0	120	125	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1	125	130	21	21	21	21	21	21	21
0	130	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5253	0	55	9	16	24	32	37	44	52
11583	>= 55		11	30	36	41	46	52	77
8588	>= 60		11	31	36	41	46	53	77
5634	>= 65		11	31	36	41	47	54	77
3546	>= 70		11	31	36	40	47	54	77
2076	>= 75		15	31	36	40	46	54	77

Table 6-1e. Distribution of North American Background concentrations by total ozone bin for the West region above 1500 m in the spring from GEOS-Chem.

Region: West Above 1500 m			Season: MAMC			Model: GEOS-Chem			
Number of Values	Total Ozone Bin Range		Min	5%	25%	50%	75%	95%	Max
0	0	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	5	10	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	10	15	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	15	20	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	20	25	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2	25	30	23	23	23	23	23	23	23
9	30	35	22	23	23	26	27	29	30
70	35	40	23	24	30	32	33	35	35
282	40	45	26	29	32	34	37	38	40
767	45	50	27	31	35	37	40	42	49
1557	50	55	24	36	39	41	43	46	50
1433	55	60	25	37	41	44	47	50	54
900	60	65	32	36	42	45	50	54	59
238	65	70	29	37	41	47	51	58	59
45	70	75	38	39	49	50	51	58	58
3	75	80	34	34	37	40	48	54	56
1	80	85	48	48	48	48	48	48	48
0	85	90	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	90	95	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	95	100	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	100	105	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	105	110	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	110	115	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	115	120	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	120	125	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	125	130	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	130	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2687	0	55	22	32	36	39	42	45	50
2620	>= 55		25	37	42	45	48	53	59
1187	>= 60		29	37	42	46	50	55	59
287	>= 65		29	37	41	48	51	58	59
49	>= 70		34	38	47	50	51	58	58
4	>= 75		34	35	38	44	50	55	56

Table 6-1f. Distribution of North American Background concentrations by total ozone bin for the West region above 1500 m in the spring from CAMx.

Region: West Above 1500 m			Season: MAMC			Model: CAMx			
Number of Values	Total Ozone Bin Range		Min	5%	25%	50%	75%	95%	Max
0	0	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	5	10	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	10	15	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2	15	20	17	17	19	22	24	26	27
23	20	25	16	20	22	25	29	35	35
44	25	30	20	23	25	29	35	36	36
185	30	35	23	25	29	31	34	38	43
464	35	40	26	29	32	34	36	42	44
910	40	45	24	30	34	37	39	42	47
1267	45	50	28	33	38	41	42	46	53
1142	50	55	31	36	41	44	46	49	53
765	55	60	33	39	43	47	50	54	60
324	60	65	30	41	46	49	54	58	60
142	65	70	30	42	46	51	55	60	63
36	70	75	35	40	44	48	52	59	60
1	75	80	43	43	43	43	43	43	43
2	80	85	37	38	40	44	47	49	50
0	85	90	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	90	95	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	95	100	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	100	105	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	105	110	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	110	115	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	115	120	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	120	125	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	125	130	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	130	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4037	0	55	16	30	35	39	43	47	53
1270	>= 55		30	39	44	48	52	57	63
505	>= 60		30	41	46	49	54	59	63
181	>= 65		30	41	45	50	55	60	63
39	>= 70		35	37	44	47	51	59	60
3	>= 75		37	38	40	43	47	49	50

Table 6-1g. Distribution of North American Background concentrations by total ozone bin for the West region above 1500 m in the summer from GEOS-Chem.

Region: West Above 1500 m			Season: JJA			Model: GEOS-Chem			
Number of Values	Total Ozone Bin Range		Min	5%	25%	50%	75%	95%	Max
0	0	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	5	10	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	10	15	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2	15	20	11	11	12	13	14	14	14
6	20	25	14	14	14	15	16	17	17
10	25	30	13	13	15	16	18	21	22
27	30	35	14	14	16	19	24	26	26
73	35	40	13	18	24	28	30	33	35
174	40	45	16	24	29	31	35	37	39
315	45	50	19	25	30	34	37	42	46
624	50	55	17	28	33	37	41	44	47
1014	55	60	15	30	37	40	43	47	53
1214	60	65	23	31	38	41	46	50	56
1075	65	70	17	32	39	44	49	53	59
626	70	75	28	34	40	46	52	58	61
340	75	80	21	34	40	47	54	62	62
105	80	85	34	37	40	48	54	61	63
3	85	90	32	33	35	38	41	43	44
4	90	95	42	42	42	42	43	43	43
0	95	100	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	100	105	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	105	110	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	110	115	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	115	120	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	120	125	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	125	130	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	130	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1231	0	55	11	23	30	35	39	43	47
4381	>= 55		15	32	38	42	47	54	63
3367	>= 60		17	32	39	43	48	55	63
2153	>= 65		17	33	39	45	50	57	63
1078	>= 70		21	34	40	46	53	59	63
452	>= 75		21	35	40	47	54	62	63

Table 6-1h. Distribution of North American Background concentrations by total ozone bin for the West region above 1500 m in the summer from CAMx.

Region: West Above 1500 m			Season: JJA			Model: CAMx			
Number of Values	Total Ozone Bin Range		Min	5%	25%	50%	75%	95%	Max
0	0	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	5	10	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	10	15	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3	15	20	30	30	30	30	30	30	30
5	20	25	17	18	20	21	31	31	31
7	25	30	19	19	22	24	26	30	31
30	30	35	23	25	29	30	31	33	33
46	35	40	22	25	29	30	32	34	38
107	40	45	23	26	29	32	35	38	38
248	45	50	25	28	31	36	39	43	46
835	50	55	24	30	34	38	42	47	50
1300	55	60	25	31	36	40	45	50	57
1180	60	65	25	32	38	43	48	53	60
827	65	70	27	34	39	44	49	55	64
513	70	75	26	34	39	43	49	55	67
252	75	80	29	34	40	44	48	53	68
117	80	85	31	34	38	46	50	54	64
68	85	90	31	34	40	46	49	51	51
38	90	95	37	38	45	49	49	51	53
17	95	100	40	41	44	46	49	51	54
11	100	105	43	43	45	46	47	48	49
2	105	110	43	44	45	47	48	49	50
5	110	115	41	42	43	43	45	49	50
1	115	120	42	42	42	42	42	42	42
0	120	125	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	125	130	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	130	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1281	0	55	17	28	32	36	40	46	50
4331	>= 55		25	32	38	43	48	53	68
3031	>= 60		25	33	39	44	49	54	68
1851	>= 65		26	34	39	44	49	54	68
1024	>= 70		26	34	39	45	49	54	68
511	>= 75		29	34	40	45	49	53	68

Table 6-1i. Distribution of North American Background concentrations by total ozone bin for the West region below 1500 m in the spring from GEOS-Chem.

Region: West Below 1500 m				Season: MAMC		Model: GEOS-Chem			
Number of Values	Total Ozone Bin Range		Min	5%	25%	50%	75%	95%	Max
0	0	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	5	10	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	10	15	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	15	20	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5	20	25	21	21	21	21	21	21	21
36	25	30	17	19	21	22	24	26	26
249	30	35	19	21	24	27	29	32	32
773	35	40	19	25	29	31	33	35	37
1659	40	45	21	28	31	34	36	39	43
2064	45	50	22	31	35	38	39	42	49
2272	50	55	21	33	38	40	43	46	49
1854	55	60	25	36	40	43	46	49	54
1078	60	65	31	35	39	42	46	51	58
439	65	70	29	34	38	43	46	54	59
124	70	75	33	35	40	45	47	56	56
40	75	80	34	34	38	38	40	49	56
21	80	85	35	35	38	48	48	53	53
0	85	90	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	90	95	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	95	100	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	100	105	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	105	110	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	110	115	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	115	120	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	120	125	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	125	130	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	130	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7058	0	55	17	27	33	36	40	44	49
3556	>= 55		25	34	39	43	46	51	59
1702	>= 60		29	34	39	43	46	54	59
624	>= 65		29	34	38	43	46	54	59
185	>= 70		33	34	38	44	47	56	56
61	>= 75		34	34	38	38	48	53	56

Table 6-1j. Distribution of North American Background concentrations by total ozone bin for the West region below 1500 m in the spring from CAMx.

Region: West Below 1500 m				Season: MAMC		Model: CAMx			
Number of Values	Total Ozone Bin Range		Min	5%	25%	50%	75%	95%	Max
0	0	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2	5	10	26	26	27	27	28	28	29
14	10	15	22	23	24	27	28	30	32
41	15	20	20	21	23	28	29	34	36
102	20	25	19	22	26	28	30	35	39
292	25	30	21	23	25	27	30	34	40
793	30	35	21	24	27	29	32	35	44
1545	35	40	20	26	30	33	35	37	48
2010	40	45	21	29	33	36	38	41	48
2269	45	50	20	31	35	39	41	45	50
1632	50	55	21	32	37	41	43	48	55
972	55	60	23	31	37	41	44	50	54
488	60	65	22	31	37	41	44	52	59
270	65	70	22	30	37	40	45	56	60
116	70	75	25	30	38	39	43	47	55
47	75	80	27	34	38	39	47	50	50
20	80	85	29	32	40	46	48	49	50
0	85	90	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1	90	95	33	33	33	33	33	33	33
0	95	100	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	100	105	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	105	110	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	110	115	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	115	120	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	120	125	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	125	130	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	130	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8700	0	55	19	26	32	36	40	45	55
1914	>= 55		22	31	37	41	44	51	60
942	>= 60		22	31	37	40	44	53	60
454	>= 65		22	30	38	40	45	55	60
184	>= 70		25	31	38	39	44	50	55
68	>= 75		27	33	38	40	47	50	50

Table 6-1k. Distribution of North American Background concentrations by total ozone bin for the West region below 1500 m in the summer from GEOS-Chem.

Region: West Below 1500 m				Season: JJA		Model: GEOS-Chem			
Number of Values	Total Ozone Bin Range		Min	5%	25%	50%	75%	95%	Max
0	0	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	5	10	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11	10	15	9	9	10	11	12	14	14
97	15	20	10	10	11	12	14	15	17
235	20	25	10	12	13	15	17	19	21
433	25	30	9	12	15	17	20	22	26
578	30	35	11	14	17	20	23	27	31
633	35	40	11	16	20	24	27	31	35
723	40	45	11	17	23	27	31	36	39
1014	45	50	12	23	28	33	37	40	45
1088	50	55	17	25	32	36	39	44	47
1458	55	60	15	26	33	37	40	45	51
1607	60	65	17	30	36	41	45	50	54
1497	65	70	17	30	36	41	46	53	59
785	70	75	19	32	36	42	50	56	61
533	75	80	21	31	36	40	47	55	63
227	80	85	30	30	34	44	48	53	58
168	85	90	30	32	35	36	42	47	47
118	90	95	30	30	36	39	39	43	47
19	95	100	44	44	44	44	44	44	44
0	100	105	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	105	110	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	110	115	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	115	120	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	120	125	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	125	130	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	130	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4812	0	55	9	13	20	27	34	40	47
6412	>= 55		15	29	35	40	45	52	63
4954	>= 60		17	30	36	41	46	53	63
3347	>= 65		17	30	36	41	47	54	63
1850	>= 70		19	31	35	41	47	55	63
1065	>= 75		21	30	35	40	46	53	63

Table 6-1l. Distribution of North American Background concentrations by total ozone bin for the West region below 1500 m in the summer from CAMx.

Region: West Below 1500 m				Season: JJA		Model: CAMx			
Number of Values	Total Ozone Bin Range		Min	5%	25%	50%	75%	95%	Max
3	0	5	13.49	13.55	13.8	14.12	14.31	14.46	14.5
6	5	10	14	14	14	16	17	18	18
24	10	15	10	10	12	14	16	18	19
106	15	20	9	10	13	14	16	18	28
155	20	25	10	11	15	17	19	23	28
267	25	30	11	13	17	19	22	25	27
374	30	35	12	16	19	21	25	28	40
411	35	40	14	17	22	25	29	33	38
564	40	45	13	19	24	28	32	37	41
777	45	50	12	21	28	33	37	42	45
1285	50	55	16	25	32	36	41	46	52
1695	55	60	17	27	34	38	43	47	54
1774	60	65	12	29	36	40	45	50	56
1261	65	70	14	30	36	41	46	52	60
957	70	75	11	29	35	41	47	56	64
633	75	80	15	29	35	39	44	57	68
431	80	85	23	31	35	39	43	53	69
240	85	90	19	31	35	37	42	49	77
153	90	95	30	32	36	38	43	48	57
77	95	100	25	30	35	37	38	46	55
22	100	105	27	27	35	37	38	39	48
7	105	110	23	25	33	38	38	50	56
1	110	115	28	28	28	28	28	28	28
0	115	120	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	120	125	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1	125	130	21	21	21	21	21	21	21
0	130	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3972	0	55	9	15	22	29	36	43	52
7252	>= 55		11	29	35	39	44	52	77
5557	>= 60		11	29	35	40	45	53	77
3783	>= 65		11	30	35	40	45	54	77
2522	>= 70		11	30	35	39	45	55	77
1565	>= 75		15	30	35	38	43	54	77

Table 6-1m. Distribution of North American Background concentrations by total ozone bin for the California region in the spring from GEOS-Chem.

Region: California			Season: MAMC			Model: GEOS-Chem			
Number of Values	Total Ozone Bin Range		Min	5%	25%	50%	75%	95%	Max
0	0	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	5	10	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	10	15	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	15	20	N/A	N/A	N/A	N/A	N/A	N/A	N/A
22	20	25	17	19	19	19	20	20	21
111	25	30	18	20	21	24	25	27	27
658	30	35	16	21	25	27	29	31	34
2189	35	40	18	23	28	31	33	35	37
3876	40	45	15	25	31	34	36	39	41
3907	45	50	15	24	32	36	39	41	45
2168	50	55	16	22	30	36	39	44	49
1358	55	60	15	23	30	35	42	48	54
724	60	65	18	21	27	35	40	49	56
402	65	70	18	24	29	34	38	48	55
273	70	75	16	21	25	33	40	47	56
171	75	80	18	20	23	30	36	45	48
86	80	85	20	20	22	24	32	40	55
53	85	90	19	19	22	29	40	46	46
47	90	95	27	27	28	31	33	39	40
32	95	100	22	22	22	27	35	47	47
17	100	105	23	23	28	28	29	29	29
0	105	110	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	110	115	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1	115	120	27	27	27	27	27	27	27
0	120	125	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	125	130	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	130	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12931	0	55	15	23	30	34	37	41	49
3164	>= 55		15	21	27	34	40	48	56
1806	>= 60		16	21	26	33	39	47	56
1082	>= 65		16	21	25	32	38	47	56
680	>= 70		16	20	23	29	37	45	56
407	>= 75		18	20	23	28	35	45	55

Table 6-1n. Distribution of North American Background concentrations by total ozone bin for the California region in the spring from CAMx.

Region: California			Season: MAMC			Model: CAMx			
Number of Values	Total Ozone Bin Range		Min	5%	25%	50%	75%	95%	Max
2	0	5	27	27	28	29	31	32	32
26	5	10	21	22	25	27	31	36	37
81	10	15	21	22	26	28	33	35	40
124	15	20	20	22	27	29	31	35	40
325	20	25	21	23	26	30	33	37	41
795	25	30	21	25	27	30	33	37	42
1867	30	35	18	26	29	31	33	37	43
2857	35	40	18	26	31	33	35	37	45
3066	40	45	19	27	32	35	37	40	46
2500	45	50	19	26	32	36	39	43	48
1749	50	55	19	26	31	36	40	46	51
1057	55	60	19	26	31	35	41	49	57
693	60	65	21	26	31	35	41	47	56
406	65	70	20	25	30	34	39	46	55
264	70	75	21	26	31	35	40	46	53
137	75	80	21	25	29	33	40	46	48
79	80	85	23	27	30	34	38	44	46
47	85	90	23	24	29	33	40	42	48
14	90	95	24	25	29	31	35	39	41
6	95	100	25	25	28	30	31	39	42
0	100	105	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	105	110	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	110	115	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	115	120	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	120	125	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	125	130	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	130	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13392	0	55	18	25	30	33	36	42	51
2703	>= 55		19	26	31	35	40	48	57
1646	>= 60		20	25	30	35	40	46	56
953	>= 65		20	25	30	34	40	46	55
547	>= 70		21	25	30	34	40	45	53
283	>= 75		21	25	30	33	39	45	48

Table 6-1o. Distribution of North American Background concentrations by total ozone bin for the California region in the summer from GEOS-Chem.

Region: California			Season: JJA			Model: GEOS-Chem			
Number of Values	Total Ozone Bin Range		Min	5%	25%	50%	75%	95%	Max
0	0	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	5	10	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3	10	15	11	11	11	11	11	11	11
129	15	20	8	8	10	12	14	16	18
468	20	25	8	9	11	14	16	19	21
845	25	30	7	11	13	16	18	22	26
1049	30	35	9	12	16	18	22	27	32
1334	35	40	9	14	17	21	24	30	35
1458	40	45	11	14	19	23	28	36	42
1612	45	50	9	15	21	26	31	39	45
1615	50	55	11	16	22	27	33	39	48
1736	55	60	10	16	24	29	36	43	52
1549	60	65	13	17	24	31	37	45	52
1396	65	70	14	17	24	30	36	46	54
957	70	75	13	18	26	30	37	46	54
727	75	80	13	16	24	29	35	47	61
481	80	85	15	18	24	31	38	47	52
321	85	90	11	17	23	28	34	45	51
274	90	95	13	21	25	32	38	47	55
171	95	100	18	19	26	31	39	46	57
152	100	105	12	12	23	29	33	48	49
181	105	110	15	17	21	28	34	38	47
123	110	115	13	14	23	25	35	38	38
154	115	120	16	16	27	31	36	38	45
40	120	125	22	25	25	26	27	29	29
100	125	130	12	12	19	24	29	34	34
36	130	135	22	22	27	29	32	33	33
109	135	N/A	15	15	19	24	29	42	42
8513	0	55	7	12	17	22	27	36	48
8507	>= 55		10	17	24	30	36	45	61
6771	>= 60		11	17	24	30	36	46	61
5222	>= 65		11	17	24	30	36	46	61
3826	>= 70		11	16	24	29	36	46	61
2869	>= 75		11	16	24	29	35	46	61

Table 6-1p. Distribution of North American Background concentrations by total ozone bin for the California region in the summer from CAMx.

Region: California			Season: JJA			Model: CAMx			
Number of Values	Total Ozone Bin Range		Min	5%	25%	50%	75%	95%	Max
0	0	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1	5	10	13	13	13	13	13	13	13
14	10	15	10	10	12	13	16	20	22
73	15	20	10	11	13	15	17	20	26
179	20	25	9	11	14	16	18	21	25
297	25	30	10	14	17	19	21	24	34
527	30	35	12	16	19	21	24	28	37
645	35	40	12	17	20	23	26	33	40
876	40	45	13	18	23	26	29	35	42
1188	45	50	13	20	25	28	32	39	45
1599	50	55	15	22	27	31	35	43	49
1883	55	60	16	24	29	33	38	47	54
1975	60	65	17	24	30	34	39	48	59
1859	65	70	16	25	31	36	40	48	63
1476	70	75	18	25	32	36	40	48	60
1206	75	80	17	26	32	37	41	48	67
974	80	85	20	27	33	37	41	46	57
758	85	90	17	26	33	37	40	46	56
443	90	95	22	27	32	36	40	46	51
390	95	100	24	26	32	36	40	45	51
231	100	105	24	28	32	37	40	45	51
164	105	110	24	28	33	37	41	45	51
105	110	115	26	28	32	37	40	46	51
53	115	120	26	28	31	37	40	44	45
35	120	125	28	29	33	38	41	44	45
22	125	130	30	31	32	37	41	45	49
13	130	135	34	34	36	40	41	44	44
34	135	N/A	28	34	37	39	41	44	47
5399	0	55	9	16	22	26	31	39	49
11621	>= 55		16	25	31	36	40	47	67
9738	>= 60		16	26	32	36	40	47	67
7763	>= 65		16	26	32	36	40	47	67
5904	>= 70		17	26	32	37	40	46	67
4428	>= 75		17	27	33	37	41	46	67

Table 6-1q. Distribution of North American Background concentrations by total ozone bin for the Southeast region in the spring from GEOS-Chem.

Region: Southeast			Season: MAMC			Model: GEOS-Chem			
Number of Values	Total Ozone Bin Range		Min	5%	25%	50%	75%	95%	Max
0	0	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	5	10	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	10	15	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	15	20	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4	20	25	15	15	15	17	19	19	19
41	25	30	14	17	20	21	22	26	26
298	30	35	10	12	19	21	24	28	30
1186	35	40	12	18	22	26	28	32	36
3562	40	45	12	19	25	28	31	35	40
7057	45	50	11	19	25	29	32	36	46
7754	50	55	11	19	25	30	33	39	49
5639	55	60	12	19	25	30	34	41	54
3130	60	65	14	20	26	30	35	42	54
1422	65	70	18	22	27	31	35	41	56
533	70	75	19	23	27	31	34	42	52
182	75	80	21	23	26	30	32	35	45
58	80	85	28	28	30	32	33	38	38
16	85	90	23	23	25	26	29	29	29
2	90	95	32	32	32	32	32	32	32
1	95	100	29	29	29	29	29	29	29
0	100	105	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	105	110	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	110	115	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	115	120	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	120	125	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	125	130	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	130	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19902	0	55	10	19	25	28	32	37	49
10983	>= 55		12	20	26	30	34	41	56
5344	>= 60		14	21	26	30	35	42	56
2214	>= 65		18	22	27	30	34	41	56
792	>= 70		19	23	27	30	33	41	52
259	>= 75		21	23	27	30	32	36	45

Table 6-1r. Distribution of North American Background concentrations by total ozone bin for the Southeast region in the spring from CAMx.

Region: Southeast			Season: MAMC			Model: CAMx			
Number of Values	Total Ozone Bin Range		Min	5%	25%	50%	75%	95%	Max
3	0	5	25	25	25	25	25	25	25
3	5	10	25	25	25	25	27	29	30
25	10	15	20	20	22	24	25	30	31
37	15	20	17	19	23	26	28	31	31
136	20	25	15	17	20	23	27	32	44
306	25	30	15	18	21	23	27	34	43
757	30	35	15	19	22	25	28	33	38
1772	35	40	16	21	25	28	30	34	45
3378	40	45	16	23	27	29	32	37	49
5161	45	50	17	24	28	31	34	39	48
6111	50	55	15	24	29	32	36	42	51
5493	55	60	18	25	30	33	37	43	54
3901	60	65	18	26	31	34	38	45	57
2171	65	70	21	26	31	35	40	46	63
988	70	75	22	27	31	36	41	51	65
436	75	80	23	27	31	36	41	56	65
131	80	85	23	28	31	35	40	50	66
55	85	90	23	26	32	37	41	43	45
16	90	95	25	26	29	35	38	43	44
4	95	100	28	28	29	30	33	35	36
0	100	105	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1	105	110	31	31	31	31	31	31	31
0	110	115	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	115	120	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	120	125	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	125	130	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	130	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
17689	0	55	15	22	27	30	34	40	51
13196	>= 55		18	25	30	34	38	45	66
7703	>= 60		18	26	31	35	39	46	66
3802	>= 65		21	26	31	35	40	48	66
1631	>= 70		22	27	31	36	41	52	66
643	>= 75		23	27	31	36	41	55	66

Table 6-1s. Distribution of North American Background concentrations by total ozone bin for the Southeast region in the summer from GEOS-Chem.

Region: Southeast			Season: JJA			Model: GEOS-Chem			
Number of Values	Total Ozone Bin Range		Min	5%	25%	50%	75%	95%	Max
0	0	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	5	10	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	10	15	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	15	20	N/A	N/A	N/A	N/A	N/A	N/A	N/A
30	20	25	18	18	19	20	20	23	23
177	25	30	15	17	19	22	23	26	28
511	30	35	9	16	21	24	26	30	33
952	35	40	9	17	21	25	29	33	36
1895	40	45	9	16	22	26	30	35	40
3050	45	50	8	14	20	25	30	36	43
4961	50	55	8	14	20	26	32	38	49
5629	55	60	8	15	21	26	33	41	55
5136	60	65	9	16	21	28	35	44	56
3840	65	70	10	16	23	30	36	45	61
2759	70	75	12	17	23	30	38	49	61
1569	75	80	10	18	25	32	38	46	63
962	80	85	12	16	24	32	37	44	57
587	85	90	12	17	24	31	36	44	52
357	90	95	16	19	23	30	38	44	45
161	95	100	18	18	21	28	36	41	47
48	100	105	13	13	20	26	32	34	36
23	105	110	18	18	21	30	30	31	32
5	110	115	21	21	21	21	21	22	23
6	115	120	18	19	21	21	24	26	26
0	120	125	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	125	130	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2	130	135	19	19	19	20	21	22	22
0	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11576	0	55	8	14	20	25	30	36	49
21084	>= 55		8	16	22	29	36	44	63
15455	>= 60		9	16	23	30	36	45	63
10319	>= 65		10	17	23	30	37	46	63
6479	>= 70		10	17	24	31	37	46	63
3720	>= 75		10	17	24	31	37	45	63

Table 6-1t. Distribution of North American Background concentrations by total ozone bin for the Southeast region in the summer from CAMx.

Region: Southeast			Season: JJA			Model: CAMx			
Number of Values	Total Ozone Bin Range		Min	5%	25%	50%	75%	95%	Max
20	0	5	16	17	17	21	23	23	25
17	5	10	17	17	17	18	23	26	26
31	10	15	14	17	18	22	26	26	27
54	15	20	14	16	18	21	26	37	37
153	20	25	14	17	19	21	25	29	39
347	25	30	14	17	20	21	24	28	39
703	30	35	16	18	21	24	26	29	40
1072	35	40	16	19	23	25	28	32	39
1486	40	45	15	20	23	26	30	34	42
1995	45	50	15	20	24	28	31	37	45
2446	50	55	15	21	25	28	32	38	47
3577	55	60	14	21	26	30	34	40	52
4646	60	65	14	22	27	30	34	41	53
4983	65	70	15	23	27	31	35	40	53
4167	70	75	15	23	28	31	35	41	63
2977	75	80	15	23	27	31	34	41	53
1753	80	85	17	23	28	31	35	41	55
1038	85	90	17	23	28	31	34	41	53
552	90	95	18	23	28	31	34	42	48
288	95	100	16	22	28	31	33	41	48
154	100	105	19	24	27	30	33	39	46
93	105	110	18	23	27	29	33	40	42
56	110	115	19	22	27	29	33	40	47
26	115	120	19	23	27	29	32	42	45
11	120	125	23	23	26	28	30	32	34
4	125	130	22	23	23	26	30	30	30
7	130	135	21	22	26	29	31	32	32
4	135	N/A	22	23	25	27	29	30	31
8324	0	55	14	19	23	26	30	36	47
24336	>= 55		14	22	27	31	34	41	63
20759	>= 60		14	23	27	31	35	41	63
16113	>= 65		15	23	27	31	35	41	63
11130	>= 70		15	23	28	31	35	41	63
6963	>= 75		15	23	28	31	34	41	55

Table 6-1u. Distribution of North American Background concentrations by total ozone bin for the North Central region in the spring from GEOS-Chem.

Region: North Central				Season: MAMC		Model: GEOS-Chem			
Number of Values	Total Ozone Bin Range		Min	5%	25%	50%	75%	95%	Max
0	0	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	5	10	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	10	15	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3	15	20	11	11	12	12	12	12	12
31	20	25	16	17	18	19	22	25	26
237	25	30	15	17	19	21	22	28	30
857	30	35	10	17	20	23	28	30	33
2325	35	40	12	17	23	27	30	33	35
5956	40	45	12	18	25	31	34	36	40
8562	45	50	11	18	26	32	36	39	43
5574	50	55	12	18	24	29	35	40	46
2904	55	60	14	20	24	28	33	40	47
940	60	65	17	21	25	29	33	40	48
186	65	70	18	22	27	29	31	35	40
4	70	75	29	29	29	29	29	29	29
0	75	80	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	80	85	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	85	90	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	90	95	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	95	100	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	100	105	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	105	110	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	110	115	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	115	120	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	120	125	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	125	130	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	130	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
23545	0	55	10	18	24	30	34	38	46
4034	>= 55		14	20	24	28	33	40	48
1130	>= 60		17	21	25	29	33	40	48
190	>= 65		18	22	27	29	31	35	40
4	>= 70		29	29	29	29	29	29	29
0	>= 75		N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 6-1v. Distribution of North American Background concentrations by total ozone bin for the North Central region in the spring from CAMx.

Region: North Central				Season: MAMC		Model: CAMx			
Number of Values	Total Ozone Bin Range		Min	5%	25%	50%	75%	95%	Max
6	0	5	19	21	28	28	30	30	30
23	5	10	12	16	18	20	25	30	30
120	10	15	8	12	17	21	25	29	30
282	15	20	9	13	18	23	26	30	35
648	20	25	10	15	19	23	27	30	36
1559	25	30	12	16	21	24	27	32	41
3144	30	35	13	19	23	26	29	32	46
4616	35	40	15	21	26	29	31	34	45
4413	40	45	15	22	27	30	33	37	46
3868	45	50	17	23	28	32	35	39	47
3123	50	55	18	25	29	32	36	40	48
2830	55	60	20	26	30	33	36	41	51
1872	60	65	21	27	31	34	37	42	57
761	65	70	21	27	31	34	39	44	59
229	70	75	24	27	32	36	40	49	52
67	75	80	28	29	33	36	39	46	49
17	80	85	27	29	32	33	38	42	44
0	85	90	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	90	95	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1	95	100	88	88	88	88	88	88	88
0	100	105	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	105	110	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	110	115	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	115	120	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	120	125	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	125	130	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	130	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
21802	0	55	8	20	25	29	32	37	48
5777	>= 55		20	26	31	33	37	42	88
2947	>= 60		21	27	31	34	38	43	88
1075	>= 65		21	28	32	35	39	45	88
314	>= 70		24	28	32	35	40	48	88
85	>= 75		27	29	32	35	39	46	88

Table 6-1w. Distribution of North American Background concentrations by total ozone bin for the North Central region in the summer from GEOS-Chem.

Region: North Central				Season: JJA		Model: GEOS-Chem			
Number of Values	Total Ozone Bin Range		Min	5%	25%	50%	75%	95%	Max
0	0	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	5	10	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	10	15	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6	15	20	11	11	13	15	15	16	16
135	20	25	11	13	15	18	19	21	23
395	25	30	11	14	18	20	22	24	27
774	30	35	9	15	19	21	24	28	32
1351	35	40	8	15	19	22	25	30	36
2064	40	45	8	15	19	23	26	31	36
2994	45	50	7	14	19	23	27	33	39
3710	50	55	7	14	19	23	27	35	43
4137	55	60	7	14	19	23	27	37	49
4205	60	65	8	15	20	23	28	39	56
3847	65	70	8	15	20	24	29	41	57
2656	70	75	10	15	20	24	28	40	62
1579	75	80	11	16	20	24	30	41	56
744	80	85	11	17	21	25	30	39	48
377	85	90	10	17	21	25	30	37	45
89	90	95	18	19	22	28	30	41	49
58	95	100	19	19	21	25	29	38	38
29	100	105	19	19	21	24	26	41	41
14	105	110	22	22	24	26	32	34	34
0	110	115	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	115	120	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	120	125	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	125	130	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	130	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11429	0	55	7	14	19	22	26	33	43
17735	>= 55		7	15	20	24	28	39	62
13598	>= 60		8	15	20	24	29	40	62
9393	>= 65		8	16	20	24	29	40	62
5546	>= 70		10	16	20	24	29	40	62
2890	>= 75		10	17	21	24	30	40	56

Table 6-1x. Distribution of North American Background concentrations by total ozone bin for the North Central region in the summer from CAMx.

Region: North Central				Season: JJA		Model: CAMx			
Number of Values	Total Ozone Bin Range		Min	5%	25%	50%	75%	95%	Max
2	0	5	19	19	19	19	19	19	19
5	5	10	21	21	21	25	25	26	26
3	10	15	18	19	21	24	24	25	25
24	15	20	13	14	20	23	25	29	34
81	20	25	15	16	19	23	28	32	35
263	25	30	15	17	20	23	26	32	35
643	30	35	15	19	23	25	27	31	37
1341	35	40	16	20	24	26	29	33	39
1991	40	45	16	21	25	29	32	36	42
2608	45	50	17	22	26	29	33	37	45
3011	50	55	17	22	27	30	34	39	48
3402	55	60	18	24	28	31	34	39	49
3897	60	65	17	25	29	32	36	41	51
4089	65	70	18	26	30	32	36	41	56
3289	70	75	21	27	31	33	36	42	55
2146	75	80	20	28	31	34	37	42	51
1156	80	85	22	28	31	34	37	42	49
581	85	90	23	28	32	34	37	41	55
304	90	95	25	29	32	35	38	42	45
155	95	100	23	28	31	35	38	43	45
86	100	105	24	27	31	34	37	41	45
45	105	110	22	25	31	34	37	43	44
23	110	115	27	28	31	33	35	40	44
8	115	120	32	32	32	34	35	39	41
0	120	125	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7	125	130	26	28	33	39	39	40	41
2	130	135	34	35	36	38	39	41	41
2	135	N/A	33	33	33	33	33	33	33
9972	0	55	13	21	25	29	32	37	48
19192	>= 55		17	26	30	33	36	41	56
15790	>= 60		17	26	30	33	36	41	56
11893	>= 65		18	27	31	33	36	42	56
7804	>= 70		20	27	31	33	37	42	55
4515	>= 75		20	28	31	34	37	42	55

Table 6-1y. Distribution of North American Background concentrations by total ozone bin for the Northeast region in the spring from GEOS-Chem.

Region: Northeast			Season: MAMC			Model: GEOS-Chem			
Number of Values	Total Ozone Bin Range		Min	5%	25%	50%	75%	95%	Max
0	0	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	5	10	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	10	15	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6	15	20	15	15	15	15	15	16	16
26	20	25	15	15	16	17	19	19	19
176	25	30	13	15	18	19	21	25	26
734	30	35	9	15	19	22	26	30	34
2152	35	40	10	17	23	28	32	34	37
7203	40	45	9	20	28	32	34	37	40
5584	45	50	9	18	25	31	35	38	41
2737	50	55	9	16	21	25	30	36	41
1290	55	60	11	16	19	23	27	33	39
531	60	65	13	16	21	23	26	33	36
123	65	70	13	17	21	22	24	29	29
45	70	75	19	19	21	24	26	26	26
8	75	80	23	23	23	23	24	25	25
4	80	85	24	24	24	24	24	24	24
0	85	90	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	90	95	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	95	100	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	100	105	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	105	110	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	110	115	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	115	120	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	120	125	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	125	130	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	130	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
18618	0	55	9	18	24	30	34	37	41
2001	>= 55		11	16	20	23	26	33	39
711	>= 60		13	17	21	23	26	33	36
180	>= 65		13	18	21	23	25	29	29
57	>= 70		19	19	23	24	25	26	26
12	>= 75		23	23	23	24	24	25	25

Table 6-1z. Distribution of North American Background concentrations by total ozone bin for the Northeast region in the spring from CAMx.

Region: Northeast			Season: MAMC			Model: CAMx			
Number of Values	Total Ozone Bin Range		Min	5%	25%	50%	75%	95%	Max
7	0	5	23	24	28	29	30	30	30
28	5	10	13	16	19	24	30	31	31
54	10	15	12	13	15	22	29	31	32
112	15	20	12	14	18	24	29	31	34
328	20	25	12	16	19	25	29	33	35
853	25	30	13	17	21	25	28	32	36
2270	30	35	15	20	25	27	29	33	36
3649	35	40	16	22	26	29	32	34	39
3670	40	45	16	22	27	31	33	35	41
2853	45	50	17	22	27	31	34	37	42
2399	50	55	17	22	28	31	34	38	49
1689	55	60	18	23	28	30	34	38	48
1288	60	65	19	24	28	31	34	37	48
798	65	70	19	24	28	31	34	37	46
369	70	75	20	24	28	31	35	39	42
172	75	80	21	25	29	32	35	39	41
49	80	85	23	25	29	33	35	39	40
23	85	90	20	22	27	34	35	36	38
5	90	95	30	31	32	33	34	35	36
1	95	100	20	20	20	20	20	20	20
2	100	105	20	20	21	22	23	24	24
0	105	110	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	110	115	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	115	120	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	120	125	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	125	130	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	130	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
16223	0	55	12	21	26	29	32	36	49
4396	>= 55		18	23	28	31	34	38	48
2707	>= 60		19	24	28	31	34	38	48
1419	>= 65		19	24	28	31	34	38	46
621	>= 70		20	24	28	32	35	39	42
252	>= 75		20	24	29	33	35	39	41

Table 6-1z1. Distribution of North American Background concentrations by total ozone bin for the Northeast region in the summer from GEOS-Chem.

Region: Northeast			Season: JJA			Model: GEOS-Chem			
Number of Values	Total Ozone Bin Range		Min	5%	25%	50%	75%	95%	Max
0	0	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	5	10	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1	10	15	13	13	13	13	13	13	13
65	15	20	9	10	12	14	16	17	19
480	20	25	6	11	13	15	16	19	21
1016	25	30	6	11	14	16	18	20	26
1421	30	35	6	11	14	17	20	25	31
1765	35	40	7	11	14	17	20	25	35
1824	40	45	5	10	14	17	21	26	35
1845	45	50	5	10	14	18	21	27	37
2232	50	55	7	10	14	17	22	28	38
2236	55	60	7	10	14	18	22	28	46
1954	60	65	5	10	15	18	22	29	49
1703	65	70	6	11	15	20	23	31	49
1489	70	75	6	10	14	18	23	35	52
1305	75	80	6	11	15	20	26	35	53
985	80	85	7	9	14	17	22	40	52
699	85	90	8	9	14	19	23	41	50
419	90	95	7	11	15	20	26	40	47
206	95	100	10	12	15	19	32	46	49
91	100	105	10	12	14	18	24	38	50
38	105	110	11	11	15	28	38	42	44
22	110	115	14	14	27	33	37	39	40
5	115	120	15	15	15	15	15	15	15
2	120	125	13	13	13	13	13	13	13
1	125	130	15	15	15	15	15	15	15
0	130	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	135	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10649	0	55	5	10	14	17	20	26	38
11155	>= 55		5	10	14	18	23	34	53
8919	>= 60		5	10	15	19	23	36	53
6965	>= 65		6	10	15	19	24	37	53
5262	>= 70		6	10	14	19	24	38	53
3773	>= 75		6	10	15	19	25	40	53

Table 6-1z2. Distribution of North American Background concentrations by total ozone bin for the Northeast region in the summer from CAMx.

Region: Northeast			Season: JJA			Model: CAMx			
Number of Values	Total Ozone Bin Range		Min	5%	25%	50%	75%	95%	Max
14	0	5	17	17	18	19	21	22	23
23	5	10	15	16	19	20	22	23	28
36	10	15	14	15	17	19	22	26	29
102	15	20	9	14	15	17	19	21	28
313	20	25	8	12	15	17	19	21	28
718	25	30	9	13	17	19	21	25	30
880	30	35	11	16	19	21	24	27	30
1260	35	40	10	17	20	23	27	31	34
1430	40	45	11	18	21	25	28	33	36
1565	45	50	9	18	22	26	29	34	38
1721	50	55	11	18	23	26	30	35	42
1888	55	60	12	19	23	27	30	35	42
1970	60	65	11	20	25	28	31	35	43
2127	65	70	12	21	26	28	31	36	43
2234	70	75	16	22	26	29	32	37	51
1878	75	80	14	22	27	30	32	37	49
1396	80	85	13	22	27	30	33	37	43
902	85	90	18	22	27	30	33	37	43
585	90	95	18	23	27	30	33	37	41
351	95	100	19	23	27	30	33	36	40
183	100	105	21	24	28	30	33	35	40
93	105	110	21	22	28	31	33	36	38
65	110	115	22	23	27	30	33	34	36
29	115	120	19	21	27	29	34	34	34
16	120	125	27	28	30	32	33	34	34
10	125	130	22	23	29	31	32	34	34
10	130	135	24	26	29	31	33	34	34
5	135	N/A	27	28	29	31	32	32	32
8062	0	55	8	16	20	23	28	33	42
13742	>= 55		11	21	26	29	32	36	51
11854	>= 60		11	22	26	29	32	36	51
9884	>= 65		12	22	26	29	32	37	51
7757	>= 70		13	22	27	30	33	37	51
5523	>= 75		13	22	27	30	33	37	49