May 19, 2023 STI-1923042-TM

To: Josh Stebbins, Sierra Club

From: Lynn Alley and Kenneth Craig, Sonoma Technology

Re: Analysis of Air Quality Impacts from Onroad Mobile Sources on Ozone Nonattainment areas in Connecticut, Illinois, Maryland, Michigan, New Jersey, and Pennsylvania

Introduction and Summary

Sonoma Technology performed source apportionment modeling using the Comprehensive Air Quality Model with Extensions (CAMx) with Ozone Source Apportionment Technology (OSAT) to support the Sierra Club in evaluating ozone impacts from onroad mobile sources and other emission sources on downwind receptors in nonattainment areas. The source apportionment modeling was conducted for the 2016 ozone season (April to October) for a domain covering the continental United States at 12-km spatial resolution, and results were compiled into a database with an online dashboard application that can be used for data mining and analysis. CAMx OSAT simulations were also conducted for the 2023 future year using a projection of 2023 future year emissions.[1]

The source apportionment modeling simulations relied on the U.S. Environmental Protection Agency (EPA) 2016v2 (2016fj_16j) modeling platform, which draws on emissions data from the EPA National Emissions Inventory and data developed by the National Emissions Inventory Collaborative.[2] EPA also developed emission inventories for the 2023 future year (2023fj_16j) to project the 2016 base year emissions into 2023. The EPA modeling platform tends to underpredict maximum daily average 8-hr (MDA8) ozone concentrations for days when the MDA8 ozone is greater than or equal to 60 ppb. Modeling results for the monitoring sites included in this report generally follow this trend. Overall, EPA found that "the ozone model performance results for the CAMx 2016fj (2016v2) simulation are within or close to the ranges found in other recent peer-reviewed applications" and that "the model performance results demonstrate the scientific credibility of the 2016v2 modeling platform" (U.S. Environmental Protection Agency, 2022b).

Biases in the modeled ozone concentrations can contribute to uncertainty in the source apportionment contribution results. To help mitigate this uncertainty, the source apportionment modeling results are used in a "relative" sense rather than an "absolute" sense where possible. For

[1] Future year ozone is modeled using emissions that have been projected to the future year, but using meteorology, boundary conditions, and other inputs representative of the 2016 base year.

[2] The National Emissions Inventory Collaborative is a partnership between state emissions inventory staff, multi-jurisdictional organizations, federal land managers, EPA, and others to develop a North American air pollution emissions modeling platform for use in air quality planning.

this report, relative source contributions for the 2016 base year were calculated based on a daily 8-hr average basis by multiplying the absolute modeled source contribution by the ratio of the monitored concentration and the total modeled ozone value. For the future year source contributions, the ratio of the total modeled MDA8 ozone concentration between 2023 and 2016 was used to estimate projected future year (2023) observed ozone concentrations, and this projected observed ozone was used to apportion the modeled ozone. These approaches have been used in past ozone source apportionment modeling analyses (e.g., Craig et al., 2020) and are similar to methods used by EPA to calculate ozone source contributions from a photochemical grid model (U.S. Environmental Protection Agency, 2022b). Anchoring the modeled apportionment results to ambient monitoring data can help mitigate uncertainty associated with imperfect model performance (Foley et al., 2015; Jones et al., 2005). The onroad mobile source ozone source apportionment results in this report should be considered indicative of the types of ozone impacts that can be expected from these mobile sources. Additional details on the models, data, and methods used can be found in **Appendix A**.

The results from this ozone source apportionment modeling were used to analyze impacts of emissions from onroad mobile sources (light duty vehicles [LDV], medium and heavy duty vehicles [MHDV], and the impacts of these two mobile source sectors combined) in Connecticut, Illinois, Maryland, Michigan, New Jersey, and Pennsylvania on air quality monitoring station (AQS) locations and in environmental justice (EJ) zip codes in state nonattainment areas. Maximum modeled contributions are shown on days when the monitored MDA8 ozone concentration exceeded the 2015 ozone standard (70 ppb) in areas that were in nonattainment for either the 2008 National Ambient Air Quality Standards (NAAQS) and/or the 2015 NAAQS.

In summary, the modeling results showed that on numerous nonattainment days in 2016, emissions from onroad mobile sources in each state (CT, IL, MD, MI, NJ, PA) resulted in impacts of greater than 1% of the ozone NAAQS (i.e., ozone impacts exceeding 0.70 ppb) at AQS monitoring locations and EJ zip code receptors within ozone nonattainment areas. The maximum modeled 8-hour ozone impact occurred in Detroit, Michigan on July 27, 2016 due to the total of all Michigan onroad mobile source emissions: The 2016 base year maximum ozone modeled impact at a nonattainment area monitor was 14.36 ppb and the 2023 future year maximum ozone modeled impact was 10.02 ppb. For EJ zip codes in Detroit, the 2016 base year maximum ozone modeled impact was 8.99 ppb and the 2023 future year maximum ozone modeled impact was 6.79 ppb.

Significant impacts occurred for the 2016 base emissions year and the 2023 projected future emissions year for all state nonattainment areas analyzed in this report. The substantial decrease in projected ozone contributions in 2023 is tied to the ~50% reduction in onroad mobile source NO_x emissions in the EPA modeling platform between 2016 and 2023 (see **Appendix A** for details). Despite this large projected decrease in NOx emissions, modeled impacts from onroad mobile sources remain significant in the 2023 projections.

Ozone Nonattainment Areas

For each state of interest—Connecticut, Illinois, Maryland, Michigan, New Jersey, and Pennsylvania—modeled contributions from onroad mobile sources (light duty vehicles [LDV], medium and heavy duty vehicles [MHDV], and the impacts of these two mobile source sectors combined) are presented. The LDV source tag includes motorcycles, passenger cars and trucks, and light commercial trucks (MOVES3 model source types 11, 21, 31, and 32). The MHDV source tag includes short- and long-haul single unit and combination trucks, refuse trucks, buses, and motorhomes (MOVES3 model source types 41, 42, 43, 51, 52, 53, 54, 61, and 62).

Onroad mobile source impacts were analyzed on days when the observed MDA8 ozone concentration exceeded the 2015 ozone NAAQS of 70 ppb at AQS monitors located within a 2008 and/or 2015 ozone nonattainment area. For selected states, modeled impacts were also evaluated at EJ zip codes in nonattainment areas on monitor exceedance days.

Relative source contributions at monitoring locations are presented, with contributions that equal or exceed 1% of the 2015 ozone NAAQS (0.70 ppb) highlighted in red and contributions that equal or exceed 0.5% of the 2015 ozone NAAQS (0.35 ppb) highlighted in yellow. Maximum source contributions for LDV, MHDV, and Total Vehicle (LDV+MHDV) are highlighted in bold. Relative source contributions from the model are adjusted to the monitoring data at AQS monitor locations using the methodology discussed in **Appendix A.** The resulting value gives a relative modeled contribution during a monitor exceedance day. Modeled contributions at EJ zip codes in nonattainment areas are presented as absolute modeled concentrations since there are no ozone monitors at the EJ zip code locations.

Spatial plots showing the absolute maximum modeled MDA8 ozone impacts (ppb) from onroad mobile sources are also presented for each state. LDV impacts, MHDV impacts, and the combination of the impacts (LDV+MHDV) for the 2016 base year and the 2023 projected future year are shown in separate plots. Transportation emissions were modeled as an “area wide” emissions source. Each grid cell in the model had some mobile source emissions. Emissions were much larger in urban areas compared to rural areas. Ozone impacts were widespread and far-reaching because the model tracked ozone attributable to all the onroad mobile source NOx and VOC emissions that are spread throughout each state. Maximum modeled impacts often occur in or near urban areas.

Connecticut

Impacts from Connecticut onroad mobile sources were evaluated at AQS monitors and at EJ zip codes located within Greater Connecticut and the CT portion of the New York-Northern New Jersey-Long Island 2008 and 2015 ozone nonattainment areas. Impacts were pulled for days where the monitored MDA8 ozone concentrations in the nonattainment area exceeded the 70 ppb NAAQS.

2016 modeled contributions and projected 2023 modeled contributions from Connecticut onroad mobile sources on 2016 nonattainment days are shown in **Tables 1 to 4**. Spatial plots showing absolute MDA8 modeled ozone impacts from Connecticut mobiles sources (LDV, MHDV, and LDV+MHDV) during the 2016 ozone season (April to October) are shown in Figure 1.

Table 1. Maximum **2016** Modeled Impacts from **Connecticut** onroad mobile sources on days that exceeded the ozone NAAQS of 70 ppb at any monitor in the nonattainment area during the 2016 ozone season. 8-hr maximum modeled ozone contributions are relative values (ppb) at AQS monitors and absolute values (ppb) at EJ zip codes. Values that equal or exceed 1% of the NAAQS (0.70 ppb) are highlighted in red, while values that equal or exceed 0.5% of the NAAQS (0.35 ppb) are highlighted in yellow. Maximum source contributions are highlighted in **bold**.

Greater Connecticut Nonattainment Area Receptors

Ozone Nonattainment Day	Max Ozone Impact at any AQS Monitor (ppb)			Max Ozone Impact at any EJ zip code (ppb)		
	LDV	MHDV	Total Vehicle	LDV	MHDV	Total Vehicle
22-Apr	0.14	0.04	0.18	0.46	0.15	0.61
25-May	1.17	0.50	1.67	0.78	0.31	1.09
26-May	**3.75**	**1.73**	**5.48**	2.95	**1.37**	4.32
27-May	0.29	0.09	0.38	0.69	0.27	0.96
28-May	2.46	0.37	2.83	2.06	0.31	2.37
7-Jun	0.16	0.08	0.24	1.08	0.49	1.57
16-Jun	0.27	0.13	0.40	2.80	1.34	4.14
26-Jun	1.09	0.25	1.34	**3.85**	0.67	**4.52**
6-Jul	2.37	1.01	3.38	1.76	0.76	2.52
15-Jul	1.97	0.92	2.89	2.23	0.83	3.06
16-Jul	0.98	0.40	1.38	2.16	0.46	2.62
17-Jul	0.24	0.06	0.30	3.42	0.54	3.96
21-Jul	0.94	0.43	1.37	1.08	0.36	1.44
22-Jul	1.67	0.59	2.26	1.17	0.41	1.58
25-Jul	1.61	0.70	2.31	1.98	0.86	2.84
28-Jul	1.56	0.66	2.22	1.28	0.54	1.82
5-Aug	2.66	0.98	3.64	2.04	0.75	2.79
25-Aug	0.30	0.13	0.43	1.23	0.58	1.81
8-Sep	0.36	0.13	0.49	1.67	0.75	2.42
14-Sep	0.32	0.13	0.45	0.82	0.36	1.18

Table 2. Maximum **2023** Projected Modeled Impacts from **Connecticut** onroad mobile sources on days that exceeded the ozone NAAQS of 70 ppb at any monitor in the nonattainment area during the 2016 ozone season. 8-hr maximum modeled ozone contributions are relative values (ppb) at AQS monitors and absolute values (ppb) at EJ zip codes. Values that equal or exceed 1% of the NAAQS (0.70 ppb) are highlighted in red, while values that equal or exceed 0.5% of the NAAQS (0.35 ppb) are highlighted in yellow. Maximum source contributions are highlighted in **bold**.

Greater Connecticut Nonattainment Area Receptors

Ozone Nonattainment Day	Max Ozone Impact at any AQS Monitor (ppb)			Max Ozone Impact at any EJ zip code (ppb)		
	LDV	MHDV	Total Vehicle	LDV	MHDV	Total Vehicle
22-Apr	0.08	0.04	0.12	0.36	0.23	0.59
25-May	0.64	0.53	1.17	0.30	0.27	0.57
26-May	**1.39**	**1.32**	**2.71**	1.10	1.04	2.14
27-May	0.22	0.13	0.35	0.38	0.31	0.69
28-May	0.86	0.26	1.12	0.71	0.22	0.93
7-Jun	0.07	0.06	0.13	0.43	0.40	0.83
16-Jun	0.14	0.12	0.26	1.09	**1.05**	**2.14**
26-Jun	0.38	0.17	0.55	**1.41**	0.50	1.91
6-Jul	0.84	0.84	1.68	0.69	0.61	1.30
15-Jul	0.83	0.77	1.60	0.84	0.65	1.49
16-Jul	0.42	0.28	0.70	0.63	0.30	0.93
17-Jul	0.09	0.04	0.13	1.22	0.40	1.62
21-Jul	0.44	0.35	0.79	0.39	0.27	0.66
22-Jul	0.63	0.45	1.08	0.47	0.36	0.83
25-Jul	0.64	0.54	1.18	0.78	0.67	1.45
28-Jul	0.56	0.49	1.05	0.46	0.40	0.86
5-Aug	1.01	0.76	1.77	0.84	0.64	1.48
25-Aug	0.13	0.11	0.24	0.59	0.56	1.15
8-Sep	0.15	0.11	0.26	0.77	0.69	1.46
14-Sep	0.17	0.15	0.32	0.36	0.33	0.69

Table 3. Maximum **2016** Modeled Impacts from **Connecticut** onroad mobile sources on days that exceeded the ozone NAAQS of 70 ppb at any monitor in the nonattainment area during the 2016 ozone season. 8-hr maximum modeled ozone contributions are relative values (ppb) at AQS monitors and absolute values (ppb) at EJ zip codes. Values that equal or exceed 1% of the NAAQS (0.70 ppb) are highlighted in red, while values that equal or exceed 0.5% of the NAAQS (0.35 ppb) are highlighted in yellow. Maximum source contributions are highlighted in **bold**.

New York-Northern New Jersey-Long Island, CT Nonattainment Area Receptors

Ozone Nonattainment Day	Max Ozone Impact at any AQS Monitor (ppb)			Max Ozone Impact at any EJ zip code (ppb)		
	LDV	MHDV	Total Vehicle	LDV	MHDV	Total Vehicle
22-Apr	0.48	0.15	0.63	0.11	0.04	0.15
12-May	1.67	0.79	2.46	0.63	0.30	0.93
25-May	2.08	0.83	2.91	0.51	0.24	0.75
26-May	2.22	1.11	3.33	0.97	**0.50**	1.47
27-May	0.12	0.03	0.15	0.13	0.07	0.20
28-May	1.74	0.28	2.02	0.34	0.07	0.41
29-May	0.58	0.07	0.65	0.26	0.05	0.31
7-Jun	0.45	0.21	0.66	0.29	0.15	0.44
16-Jun	1.57	0.66	2.23	0.77	0.31	1.08
21-Jun	2.08	0.93	3.01	0.85	0.43	1.28
23-Jun	2.19	1.03	3.22	0.46	0.20	0.66
26-Jun	1.10	0.24	1.34	0.71	0.16	0.87
6-Jul	**2.76**	**1.20**	**3.96**	0.92	0.47	1.39
12-Jul	0.67	0.27	0.94	0.83	0.37	1.20
15-Jul	1.84	0.60	2.44	0.73	0.30	1.03
17-Jul	0.81	0.14	0.95	**1.49**	0.27	**1.76**
18-Jul	0.93	0.38	1.31	0.33	0.17	0.50
21-Jul	1.83	0.72	2.55	0.72	0.36	1.08
22-Jul	1.10	0.36	1.46	0.19	0.07	0.26
11-Aug	0.71	0.27	0.98	0.06	0.03	0.09
12-Aug	1.39	0.44	1.83	0.38	0.14	0.52
13-Aug	0.55	0.10	0.65	0.65	0.11	0.76
24-Aug	0.52	0.25	0.77	0.82	0.41	1.23
31-Aug	0.33	0.13	0.46	0.43	0.20	0.63
8-Sep	0.33	0.13	0.46	0.26	0.10	0.36
14-Sep	0.50	0.19	0.69	0.20	0.09	0.29

Table 4. Maximum **2023** Projected Modeled Impacts from **Connecticut** onroad mobile sources on days that exceeded the ozone NAAQS of 70 ppb at any monitor in the nonattainment area during the 2016 ozone season. 8-hr maximum modeled ozone contributions are relative values (ppb) at AQS monitors and absolute values (ppb) at EJ zip codes. Values that equal or exceed 1% of the NAAQS (0.70 ppb) are highlighted in red, while values that equal or exceed 0.5% of the NAAQS (0.35 ppb) are highlighted in yellow. Maximum source contributions are highlighted in **bold**.

New York-Northern New Jersey-Long Island, CT Nonattainment Area Receptors

Ozone Nonattainment Day	Max Ozone Impact at any AQS Monitor (ppb)			Max Ozone Impact at any EJ zip code (ppb)		
	LDV	MHDV	Total Vehicle	LDV	MHDV	Total Vehicle
22-Apr	0.30	0.18	0.48	0.04	0.05	0.09
12-May	0.58	0.51	1.09	0.29	0.30	0.59
25-May	0.78	0.62	1.40	0.24	0.25	0.49
26-May	0.82	0.80	1.62	**0.61**	**0.58**	**1.19**
27-May	0.10	0.06	0.16	0.07	0.10	0.17
28-May	0.66	0.21	0.87	0.17	0.06	0.23
29-May	0.20	0.05	0.25	0.14	0.05	0.19
7-Jun	0.20	0.19	0.39	0.16	0.17	0.33
16-Jun	0.64	0.54	1.18	0.35	0.31	0.66
21-Jun	0.80	0.72	1.52	0.40	0.44	0.84
23-Jun	**1.03**	**0.95**	**1.98**	0.32	0.30	0.62
26-Jun	0.39	0.17	0.56	0.28	0.13	0.41
6-Jul	1.03	0.90	1.93	0.36	0.38	0.74
12-Jul	0.27	0.21	0.48	0.39	0.37	0.76
15-Jul	0.54	0.34	0.88	0.27	0.24	0.51
17-Jul	0.28	0.10	0.38	0.51	0.19	0.70
18-Jul	0.44	0.36	0.80	0.16	0.16	0.32
21-Jul	0.68	0.64	1.32	0.28	0.28	0.56
22-Jul	0.49	0.32	0.81	0.10	0.10	0.20
11-Aug	0.54	0.40	0.94	0.04	0.04	0.08
12-Aug	0.63	0.40	1.03	0.18	0.16	0.34
13-Aug	0.25	0.10	0.35	0.30	0.10	0.40
24-Aug	0.23	0.22	0.45	0.35	0.37	0.72
31-Aug	0.17	0.16	0.33	0.21	0.20	0.41
8-Sep	0.18	0.14	0.32	0.17	0.14	0.31
14-Sep	0.26	0.21	0.47	0.11	0.11	0.22

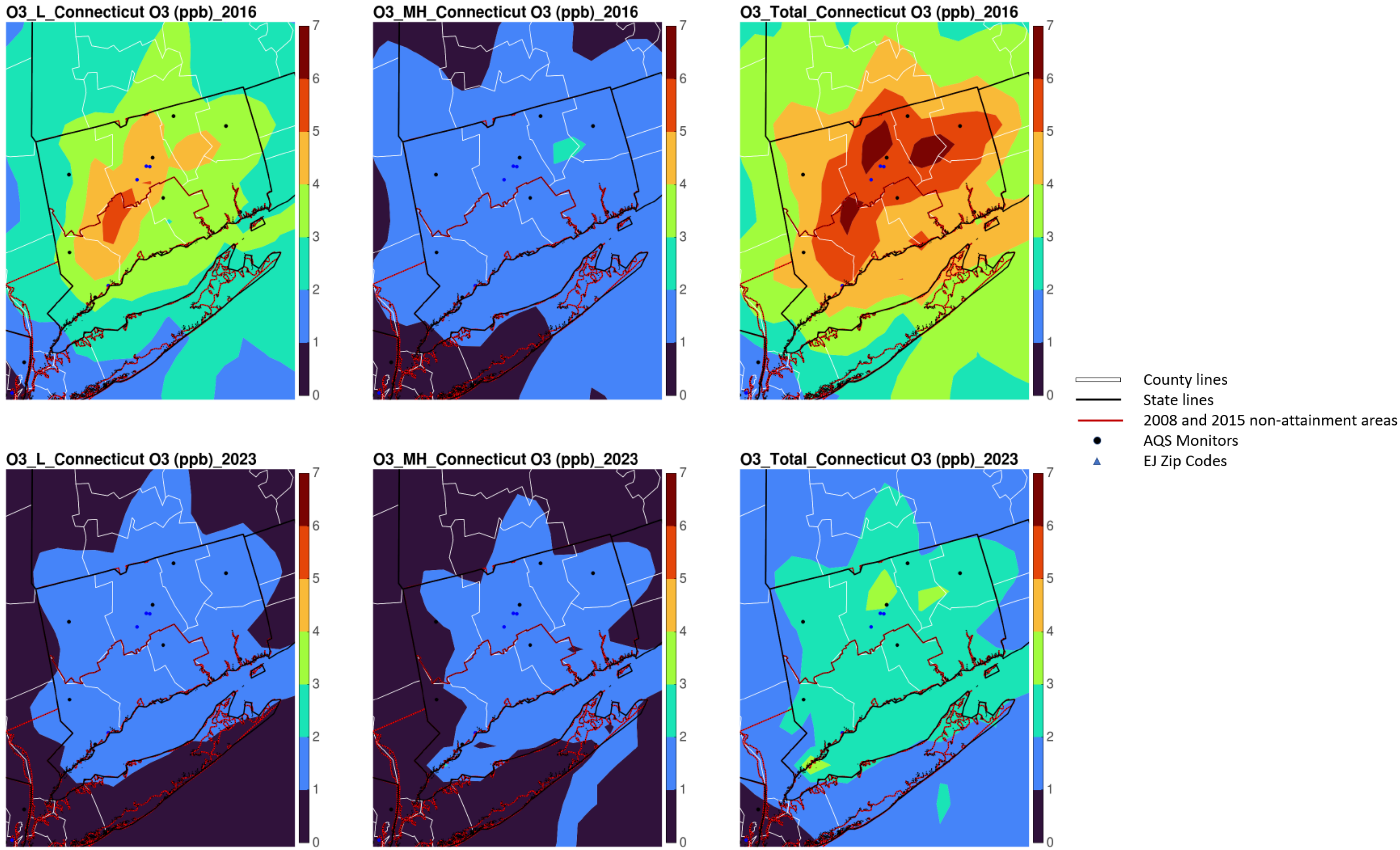

Figure 1. Absolute maximum modeled MDA8 ozone impacts (ppb) due to Connecticut onroad mobile sources during the 2016 ozone season (April to October). "L" denotes LDVs, "MH" denotes MHDVs, and "Total" denotes the combination of LDVs and MHDVs. 2016 shows base year modeled ozone impacts and 2023 shows projected future year modeled ozone impacts.

Illinois

Impacts from Illinois onroad mobile sources were evaluated at AQS monitors and at EJ zip codes located within the IL portion of Chicago and the IL portion of the St. Louis 2008 and 2015 ozone nonattainment areas. Impacts were pulled for days where the monitored MDA8 ozone concentrations in the nonattainment area exceeded the 70 ppb NAAQS.

2016 modeled contributions and projected 2023 modeled contributions from Illinois onroad mobile sources on 2016 nonattainment days are shown in **Tables 5 to 8**. Spatial plots showing absolute MDA8 modeled ozone impacts from Illinois mobiles sources (LDV, MHDV, and LDV+MHDV) during the 2016 ozone season (April to October) are shown in **Figure 2.**

Table 5. Maximum **2016** Modeled Impacts from **Illinois** onroad mobile sources on days that exceeded the ozone NAAQS of 70 ppb at any monitor in the nonattainment area during the 2016 ozone season. 8-hr maximum modeled ozone contributions are relative values (ppb) at AQS monitors and absolute values (ppb) at EJ zip codes. Values that equal or exceed 1% of the NAAQS (0.70 ppb) are highlighted in red, while values that equal or exceed 0.5% of the NAAQS (0.35 ppb) are highlighted in yellow. Maximum source contributions are highlighted in **bold.**

Chicago, IL Nonattainment Area Receptors

Ozone Nonattainment Day	Max Ozone Impact at any AQS Monitor (ppb)			Max Ozone Impact at any EJ zip code (ppb)		
	LDV	MHDV	Total Vehicle	LDV	MHDV	Total Vehicle
16-Apr	0.42	0.35	0.77	0.72	0.57	1.29
17-Apr	1.47	0.66	2.13	1.03	0.79	1.82
18-Apr	0.99	1.75	2.74	0.70	1.53	2.23
23-May	1.04	1.24	2.28	0.68	1.40	2.08
24-May	2.29	3.23	5.52	1.08	1.89	2.97
3-Jun	1.75	2.72	4.47	1.28	2.33	3.61
11-Jun	3.15	2.04	5.19	1.96	1.33	3.29
13-Jun	1.79	2.98	4.77	1.17	1.95	3.12
14-Jun	1.05	1.50	2.55	0.54	0.80	1.34
15-Jun	3.41	4.22	7.63	1.04	2.38	3.42
18-Jun	1.93	1.10	3.03	3.13	2.24	5.37
19-Jun	2.09	1.67	4.96	2.09	1.67	3.76
24-Jun	1.92	2.28	4.20	1.57	1.73	3.30
25-Jun	3.54	3.16	6.70	2.20	2.52	4.72
19-Jul	3.48	4.58	8.06	2.54	4.16	6.70
20-Jul	2.88	3.40	6.28	2.04	3.09	5.13
22-Jul	3.19	3.19	6.38	2.63	3.56	6.19
26-Jul	3.05	4.22	7.27	2.75	4.89	7.64
27-Jul	**4.96**	6.30	**11.26**	**3.28**	4.83	**8.11**
3-Aug	2.71	4.91	7.62	2.06	4.76	6.82
4-Aug	2.54	4.12	6.66	1.89	3.26	5.15
10-Aug	4.49	**6.42**	10.91	2.65	**5.21**	7.86

Table 6. Maximum **2023** Projected Modeled Impacts from **Illinois** onroad mobile sources on days that exceeded the ozone NAAQS of 70 ppb at any monitor in the nonattainment area during the 2016 ozone season. 8-hr maximum modeled ozone contributions are relative values (ppb) at AQS monitors and absolute values (ppb) at EJ zip codes. Values that equal or exceed 1% of the NAAQS (0.70 ppb) are highlighted in red, while values that equal or exceed 0.5% of the NAAQS (0.35 ppb) are highlighted in yellow. Maximum source contributions are highlighted in **bold.**

Chicago, IL Nonattainment Area Receptors

Ozone Nonattainment Day	Max Ozone Impact at any AQS Monitor (ppb)			Max Ozone Impact at any EJ zip code (ppb)		
	LDV	MHDV	Total Vehicle	LDV	MHDV	Total Vehicle
16-Apr	0.22	0.35	0.57	0.44	0.56	1.00
17-Apr	0.98	0.68	1.66	0.63	0.75	1.38
18-Apr	0.64	1.87	2.51	0.44	1.51	1.95
23-May	0.74	1.40	2.14	0.43	1.64	2.07
24-May	1.29	2.96	4.25	0.58	1.79	2.37
3-Jun	1.20	3.31	4.51	0.84	2.69	3.53
11-Jun	1.51	2.07	3.58	0.70	1.50	2.20
13-Jun	1.08	3.78	4.86	0.71	2.10	2.81
14-Jun	0.69	1.56	2.25	0.32	0.91	1.23
15-Jun	2.00	4.27	6.27	0.71	2.43	3.14
18-Jun	1.46	1.56	3.02	1.90	2.44	4.34
19-Jun	0.97	1.27	2.24	0.97	1.27	2.24
24-Jun	1.78	0.18	2.25	1.13	2.46	3.59
25-Jun	1.78	2.56	4.34	1.13	1.87	3.00
19-Jul	2.14	4.91	7.05	1.36	4.75	6.11
20-Jul	1.80	3.72	5.52	1.21	3.31	4.52
22-Jul	2.06	3.48	5.54	1.63	4.00	5.63
26-Jul	2.07	5.85	7.92	1.60	4.92	6.52
27-Jul	**3.06**	**7.07**	**10.13**	**2.03**	**5.22**	**7.25**
3-Aug	1.46	4.50	5.96	1.12	4.36	5.48
4-Aug	1.65	4.61	6.26	1.12	3.34	4.46
10-Aug	2.40	5.94	8.34	1.53	5.12	6.65

Table 7. Maximum **2016** Modeled Impacts from **Illinois** onroad mobile sources on days that exceeded the ozone NAAQS of 70 ppb at any monitor in the nonattainment area during the 2016 ozone season. 8-hr maximum modeled ozone contributions are relative values (ppb) at AQS monitors and absolute values (ppb) at EJ zip codes. Values that equal or exceed 1% of the NAAQS (0.70 ppb) are highlighted in red, while values that equal or exceed 0.5% of the NAAQS (0.35 ppb) are highlighted in yellow. Maximum source contributions are highlighted in **bold**.

St. Louis, IL Nonattainment Area Receptors

Ozone Nonattainment Day	Max Ozone Impact at any AQS Monitor (ppb)			Max Ozone Impact at any EJ zip code (ppb)		
	LDV	MHDV	Total Vehicle	LDV	MHDV	Total Vehicle
23-May	**1.52**	1.31	2.83	1.11	1.12	2.23
9-Jun	0.50	0.62	1.12	0.56	0.74	1.30
10-Jun	1.24	1.57	2.81	0.51	0.63	1.14
13-Jun	1.44	1.84	3.28	0.89	1.10	1.99
16-Jun	0.21	0.25	0.46	0.24	0.30	0.54
18-Jun	0.97	0.74	1.71	0.97	0.66	1.63
24-Jun	0.39	0.41	0.80	0.59	0.61	1.20
4-Aug	1.41	**2.02**	**3.43**	**1.50**	**2.17**	**3.67**
9-Aug	0.80	1.02	1.82	0.63	0.83	1.46
22-Sep	0.37	0.41	0.78	0.39	0.50	0.89
23-Sep	0.25	0.31	0.56	0.48	0.61	1.09

Table 8. Maximum **2023** Projected Modeled Impacts from **Illinois** onroad mobile sources on days that exceeded the ozone NAAQS of 70 ppb at any monitor in the nonattainment area during the 2016 ozone season. 8-hr maximum modeled ozone contributions are relative values (ppb) at AQS monitors and absolute values (ppb) at EJ zip codes. Values that equal or exceed 1% of the NAAQS (0.70 ppb) are highlighted in red, while values that equal or exceed 0.5% of the NAAQS (0.35 ppb) are highlighted in yellow. Maximum source contributions are highlighted in **bold**.

St. Louis, IL Nonattainment Area Receptors

Ozone Nonattainment Day	Max Ozone Impact at any AQS Monitor (ppb)			Max Ozone Impact at any EJ zip code (ppb)		
	LDV	MHDV	Total Vehicle	LDV	MHDV	Total Vehicle
23-May	**0.73**	0.97	1.70	0.55	0.89	1.44
9-Jun	0.24	0.46	0.70	0.27	0.53	0.80
10-Jun	0.69	1.33	2.02	0.25	0.49	0.74
13-Jun	0.70	1.38	2.08	0.45	0.86	1.31
16-Jun	0.11	0.20	0.31	0.16	0.35	0.51
18-Jun	0.45	0.52	0.97	0.42	0.46	0.88
24-Jun	0.21	0.35	0.56	0.35	0.59	0.94
4-Aug	0.70	**1.53**	**2.23**	**0.74**	**1.64**	**2.38**
9-Aug	0.49	1.02	1.51	0.37	0.78	1.15
22-Sep	0.22	0.37	0.59	0.22	0.45	0.67
23-Sep	0.15	0.28	0.43	0.27	0.59	0.86

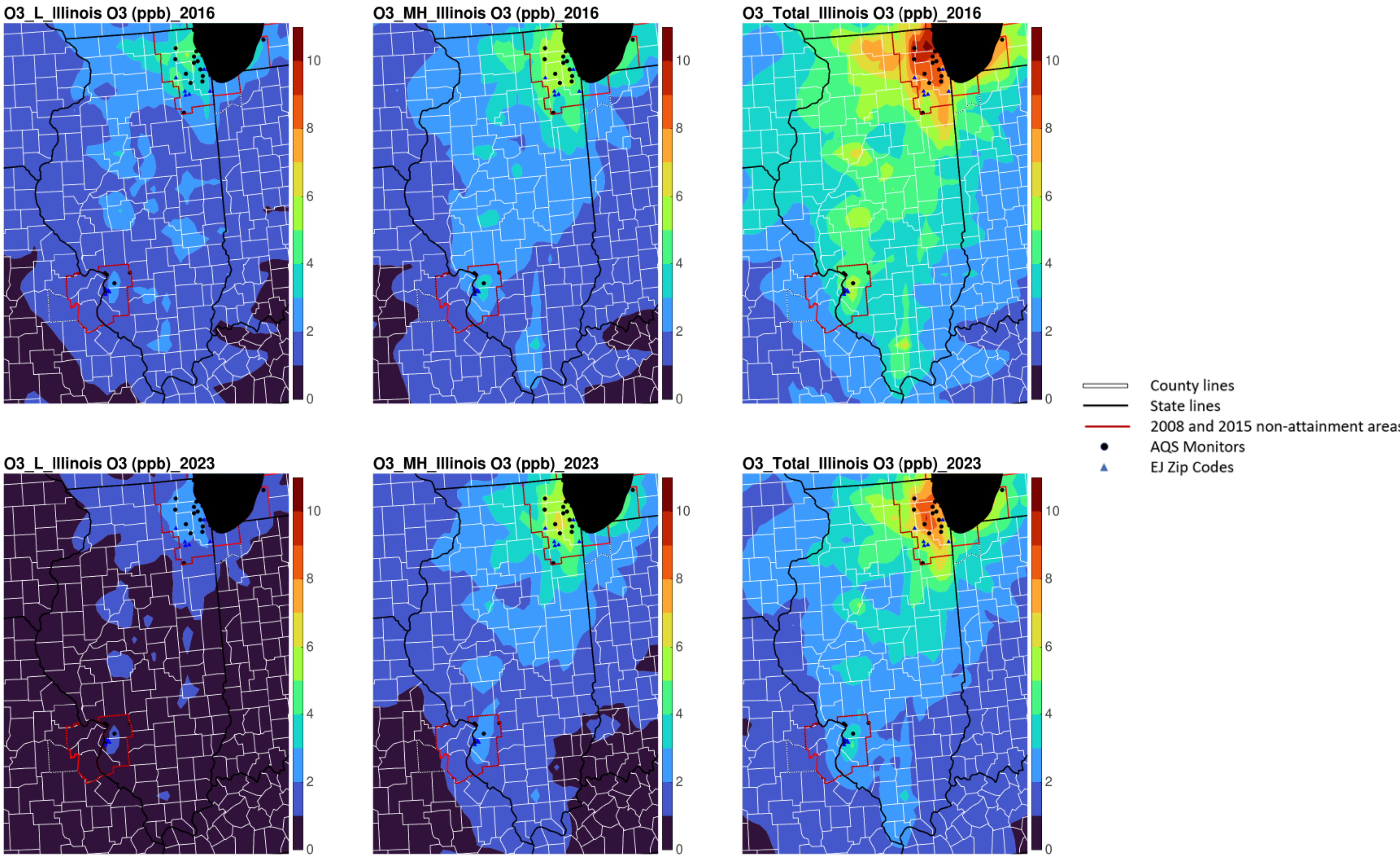

Figure 2. Absolute maximum modeled MDA8 ozone impacts (ppb) due to Illinois onroad mobile sources during the 2016 ozone season (April to October). "L" denotes LDVs, "MH" denotes MHDVs, and "Total" denotes the combination of LDVs and MHDVs. 2016 shows base year modeled ozone impacts and 2023 shows projected future year modeled ozone impacts.

Maryland

Impacts from Maryland onroad mobile sources were evaluated at AQS monitors located within Baltimore, the MD portion of the Philadelphia-Wilmington-Atlantic City, and the MD portion of Washington D.C. 2008 and 2015 ozone nonattainment areas. Impacts were pulled for days where the monitored MDA8 ozone concentrations in the nonattainment area exceeded the 70 ppb NAAQS.

2016 modeled contributions and projected 2023 modeled contributions from Maryland onroad mobile sources on 2016 nonattainment days are shown in **Tables 9 to 14**. Spatial plots showing absolute MDA8 modeled ozone impacts from Maryland mobiles sources (LDV, MHDV, and LDV+MHDV) during the 2016 ozone season (April to October) are shown in **Figure 3.**

Table 9. Maximum **2016** Modeled Impacts from **Maryland** onroad mobile sources on days that exceeded the ozone NAAQS of 70 ppb at any monitor in the nonattainment area during the 2016 ozone season. 8-hr maximum modeled ozone contributions are relative values (ppb) at AQS monitors. Values that equal or exceed 1% of the NAAQS (0.70 ppb) are highlighted in red, while values that equal or exceed 0.5% of the NAAQS (0.35 ppb) are highlighted in yellow. Maximum source contributions are highlighted in **bold**.

Baltimore, MD Nonattainment Area Receptors

Ozone Nonattainment Day	Max Ozone Impact at any AQS Monitor (ppb)		
	LDV	MHDV	Total Vehicle
25-May	2.86	3.08	5.94
26-May	2.39	2.62	5.01
27-May	3.13	3.31	6.44
28-May	4.83	5.52	10.35
1-Jun	3.93	4.82	8.75
20-Jun	4.45	5.26	9.71
6-Jul	3.66	4.86	8.52
16-Jul	3.68	4.58	8.26
19-Jul	3.23	3.90	7.13
21-Jul	4.74	**5.96**	10.70
22-Jul	3.82	4.12	7.94
25-Jul	4.27	5.23	9.50
26-Jul	2.79	3.41	6.20
27-Jul	4.29	3.88	8.17
29-Jul	2.92	3.13	6.05
29-Aug	**5.45**	5.70	**11.15**
31-Aug	5.09	5.86	10.95
7-Sep	1.36	1.44	2.80
14-Sep	3.57	4.30	7.87
22-Sep	1.26	1.42	2.68
23-Sep	4.34	3.93	8.27

Table 10. Maximum **2023** Projected Modeled Impacts from **Maryland** onroad mobile sources on days that exceeded the ozone NAAQS of 70 ppb at any monitor in the nonattainment area during the 2016 ozone season. 8-hr maximum modeled ozone contributions are relative values (ppb) at AQS monitors. Values that equal or exceed 1% of the NAAQS (0.70 ppb) are highlighted in red, while values that equal or exceed 0.5% of the NAAQS (0.35 ppb) are highlighted in yellow. Maximum source contributions are highlighted in **bold**.

Baltimore, MD Nonattainment Area Receptors

Ozone Nonattainment Day	Max Ozone Impact at any AQS Monitor (ppb)		
	LDV	**MHDV**	**Total Vehicle**
25-May	1.28	2.73	4.01
26-May	1.31	2.78	4.09
27-May	0.84	3.25	4.09
28-May	2.20	4.85	7.05
1-Jun	1.90	4.35	6.25
20-Jun	1.98	4.58	6.56
6-Jul	1.57	4.18	5.75
16-Jul	1.82	4.66	6.48
19-Jul	1.23	2.82	4.05
21-Jul	2.17	5.16	7.33
22-Jul	1.85	3.97	5.82
25-Jul	2.29	4.96	7.25
26-Jul	1.22	2.98	4.20
27-Jul	2.40	4.68	7.08
29-Jul	1.54	3.22	4.76
29-Aug	**2.86**	**5.97**	**8.83**
31-Aug	2.33	5.20	7.53
7-Sep	0.99	2.27	3.26
14-Sep	1.84	4.29	6.13
22-Sep	0.65	1.46	2.11
23-Sep	2.43	4.61	7.04

Table 11. Maximum **2016** Modeled Impacts from **Maryland** onroad mobile sources on days that exceeded the ozone NAAQS of 70 ppb at any monitor in the nonattainment area during the 2016 ozone season. 8-hr maximum modeled ozone contributions are relative values (ppb) at AQS monitors. Values that equal or exceed 1% of the NAAQS (0.70 ppb) are highlighted in red, while values that equal or exceed 0.5% of the NAAQS (0.35 ppb) are highlighted in yellow. Maximum source contributions are highlighted in **bold**.

Philadelphia-Wilmington-Atlantic City, MD Nonattainment Area Receptors

Ozone Nonattainment Day	Max Ozone Impact at any AQS Monitor (ppb)		
	LDV	MHDV	Total Vehicle
25-May	1.84	2.24	4.08
11-Jun	1.88	2.16	4.04
20-Jun	**4.11**	**5.02**	**9.13**
25-Jul	3.63	4.96	8.59
27-Aug	0.99	0.93	1.92
14-Sep	0.87	1.25	2.12
22-Sep	0.17	0.19	0.36
23-Sep	3.31	3.48	6.79

Table 12. Maximum **2023** Projected Modeled Impacts from **Maryland** onroad mobile sources on days that exceeded the ozone NAAQS of 70 ppb at any monitor in the nonattainment area during the 2016 ozone season. 8-hr maximum modeled ozone contributions are relative values (ppb) at AQS monitors. Values that equal or exceed 1% of the NAAQS (0.70 ppb) are highlighted in red, while values that equal or exceed 0.5% of the NAAQS (0.35 ppb) are highlighted in yellow. Maximum source contributions are highlighted in **bold**.

Philadelphia-Wilmington-Atlantic City, MD Nonattainment Area Receptors

Ozone Nonattainment Day	Max Ozone Impact at any AQS Monitor (ppb)		
	LDV	MHDV	Total Vehicle
25-May	0.62	1.45	2.07
11-Jun	0.92	2.13	3.05
20-Jun	**1.71**	3.93	**5.64**
25-Jul	1.58	**3.98**	5.56
27-Aug	0.40	0.70	1.10
14-Sep	0.42	1.14	1.56
22-Sep	0.18	0.43	0.61
23-Sep	1.65	3.33	4.98

Table 13. Maximum **2016** Modeled Impacts from **Maryland** onroad mobile sources on days that exceeded the ozone NAAQS of 70 ppb at any monitor in the nonattainment area during the 2016 ozone season. 8-hr maximum modeled ozone contributions are relative values (ppb) at AQS monitors. Values that equal or exceed 1% of the NAAQS (0.70 ppb) are highlighted in red, while values that equal or exceed 0.5% of the NAAQS (0.35 ppb) are highlighted in yellow. Maximum source contributions are highlighted in **bold**.

Washington D.C., MD Nonattainment Area Receptors

Ozone Nonattainment Day	Max Ozone Impact at any AQS Monitor (ppb)		
	LDV	MHDV	Total Vehicle
18-Apr	2.36	1.79	4.15
19-Apr	1.21	1.15	2.36
25-May	2.20	2.13	4.33
26-May	2.06	1.87	3.93
1-Jun	4.38	5.39	9.77
20-Jun	3.58	3.19	6.77
21-Jul	**5.62**	**5.83**	**11.45**
26-Jul	3.67	4.16	7.83
27-Jul	2.80	2.32	5.12
23-Sep	5.02	3.97	8.99

Table 14. Maximum 2023 Projected Modeled Impacts from **Maryland** onroad mobile sources on days that exceeded the ozone NAAQS of 70 ppb at any monitor in the nonattainment area during the 2016 ozone season. 8-hr maximum modeled ozone contributions are relative values (ppb) at AQS monitors. Values that equal or exceed 1% of the NAAQS (0.70 ppb) are highlighted in red, while values that equal or exceed 0.5% of the NAAQS (0.35 ppb) are highlighted in yellow. Maximum source contributions are highlighted in **bold**.

Washington D.C., MD Nonattainment Area Receptors

Ozone Nonattainment Day	Max Ozone Impact at any AQS Monitor (ppb)		
	LDV	MHDV	Total Vehicle
18-Apr	1.54	2.37	3.91
19-Apr	0.73	1.41	2.14
25-May	1.18	2.15	3.33
26-May	1.04	1.77	2.81
1-Jun	1.99	4.47	6.46
20-Jun	1.64	2.69	4.33
21-Jul	2.64	**5.25**	**7.89**
26-Jul	1.86	4.08	5.94
27-Jul	2.16	4.00	6.16
23-Sep	**2.78**	4.23	7.01

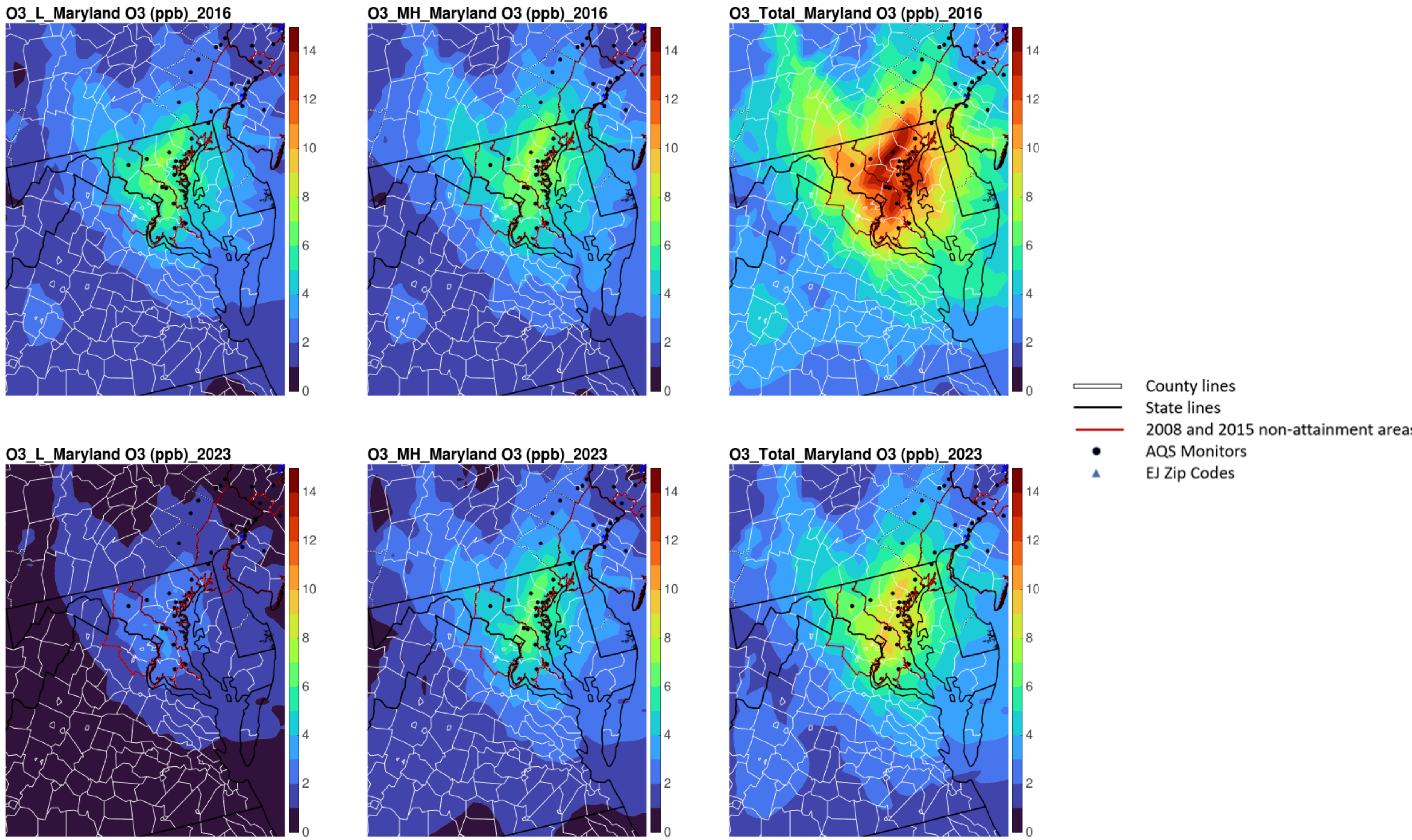

Figure 3. Absolute maximum modeled MDA8 ozone impacts (ppb) due to Maryland onroad mobile sources during the 2016 ozone season (April to October). "L" denotes LDVs, "MH" denotes MHDVs, and "Total" denotes the combination of LDVs and MHDVs. 2016 shows base year modeled ozone impacts and 2023 shows projected future year modeled ozone impacts.

Michigan

Impacts from Michigan onroad mobile sources were evaluated at AQS monitors and EJ zip codes located within Allegan County, Berrien County, Detroit, and Muskegon County 2015 ozone nonattainment areas. Impacts were pulled for days where the monitored MDA8 ozone concentrations in the nonattainment area exceeded the 70 ppb NAAQS.

2016 modeled contributions and projected 2023 modeled contributions from Michigan onroad mobile sources on 2016 nonattainment days are shown in **Tables 15 to 22**. Spatial plots showing absolute MDA8 modeled ozone impacts from Michigan mobiles sources (LDV, MHDV, and LDV+MHDV) during the 2016 ozone season (April to October) are shown in **Figure 4.**

Table 15. Maximum **2016** Modeled Impacts from **Michigan** onroad mobile sources on days that exceeded the ozone NAAQS of 70 ppb at any monitor in the nonattainment area during the 2016 ozone season. 8-hr maximum modeled ozone contributions are relative values (ppb) at AQS monitors. Values that equal or exceed 1% of the NAAQS (0.70 ppb) are highlighted in red, while values that equal or exceed 0.5% of the NAAQS (0.35 ppb) are highlighted in yellow. Maximum source contributions are highlighted in **bold**.

Allegan County, MI Nonattainment Area Receptors

Ozone Nonattainment Day	Max Ozone Impact at any AQS Monitor (ppb)		
	LDV	MHDV	Total Vehicle
16-Apr	2.68	0.79	3.47
17-Apr	2.48	0.53	3.01
18-Apr	1.96	0.91	2.87
25-May	1.97	1.38	3.35
10-Jun	0.71	0.37	1.08
11-Jun	0.29	0.08	0.37
19-Jun	0.91	0.28	1.19
25-Jun	**3.19**	**1.43**	**4.62**
6-Jul	0.30	0.18	0.48

Table 16. Maximum Projected **2023** Modeled Impacts from **Michigan** onroad mobile sources on days that exceeded the ozone NAAQS of 70 ppb at any monitor in the nonattainment area during the 2016 ozone season. 8-hr maximum modeled ozone contributions are relative values (ppb) at AQS monitors. Values that equal or exceed 1% of the NAAQS (0.70 ppb) are highlighted in red, while values that equal or exceed 0.5% of the NAAQS (0.35 ppb) are highlighted in yellow. Maximum source contributions are highlighted in **bold**.

Allegan County, MI Nonattainment Area Receptors

Ozone Nonattainment Day	Max Ozone Impact at any AQS Monitor (ppb)		
	LDV	MHDV	Total Vehicle
16-Apr	1.34	0.65	1.99
17-Apr	1.40	0.48	1.88
18-Apr	1.37	1.05	2.42
25-May	0.90	1.01	1.91
10-Jun	0.34	0.30	0.64
11-Jun	0.12	0.05	0.17
19-Jun	0.41	0.20	0.61
25-Jun	**1.41**	**1.08**	**2.49**
6-Jul	0.14	0.14	0.28

Table 17. Maximum **2016** Modeled Impacts from **Michigan** onroad mobile sources on days that exceeded the ozone NAAQS of 70 ppb at any monitor in the nonattainment area during the 2016 ozone season. 8-hr maximum modeled ozone contributions are relative values (ppb) at AQS monitors. Values that equal or exceed 1% of the NAAQS (0.70 ppb) are highlighted in red, while values that equal or exceed 0.5% of the NAAQS (0.35 ppb) are highlighted in yellow. Maximum source contributions are highlighted in **bold**.

Berrien County, MI Nonattainment Area Receptors

Ozone Nonattainment Day	Max Ozone Impact at any AQS Monitor (ppb)		
	LDV	MHDV	Total Vehicle
17-Apr	2.31	0.83	3.14
18-Apr	2.10	**1.57**	3.67
23-May	**2.48**	1.30	**3.78**
24-May	1.17	0.66	1.83
10-Jun	0.51	0.33	0.84
11-Jun	0.15	0.05	0.20
15-Jun	0.54	0.38	0.92
19-Jun	0.83	0.28	1.11
20-Jun	0.37	0.26	0.63
25-Jun	2.14	0.93	3.07
30-Jun	0.69	0.42	1.11

Table 18. Maximum **2023** Modeled Impacts from **Michigan** onroad mobile sources on days that exceeded the ozone NAAQS of 70 ppb at any monitor in the nonattainment area during the 2016 ozone season. 8-hr maximum modeled ozone contributions are relative values (ppb) at AQS monitors. Values that equal or exceed 1% of the NAAQS (0.70 ppb) are highlighted in red, while values that equal or exceed 0.5% of the NAAQS (0.35 ppb) are highlighted in yellow. Maximum source contributions are highlighted in **bold**.

Berrien County, MI Nonattainment Area Receptors

Ozone Nonattainment Day	Max Ozone Impact at any AQS Monitor (ppb)		
	LDV	MHDV	Total Vehicle
17-Apr	1.16	0.70	1.86
18-Apr	1.23	**1.53**	**2.76**
23-May	**1.24**	1.14	2.38
24-May	0.61	0.60	1.21
10-Jun	0.27	0.29	0.56
11-Jun	0.08	0.05	0.13
15-Jun	0.26	0.30	0.56
19-Jun	0.37	0.22	0.59
20-Jun	0.21	0.23	0.44
25-Jun	0.94	0.70	1.64
30-Jun	0.30	0.32	0.62

Table 19. Maximum **2016** Modeled Impacts from **Michigan** onroad mobile sources on days that exceeded the ozone NAAQS of 70 ppb at any monitor in the nonattainment area during the 2016 ozone season. 8-hr maximum modeled ozone contributions are relative values (ppb) at AQS monitors and absolute values (ppb) at EJ zip codes. Values that equal or exceed 1% of the NAAQS (0.70 ppb) are highlighted in red, while values that equal or exceed 0.5% of the NAAQS (0.35 ppb) are highlighted in yellow. Maximum source contributions are highlighted in **bold**.

Detroit, MI Nonattainment Area Receptors

Ozone Nonattainment Day	Max Ozone Impact at any AQS Monitor (ppb)			Max Ozone Impact at any EJ zip code (ppb)		
	LDV	MHDV	Total Vehicle	LDV	MHDV	Total Vehicle
17-Apr	1.75	0.72	2.47	0.63	0.15	0.78
18-Apr	2.92	1.47	4.39	1.05	0.86	1.91
23-May	2.07	1.43	3.50	0.93	0.61	1.54
24-May	3.42	2.31	5.73	1.69	1.19	2.88
25-May	2.37	2.20	4.57	0.58	0.56	1.14
10-Jun	0.82	0.67	1.49	0.26	0.22	0.48
18-Jun	5.74	3.00	8.74	2.21	0.88	3.09
19-Jun	3.55	0.98	4.53	1.01	0.36	1.37
30-Jun	5.75	3.24	8.99	3.32	2.05	5.37
27-Jul	**7.94**	**6.42**	**14.36**	**4.96**	4.03	**8.99**
10-Aug	6.50	5.27	11.77	4.81	**4.08**	8.89

Table 20. Maximum **2023** Projected Modeled Impacts from **Michigan** onroad mobile sources on days that exceeded the ozone NAAQS of 70 ppb at any monitor in the nonattainment area during the 2016 ozone season. 8-hr maximum modeled ozone contributions are relative values (ppb) at AQS monitors and absolute values (ppb) at EJ zip codes. Values that equal or exceed 1% of the NAAQS (0.70 ppb) are highlighted in red, while values that equal or exceed 0.5% of the NAAQS (0.35 ppb) are highlighted in yellow. Maximum source contributions are highlighted in **bold**.

Detroit, MI Nonattainment Area Receptors

Ozone Nonattainment Day	Max Ozone Impact at any AQS Monitor (ppb)			Max Ozone Impact at any EJ zip code (ppb)		
	LDV	MHDV	Total Vehicle	LDV	MHDV	Total Vehicle
17-Apr	1.30	0.38	1.68	0.45	0.15	0.60
18-Apr	1.76	1.33	3.09	0.64	0.89	1.53
23-May	1.00	1.04	2.04	0.67	0.66	1.33
24-May	1.96	2.18	4.14	0.90	1.10	2.00
25-May	1.44	2.15	3.59	0.33	0.54	0.87
10-Jun	0.62	0.96	1.58	0.19	0.31	0.50
18-Jun	3.30	2.55	5.85	1.67	1.08	2.75
19-Jun	1.91	0.77	2.68	0.56	0.30	0.86
30-Jun	3.77	4.22	7.99	1.74	1.91	3.65
27-Jul	**4.31**	5.71	10.02	2.54	3.44	5.98
10-Aug	4.28	**5.84**	**10.12**	**2.86**	**3.93**	**6.79**

Table 21. Maximum **2016** Modeled Impacts from **Michigan** onroad mobile sources on days that exceeded the ozone NAAQS of 70 ppb at any monitor in the nonattainment area during the 2016 ozone season. 8-hr maximum modeled ozone contributions are relative values (ppb) at AQS monitors. Values that equal or exceed 1% of the NAAQS (0.70 ppb) are highlighted in red, while values that equal or exceed 0.5% of the NAAQS (0.35 ppb) are highlighted in yellow. Maximum source contributions are highlighted in **bold**.

Muskegon County, MI Nonattainment Area Receptors

Ozone Nonattainment Day	Max Ozone Impact at any AQS Monitor (ppb)		
	LDV	MHDV	Total Vehicle
17-Apr	3.38	0.54	3.92
18-Apr	**3.44**	**1.24**	**4.68**
24-May	0.80	0.35	1.15
25-May	1.34	0.70	2.04
10-Jun	0.37	0.17	0.54
19-Jun	0.56	0.16	0.72
25-Jun	1.90	0.93	2.83

Table 22. Maximum **2023** Projected Modeled Impacts from **Michigan** onroad mobile sources on days that exceeded the ozone NAAQS of 70 ppb at any monitor in the nonattainment area during the 2016 ozone season. 8-hr maximum modeled ozone contributions are relative values (ppb) at AQS monitors. Values that equal or exceed 1% of the NAAQS (0.70 ppb) are highlighted in red, while values that equal or exceed 0.5% of the NAAQS (0.35 ppb) are highlighted in yellow. Maximum source contributions are highlighted in **bold**.

Muskegon County, MI Nonattainment Area Receptors

Ozone Nonattainment Day	Max Ozone Impact at any AQS Monitor (ppb)		
	LDV	MHDV	Total Vehicle
17-Apr	1.55	0.37	1.92
18-Apr	**1.74**	**0.99**	**2.73**
24-May	0.40	0.29	0.69
25-May	0.66	0.53	1.19
10-Jun	0.18	0.15	0.33
19-Jun	0.27	0.13	0.40
25-Jun	0.80	0.70	1.50

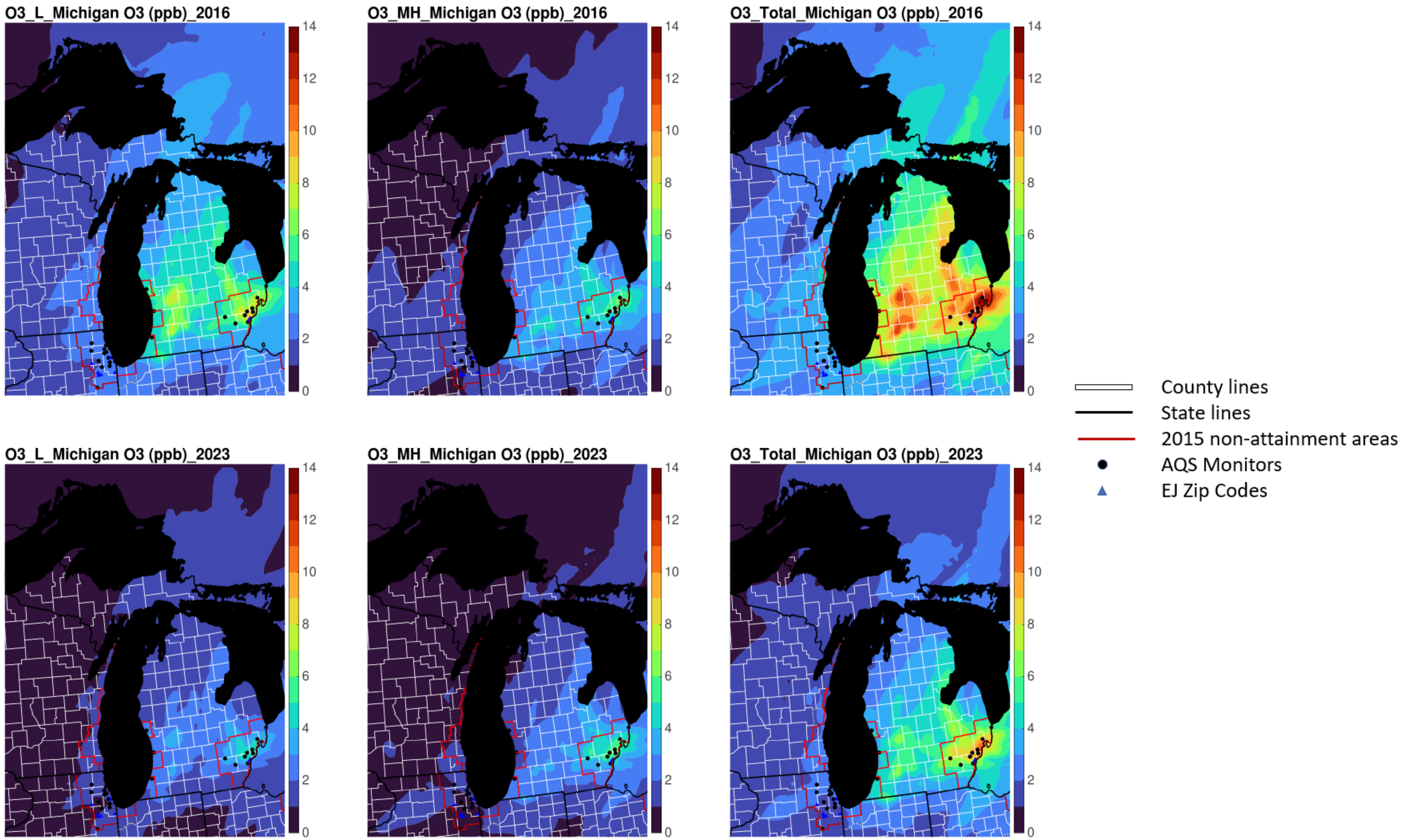

Figure 4. Absolute maximum modeled MDA8 ozone impacts (ppb) due to Michigan onroad mobile sources during the 2016 ozone season (April to October). "L" denotes LDVs, "MH" denotes MHDVs, and "Total" denotes the combination of LDVs and MHDVs. 2016 shows base year modeled ozone impacts and 2023 shows projected future year modeled ozone impacts.

New Jersey

Impacts from New Jersey onroad mobile sources were evaluated at AQS monitors and EJ zip codes located within the NJ portion of New York-Northern New Jersey-Long Island and the NJ portion of Philadelphia-Wilmington-Atlantic City 2008 and 2015 ozone nonattainment areas. Impacts were pulled for days where the monitored MDA8 ozone concentrations in the nonattainment area exceeded the 70 ppb NAAQS.

2016 modeled contributions and projected 2023 modeled contributions from New Jersey onroad mobile sources on 2016 nonattainment days are shown in **Tables 23 to 26**. Spatial plots showing absolute MDA8 modeled ozone impacts from New Jersey mobiles sources (LDV, MHDV, and LDV+MHDV) during the 2016 ozone season (April to October) are shown in **Figure 5.**

Table 23. Maximum **2016** Modeled Impacts from **New Jersey** onroad mobile sources on days that exceeded the ozone NAAQS of 70 ppb at any monitor in the nonattainment area during the 2016 ozone season. 8-hr maximum modeled ozone contributions are relative values (ppb) at AQS monitors and absolute values (ppb) at EJ zip codes. Values that equal or exceed 1% of the NAAQS (0.70 ppb) are highlighted in red, while values that equal or exceed 0.5% of the NAAQS (0.35 ppb) are highlighted in yellow. Maximum source contributions are highlighted in **bold**.

New York-Northern New Jersey-Long Island, NJ Nonattainment Area Receptors

Ozone Nonattainment Day	Max Ozone Impact at any AQS Monitor (ppb)			Max Ozone Impact at any EJ zip code (ppb)		
	LDV	MHDV	Total Vehicle	LDV	MHDV	Total Vehicle
25-May	1.36	1.57	2.93	1.02	1.32	2.34
26-May	1.80	2.53	4.33	1.68	2.31	3.99
27-May	1.73	1.93	3.66	1.16	1.28	2.44
28-May	1.97	2.25	4.22	2.27	2.54	4.81
1-Jun	1.68	2.21	3.89	1.82	1.95	3.77
11-Jun	0.86	0.50	1.36	0.42	0.48	0.90
15-Jun	1.12	1.66	2.78	1.82	2.40	4.22
19-Jun	**3.75**	3.48	**7.23**	1.97	1.47	3.44
20-Jun	2.04	2.71	4.75	2.07	2.68	4.75
24-Jun	1.19	1.15	2.34	0.81	0.71	1.52
6-Jul	2.05	2.17	4.22	2.37	3.15	5.52
16-Jul	0.88	0.87	1.75	2.40	2.36	4.76
21-Jul	1.96	2.65	4.56	1.94	2.71	4.65
22-Jul	1.16	1.47	2.63	1.33	1.63	2.96
28-Jul	2.60	**3.64**	6.24	**2.92**	**3.88**	**6.80**
29-Jul	2.88	3.04	5.92	1.98	2.53	4.51
24-Aug	1.85	2.40	4.25	2.41	3.42	5.83
23-Sep	0.78	0.74	1.52	1.86	2.17	4.03

Table 24. Maximum **2023** Projected Modeled Impacts from **New Jersey** onroad mobile sources on days that exceeded the ozone NAAQS of 70 ppb at any monitor in the nonattainment area during the 2016 ozone season. 8-hr maximum modeled ozone contributions are relative values (ppb) at AQS monitors and absolute values (ppb) at EJ zip codes. Values that equal or exceed 1% of the NAAQS (0.70 ppb) are highlighted in red, while values that equal or exceed 0.5% of the NAAQS (0.35 ppb) are highlighted in yellow. Maximum source contributions are highlighted in **bold**.

New York-Northern New Jersey-Long Island, NJ Nonattainment Area Receptors

Ozone Nonattainment Day	Max Ozone Impact at any AQS Monitor (ppb)			Max Ozone Impact at any EJ zip code (ppb)		
	LDV	MHDV	Total Vehicle	LDV	MHDV	Total Vehicle
25-May	0.38	1.26	1.64	0.32	1.06	1.38
26-May	0.64	1.87	2.51	0.76	1.90	2.66
27-May	0.73	1.54	2.27	0.55	1.17	1.72
28-May	0.78	1.63	2.41	0.86	1.81	2.67
1-Jun	0.70	1.76	2.46	0.60	1.19	1.79
11-Jun	0.27	0.35	0.62	0.19	0.44	0.63
15-Jun	0.42	1.17	1.59	0.61	2.02	2.63
19-Jun	1.39	2.40	3.79	0.85	1.23	2.08
20-Jun	0.83	2.04	2.87	0.97	2.31	3.28
24-Jun	0.50	0.93	1.43	0.33	0.53	0.86
6-Jul	0.92	1.73	2.65	0.94	2.38	3.32
16-Jul	0.39	0.68	1.07	1.03	1.90	2.93
21-Jul	0.22	1.98	3.28	0.72	1.90	2.62
22-Jul	0.47	1.15	1.62	0.52	1.27	1.79
28-Jul	1.09	2.99	4.08	**1.12**	**3.06**	**4.18**
29-Jul	**1.43**	**3.01**	**4.44**	0.82	1.86	2.68
24-Aug	0.89	2.23	3.12	1.07	2.93	4.00
23-Sep	0.34	0.62	0.96	0.87	2.10	2.97

Table 25. Maximum **2016** Modeled Impacts from **New Jersey** onroad mobile sources on days that exceeded the ozone NAAQS of 70 ppb at any monitor in the nonattainment area during the 2016 ozone season. 8-hr maximum modeled ozone contributions are relative values (ppb) at AQS monitors. Values that equal or exceed 1% of the NAAQS (0.70 ppb) are highlighted in red, while values that equal or exceed 0.5% of the NAAQS (0.35 ppb) are highlighted in yellow. Maximum source contributions are highlighted in **bold**.

Philadelphia-Wilmington-Atlantic City, NJ Nonattainment Area Receptors

Ozone Nonattainment Day	Max Ozone Impact at any AQS Monitor (ppb)		
	LDV	MHDV	Total Vehicle
12-May	1.25	0.86	2.11
25-May	0.02	0.02	0.04
26-May	0.44	0.41	0.85
27-May	0.07	0.06	0.13
28-May	1.25	0.11	0.26
1-Jun	**1.95**	**1.64**	**3.59**
11-Jun	0.48	0.30	0.78
15-Jun	0.74	0.60	1.34
20-Jun	0.35	0.32	0.67
24-Jun	1.10	0.93	2.03
26-Jun	1.35	0.94	2.29
8-Jul	0.77	0.77	1.54
21-Jul	0.38	0.39	0.77
22-Jul	0.18	0.15	0.33
25-Jul	0.23	0.23	0.46
27-Jul	1.46	1.53	2.99
24-Aug	0.33	0.34	0.67
31-Aug	0.52	0.54	1.06
14-Sep	0.94	0.71	1.65
23-Sep	1.44	0.88	2.32

Table 26. Maximum **2023** Projected Modeled Impacts from **New Jersey** onroad mobile sources on days that exceeded the ozone NAAQS of 70 ppb at any monitor in the nonattainment area during the 2016 ozone season. 8-hr maximum modeled ozone contributions are relative values (ppb) at AQS monitors. Values that equal or exceed 1% of the NAAQS (0.70 ppb) are highlighted in red, while values that equal or exceed 0.5% of the NAAQS (0.35 ppb) are highlighted in yellow. Maximum source contributions are highlighted in **bold**.

Philadelphia-Wilmington-Atlantic City, NJ Nonattainment Area Receptors

Ozone Nonattainment Day	**Max Ozone Impact at any AQS Monitor (ppb)**		
	LDV	**MHDV**	**Total Vehicle**
12-May	0.67	0.75	1.42
25-May	0.01	0.02	0.03
26-May	0.18	0.30	0.48
27-May	0.03	0.04	0.07
28-May	0.22	0.07	0.48
1-Jun	**0.79**	1.19	1.98
11-Jun	0.17	0.17	0.34
15-Jun	0.36	0.57	0.93
20-Jun	0.13	0.22	0.35
24-Jun	0.41	0.66	1.07
26-Jun	0.45	0.57	1.02
8-Jul	0.31	0.59	0.90
21-Jul	0.14	0.27	0.41
22-Jul	0.07	0.10	0.17
25-Jul	0.10	0.19	0.29
27-Jul	0.67	**1.35**	**2.02**
24-Aug	0.14	0.18	1.02
31-Aug	0.21	0.39	0.60
14-Sep	0.38	0.53	0.91
23-Sep	0.67	0.82	1.49

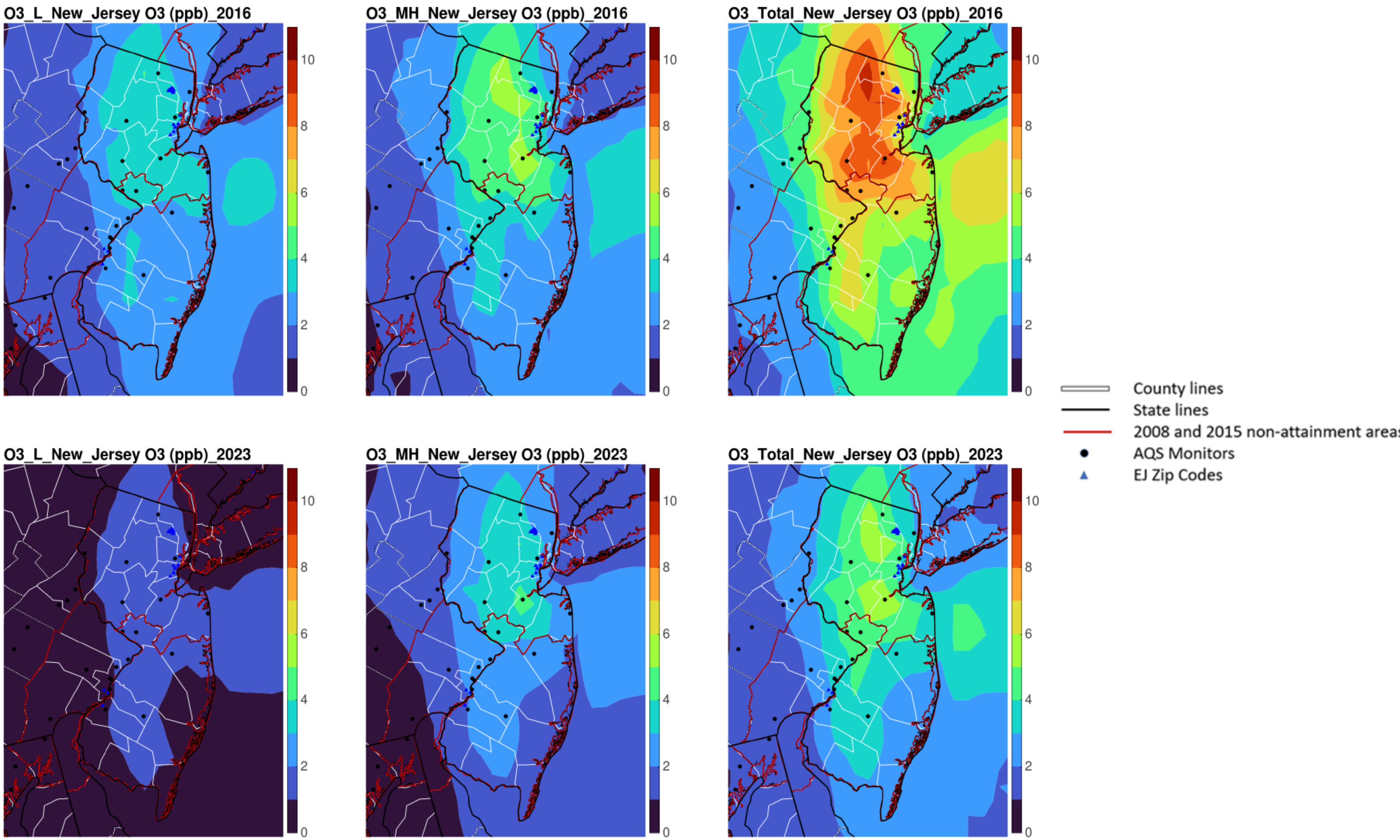

Figure 5. Absolute maximum modeled MDA8 ozone impacts (ppb) due to New Jersey onroad mobile sources during the 2016 ozone season (April to October). "L" denotes LDVs, "MH" denotes MHDVs, and "Total" denotes the combination of LDVs and MHDVs. 2016 shows base year modeled ozone impacts and 2023 shows projected future year modeled ozone impacts.

Pennsylvania

Impacts from Pennsylvania onroad mobile sources were evaluated at AQS monitors and EJ zip codes located within Lancaster County, Pittsburgh-Beaver Valley, and Reading County 2008 ozone nonattainment areas, and within the PA portion of the Philadelphia-Wilmington-Atlantic City, PA 2008 and 2015 ozone nonattainment area. Impacts were pulled for days where the monitored MDA8 ozone concentrations in the nonattainment area exceeded the 70 ppb NAAQS.

2016 modeled contributions and projected 2023 modeled contributions from Pennsylvania onroad mobile sources on 2016 nonattainment days are shown in **Tables 27 to 34**. Spatial plots showing absolute MDA8 modeled ozone impacts from Pennsylvania mobiles sources (LDV, MHDV, and LDV+MHDV) during the 2016 ozone season (April to October) are shown in **Figure 6.**

Table 27. Maximum **2016** Modeled Impacts from **Pennsylvania** onroad mobile sources on days that exceeded the ozone NAAQS of 70 ppb at any monitor in the nonattainment area during the 2016 ozone season. 8-hr maximum modeled ozone contributions are relative values (ppb) at AQS monitors. Values that equal or exceed 1% of the NAAQS (0.70 ppb) are highlighted in red, while values that equal or exceed 0.5% of the NAAQS (0.35 ppb) are highlighted in yellow. Maximum source contributions are highlighted in **bold**.

Lancaster County, PA Nonattainment Area Receptors

Ozone Nonattainment Day	Max Ozone Impact at any AQS Monitor (ppb)		
	LDV	MHDV	Total Vehicle
25-May	1.65	2.15	3.80
1-Jun	2.64	**3.29**	5.93
23-Sep	**2.92**	3.22	**6.14**

Table 28. Maximum **2023** Projected Modeled Impacts from **Pennsylvania** onroad mobile sources on days that exceeded the ozone NAAQS of 70 ppb at any monitor in the nonattainment area during the 2016 ozone season. 8-hr maximum modeled ozone contributions are relative values (ppb) at AQS monitors. Values that equal or exceed 1% of the NAAQS (0.70 ppb) are highlighted in red, while values that equal or exceed 0.5% of the NAAQS (0.35 ppb) are highlighted in yellow. Maximum source contributions are highlighted in **bold**.

Lancaster County, PA Nonattainment Area Receptors

Ozone Nonattainment Day	Max Ozone Impact at any AQS Monitor (ppb)		
	LDV	MHDV	Total Vehicle
25-May	0.81	1.82	2.63
1-Jun	1.18	2.61	3.79
23-Sep	**1.66**	**3.16**	**4.82**

Table 29. Maximum **2016** Modeled Impacts from **Pennsylvania** onroad mobile sources on days that exceeded the ozone NAAQS of 70 ppb at any monitor in the nonattainment area during the 2016 ozone season. 8-hr maximum modeled ozone contributions are relative values (ppb) at AQS monitors and absolute values (ppb) at EJ zip codes. Values that equal or exceed 1% of the NAAQS (0.70 ppb) are highlighted in red, while values that equal or exceed 0.5% of the NAAQS (0.35 ppb) are highlighted in yellow. Maximum source contributions are highlighted in **bold**.

Philadelphia-Wilmington-Atlantic City, PA Nonattainment Area Receptors

Ozone Nonattainment Day	Max Ozone Impact at any AQS Monitor (ppb)			Max Ozone Impact at any EJ zip code (ppb)		
	LDV	MHDV	Total Vehicle	LDV	MHDV	Total Vehicle
25-May	2.28	2.61	4.89	1.29	1.56	2.85
26-May	1.40	1.42	2.82	0.50	0.58	1.08
1-Jun	1.76	2.17	3.93	1.60	1.96	3.56
11-Jun	1.61	1.54	3.15	0.77	0.77	1.54
15-Jun	2.52	2.61	5.13	1.15	1.49	2.64
20-Jun	4.26	4.64	8.90	**2.85**	**3.15**	**6.00**
25-Jun	1.90	1.74	3.64	1.11	0.87	1.98
21-Jul	**4.68**	**5.59**	**10.27**	2.43	3.00	5.43
22-Jul	1.39	1.47	2.86	0.77	0.82	1.59
31-Aug	4.08	4.39	8.47	2.28	2.63	4.91
14-Sep	1.71	2.02	3.73	1.93	2.30	4.23
22-Sep	1.10	0.57	1.67	0.47	0.47	0.94
23-Sep	3.84	4.05	7.89	2.45	2.42	4.87

Table 30. Maximum **2023** Projected Modeled Impacts from **Pennsylvania** onroad mobile sources on days that exceeded the ozone NAAQS of 70 ppb at any monitor in the nonattainment area during the 2016 ozone season. 8-hr maximum modeled ozone contributions are relative values (ppb) at AQS monitors and absolute values (ppb) at EJ zip codes. Values that equal or exceed 1% of the NAAQS (0.70 ppb) are highlighted in red, while values that equal or exceed 0.5% of the NAAQS (0.35 ppb) are highlighted in yellow. Maximum source contributions are highlighted in **bold**.

Philadelphia-Wilmington-Atlantic City, PA Nonattainment Area Receptors

Ozone Nonattainment Day	Max Ozone Impact at any AQS Monitor (ppb)			Max Ozone Impact at any EJ zip code (ppb)		
	LDV	MHDV	Total Vehicle	LDV	MHDV	Total Vehicle
25-May	1.13	2.33	3.46	0.59	1.32	1.91
26-May	0.73	1.36	2.09	0.21	0.50	0.71
1-Jun	0.80	1.68	2.48	0.67	1.54	2.21
11-Jun	0.72	1.23	1.95	0.32	0.56	0.88
15-Jun	1.50	2.94	4.44	0.57	1.29	1.86
20-Jun	1.94	3.84	5.78	1.23	**2.45**	**3.68**
25-Jun	0.83	1.55	2.38	0.46	0.81	1.27
21-Jul	**2.21**	**4.90**	**7.11**	1.06	2.38	3.44
22-Jul	0.65	1.36	2.01	0.35	0.74	1.09
31-Aug	2.16	4.51	6.67	1.07	2.25	3.32
14-Sep	0.82	1.73	2.55	0.93	2.07	3.00
22-Sep	0.83	1.12	1.95	0.24	0.49	0.73
23-Sep	2.00	3.83	5.83	**1.28**	2.35	3.63

Table 31. Maximum **2016** Modeled Impacts from **Pennsylvania** onroad mobile sources on days that exceeded the ozone NAAQS of 70 ppb at any monitor in the nonattainment area during the 2016 ozone season. 8-hr maximum modeled ozone contributions are relative values (ppb) at AQS monitors and absolute values (ppb) at EJ zip codes. Values that equal or exceed 1% of the NAAQS (0.70 ppb) are highlighted in red, while values that equal or exceed 0.5% of the NAAQS (0.35 ppb) are highlighted in yellow. Maximum source contributions are highlighted in **bold**.

Pittsburgh-Beaver Valley, PA Nonattainment Area Receptors

Ozone Nonattainment Day	Max Ozone Impact at any AQS Monitor (ppb)			Max Ozone Impact at any EJ zip code (ppb)		
	LDV	MHDV	Total Vehicle	LDV	MHDV	Total Vehicle
25-Jun	2.35	2.83	5.18	2.77	**3.91**	**6.68**
21-Jul	1.68	2.05	3.73	1.65	2.22	3.87
27-Jul	2.24	**3.16**	5.40	2.39	2.96	5.35
5-Sep	**3.20**	3.08	**6.28**	**3.01**	2.77	5.78
23-Sep	1.12	1.43	2.55	1.04	1.26	2.30

Table 32. Maximum **2023** Projected Modeled Impacts from **Pennsylvania** onroad mobile sources on days that exceeded the ozone NAAQS of 70 ppb at any monitor in the nonattainment area during the 2016 ozone season. 8-hr maximum modeled ozone contributions are relative values (ppb) at AQS monitors and EJ zip codes. Values that equal or exceed 1% of the NAAQS (0.70 ppb) are highlighted in red, while values that equal or exceed 0.5% of the NAAQS (0.35 ppb) are highlighted in yellow. Maximum source contributions are highlighted in **bold**.

Pittsburgh-Beaver Valley, PA Nonattainment Area Receptors

Ozone Nonattainment Day	Max Ozone Impact at any AQS Monitor (ppb)			Max Ozone Impact at any EJ zip code (ppb)		
	LDV	MHDV	Total Vehicle	LDV	MHDV	Total Vehicle
25-Jun	1.06	2.22	3.28	1.27	2.91	4.18
21-Jul	0.88	1.81	2.69	0.89	1.97	2.86
27-Jul	1.23	**2.85**	4.08	1.57	**3.41**	**4.98**
5-Sep	**1.71**	2.72	**4.43**	**1.67**	2.53	4.20
23-Sep	0.65	1.42	2.07	0.65	1.36	2.01

Table 33. Maximum **2016** Modeled Impacts from **Pennsylvania** onroad mobile sources on days that exceeded the ozone NAAQS of 70 ppb at any monitor in the nonattainment area during the 2016 ozone season. 8-hr maximum modeled ozone contributions are relative values (ppb) at AQS monitors. Values that equal or exceed 1% of the NAAQS (0.70 ppb) are highlighted in red, while values that equal or exceed 0.5% of the NAAQS (0.35 ppb) are highlighted in yellow. Maximum source contributions are highlighted in **bold**.

Reading County, PA Nonattainment Area Receptors

Ozone Nonattainment Day	Max Ozone Impact at any AQS Monitor (ppb)		
	LDV	MHDV	Total Vehicle
25-May	1.76	2.57	4.33
24-Jun	0.81	0.93	1.74
21-Jul	**4.31**	**6.01**	**10.32**

Table 34. Maximum **2023** Projected Modeled Impacts from **Pennsylvania** onroad mobile sources on days that exceeded the ozone NAAQS of 70 ppb at any monitor in the nonattainment area during the 2016 ozone season. 8-hr maximum modeled ozone contributions are relative values (ppb) at AQS monitors. Values that equal or exceed 1% of the NAAQS (0.70 ppb) are highlighted in red, while values that equal or exceed 0.5% of the NAAQS (0.35 ppb) are highlighted in yellow. Maximum source contributions are highlighted in **bold**.

Reading County, PA Nonattainment Area Receptors

Ozone Nonattainment Day	Max Ozone Impact at any AQS Monitor (ppb)		
	LDV	MHDV	Total Vehicle
17-Apr	0.80	1.99	2.79
18-Apr	0.49	1.09	1.58
24-May	**1.85**	**4.43**	**6.28**

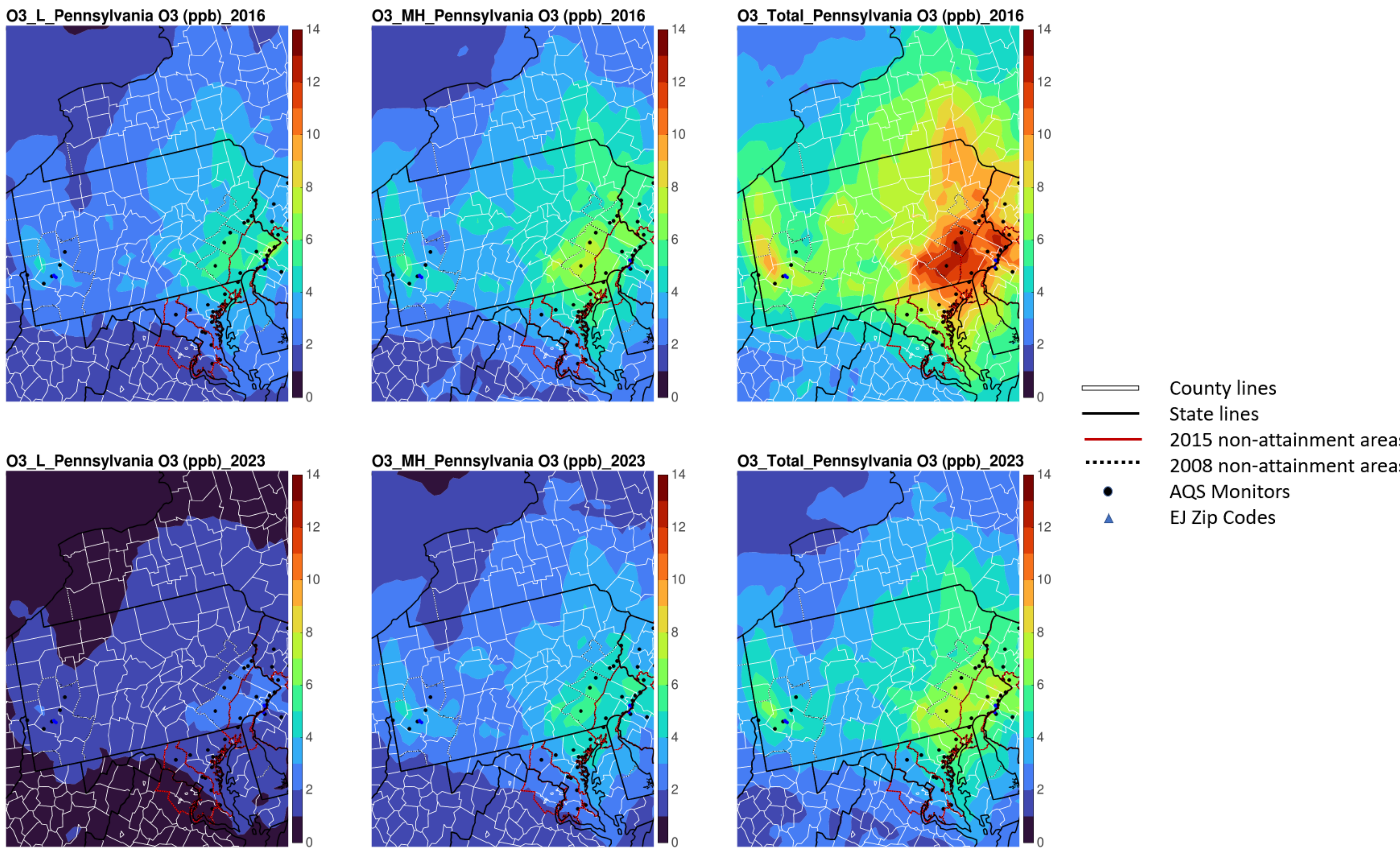

Figure 6. Absolute maximum modeled MDA8 ozone impacts (ppb) due to Pennsylvania onroad mobile sources during the 2016 ozone season (April to October). "L" denotes LDVs, "MH" denotes MHDVs, and "Total" denotes the combination of LDVs and MHDVs. 2016 shows base year modeled ozone impacts and 2023 shows projected future year modeled ozone impacts.

Appendix A. Modeling Methods

Photochemical Grid Model and Source Apportionment

To quantify the ozone impacts due to precursor emissions from mobile sources and other emission source groups, Sonoma Technology performed CAMx OSAT source apportionment model simulations for the 2016 ozone season (April to October). CAMx OSAT simulations were also conducted for the 2023 future year.[3] The modeling domain covers all lower 48 U.S. states, plus adjacent portions of Canada and Mexico, using a horizontal grid resolution of 12 km x 12 km. The domain and configurations used were based on those developed by EPA in recent ozone transport assessments using CAMx OSAT (U.S. Environmental Protection Agency, 2022a), and included the use of the carbon-bond 6 gas phase chemistry mechanism and the two-mode course/fine (CF) aerosol chemistry mechanism.

The Comprehensive Air Quality Model with Extensions (CAMx version 7.10) (Ramboll US Corporation, 2020) is a publicly available, peer-reviewed, state-of-the-science three-dimensional grid-based (Eulerian) photochemical air quality model designed to simulate the emission, transport, diffusion, chemical transformation, and removal of gaseous and particle pollutants in the atmosphere over spatial scales ranging from continental to urban. CAMx was designed to approach air quality wholistically by including capabilities for modeling multiple air quality issues, including tropospheric ozone, fine particles, visibility degradation, acid deposition, air toxics, and mercury. The ability of photochemical grid models, such as CAMx, to treat a large number of sources and their chemical interactions makes them well suited for assessing the impacts of natural and anthropogenic emissions sources on air quality. CAMx is widely used to support regulatory air quality assessments and air quality management policy decisions in the United States. In recent years, the EPA has used CAMx to support the NAAQS designation process (U.S. Environmental Protection Agency, 2015) and evaluate interstate pollutant transport (U.S. Environmental Protection Agency 2015a, 2021a, 2022a).

CAMx also includes OSAT, which can be used to estimate the contributions of individual sources, groups of sources, or source regions to ozone concentrations at a given receptor location (Yarwood et al., 1996). Source apportionment modeling is useful for understanding model performance, designing emission control strategies, and performing culpability assessments to identify emission sources that contribute significantly to pollution. The key precursor species for ozone production are volatile organic compounds (VOC) and oxides of nitrogen (NO_x). OSAT uses reactive tracers to track the fate of these precursor emissions and the ozone formation resulting from them within a CAMx simulation. The ozone and precursors are tracked and apportioned by OSAT without perturbing the host model chemistry; therefore, the OSAT results are fully consistent with the host model results for total concentrations. OSAT can efficiently estimate source contributions from multiple emission

[3] Future year ozone is modeled using emissions that have been projected to the future year, but using meteorology, boundary conditions, and other inputs representative of the 2016 base year.

sources within a single model simulation. Importantly, while source apportionment modeling can be used to estimate source contributions to ozone concentrations for a given set of emission inputs, sensitivity modeling approaches such as brute-force modeling[4] or the direct decoupled method (DDM)[5] are needed to quantify the effect of a given emission control scenario (e.g., 90% NO_x reduction) on ozone concentrations.

2016 EPA Model Platform

The CAMx OSAT simulations were based on EPA's 2016 air quality modeling platform. A modeling platform consists of a structured system of connected data and models that provide a consistent and transparent basis for assessing the air quality impact of anticipated changes in emissions. EPA typically develops and evaluates a new modeling platform each time the National Emissions Inventory (NEI) is updated (every three years). EPA has recently used the 2016 modeling platform to support the proposed Federal Implementation Plan ("Transport Rule") to help states fully resolve their obligations under the "Good Neighbor" provision of the Clean Air Act for the 2015 ozone NAAQS (U.S. Environmental Protection Agency, 2022a).

The CAMx OSAT simulations relied on EPA's 2016v2 (2016fj_16j) modeling platform. This platform draws on emissions data from the 2017 NEI (released spring of 2020) and data developed by the National Emissions Inventory Collaborative.[6] The NEI is compiled by EPA on a triennial basis, primarily from data submitted by state, local, and tribal air agencies. The 2017 NEI includes emissions from five source sectors: point sources, nonpoint (or area) sources, onroad mobile sources, nonroad mobile sources, and fire events. These NEI source sectors are divided into 20 sectors for the modeling platform. For the 2016v2 modeling platform, EPA updated the 2017 NEI data to represent year 2016 through the incorporation of 2016-specific state and local data along with adjustment methods appropriate for each emission sector.

For air quality modeling purposes, the 2016 NEI data was augmented by EPA to include biogenic emissions and data from Canadian and Mexican emissions inventories. In addition, the annualized point source data for EGUs in the NEI were replaced with hourly 2016 continuous emissions monitoring (CEMS) data from EPA's Clean Air Markets Division for SO_2 and NO_x. Annual emissions for pollutants were converted to an hourly basis using CEMS input data (U.S. Environmental Protection Agency, 2022c). The EGUs in the modeling platform are matched to units found in the National Electric Energy Data System (NEEDS) v6.20 database.[7] Onroad and nonroad mobile source emissions

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[4] The brute-force modeling method involves running the model both with and without emission controls applied to the source(s) of interest. The difference in pollutant concentrations between the two simulations yields the impact of the emission control scenario.
[5] DDM provides sensitivity coefficients that relate emissions changes to model outcomes. These sensitivity coefficients can be used to evaluate how pollutant concentrations would respond to a range of changes in emissions from a source or group of sources.
[6] The National Emissions Inventory Collaborative is a partnership between state emissions inventory staff, multi-jurisdictional organizations, federal land managers, EPA, and others to develop a North American air pollution emissions modeling platform for use in air quality planning.
[7] https://www.epa.gov/airmarkets/national-electric-energy-data-system-needs-v6 dated 5/28/2021.

were developed using the version 3 of the Motor Vehicle Emissions Simulator (MOVES3) using activity data provided by state and local agencies.

EPA also developed emission inventories for future years of 2023 (2023fj_16j), 2026 (2026fj_16j), and 2032 (2032fj_16j). EPA used sector-specific methods to project the 2016 base year emissions into the future. EGU emissions were projected using the Integrated Planning Model (IPM).[8] Onroad and nonroad mobile source emissions were projected using MOVES3 and activity data based on trends derived from the Federal Highway Administration (FHWA) county-level VM-2 reports as well as the Energy Information Administration's 2020 and 2021 Annual Energy Outlook (AEO). Emissions for other sectors were projected to the future year by adjusting the base year emissions to account for on-the-books regulations, known facility openings and closures, and estimated changes in activity. Biogenic, fire, and fertilizer emissions were held constant from the base year. A summary of NO_x and VOC emissions for the 2016 and 2023 inventories is shown in Table A-1 and Table A-2.

Table A-1. Summary of national ozone season NO_x emissions by source sector (tons) for the modeling domain. From U.S. Environmental Protection Agency (2022c), Table 5-7.

Sector	2016fj	2023fj	2026fj	2032fj
airports	56,300	64,779	67,546	73,465
cmv_c1c2_12	90,624	64,719	56,294	47,300
cmv_c3_12	264,816	277,635	287,826	300,207
nonpt	193,886	196,857	198,442	195,724
nonroad	566,188	377,891	334,265	284,630
np_oilgas	239,247	244,056	238,015	224,204
onroad	1,341,526	650,732	523,684	387,755
onroad_ca_adj	99,730	48,303	44,880	41,490
pt_oilgas	175,250	189,944	192,640	189,043
ptagfire	3,193	3,193	3,193	3,193
ptegu	605,014	264,200	239,930	265,088
ptnonipm	391,374	381,066	386,919	385,113
rail	236,771	198,559	186,854	176,801
rwc	4,280	4,528	4,596	4,601
Total U.S. Anthro	**4,268,199**	**2,966,463**	**2,765,084**	**2,578,614**
beis	587,057	587,057	587,057	587,057
ptfire-rx	20,531	20,531	20,531	20,531
ptfire-wild	55,500	55,500	55,500	55,500
Grand Total	**4,931,288**	**3,629,551**	**3,428,173**	**3,241,702**

[8] IPM is a model that accounts for variables and information such as energy demand, planned unit retirements, and planned rules to forecast unit-level energy production and configurations. EPA used IPM outputs from the Summer 2021 version of the IPM platform (see https://www.epa.gov/airmarkets/epas-power-sector-modeling-platform-v6-using-ipm-summer-2021-reference-case; https://www.epa.gov/power-sector-modeling/documentation-epas-power-sector-modeling-platform-v6-summer-2021-reference).

Table A-2. Summary of national ozone season VOC emissions by source sector (tons) for the modeling domain. From U.S. Environmental Protection Agency (2022c), Table 5-8.

Sector	2016fj	2023fj	2026fj	2032fj
airports	24,078	25,745	26,511	28,140
cmv_c1c2_12	3,538	2,476	2,121	1,805
cmv_c3_12	14,553	17,965	19,716	21,943
livestock	156,077	164,112	167,229	170,725
nonpt	344,481	324,891	313,572	305,544
nonroad	573,637	421,807	398,145	383,526
np_oilgas	980,746	979,486	992,390	986,718
onroad	552,899	348,610	293,979	235,488
onroad_ca_adj	44,432	27,229	24,394	19,788
pt_oilgas	114,505	113,824	115,484	115,296
ptagfire	6,314	6,314	6,314	6,314
ptegu	16,215	17,999	18,313	18,934
ptnonipm	248,145	245,742	246,081	245,868
rail	11,039	8,648	7,917	6,674
rwc	36,554	37,983	38,361	38,408
solvents	1,194,840	1,249,563	1,287,153	1,325,357
Total U.S. Anthro	**4,322,053**	**3,992,395**	**3,957,681**	**3,910,526**
beis	20,896,708	20,896,708	20,896,708	20,896,708
ptfire-rx	277,019	277,019	277,019	277,019
ptfire-wild	1,005,261	1,005,261	1,005,261	1,005,261
Grand Total	**26,501,041**	**26,171,383**	**26,136,669**	**26,089,515**

Source Apportionment Tagging

Sonoma Technology worked with the Sierra Club to identify sources and source groups to be tagged for ozone attribution analysis. In total, approximately 500 emission source tags were identified and modeled across multiple simulations. The tagged sources fell into one of the following categories:

- **EGU point sources (~250 tags)**: Coal and natural gas power plants, and in some cases individual units within a facility. Units may be tagged individually, by control equipment, by retirement date, and/or grouped by region.
- **Non-EGU point sources (~150 tags)**: Industrial point sources, tagged individually and/or grouped by state.
- **Transportation**: Onroad mobile sources separated by light and medium and heavy duty vehicle emissions, grouped by state.
- **Building Combustion**: Commercial, institutional, and residential fossil fuel building combustion from the NEI nonpoint sector, grouped by state or ozone nonattainment area. This excludes residential wood combustion.

Meteorology

Meteorological inputs for the CAMx-OSAT simulations were developed by EPA for the 2016 modeling platform using version 3.8 of the Weather Research and Forecasting (WRF) numerical weather prediction model (Skamarock et al., 2008). The meteorological outputs from WRF include hourly varying winds, temperature, moisture, vertical diffusion rates, clouds, and rainfall rates. Selected physics options used in the WRF simulations include the Pleim-Xiu land surface model, Asymmetric Convective Model version 2 planetary boundary layer scheme, Kain-Fritsch cumulus parameterization, Morrison double moment microphysics, and RRTMG longwave and shortwave radiation schemes. Additional details about this WRF simulation and its performance evaluation can be found in U.S. Environmental Protection Agency (2021b).

Initial and Boundary Conditions

Initial and lateral boundary conditions for the 2016v2 modeling platform were developed from three-dimensional global atmospheric chemistry simulations with the Hemispheric version of the Community Multi-scale Air Quality Model (H-CMAQ) version 3.1.1 (Mathur et al., 2017). EPA used an H-CMAQ simulation for 2016 to develop boundary conditions for a CAMx simulation at a horizontal grid resolution of 36 km x 36 km. The outputs from this simulation were used to provide initial and boundary conditions for the 12 km model simulation. OSAT tracks ozone transported through the boundaries, as well as ozone formation resulting from precursor emissions transported through the boundaries.

Post-Processing

The raw result from a CAMx OSAT simulation is hourly ozone contributions from each source tag at each grid cell in the modeling domain for the 2016 ozone season. These hourly contributions were extracted and post-processed for several hundred receptor sites, including ozone monitoring sites as well as locations identified by Sierra Club as environmental justice receptors within ozone nonattainment areas. At each receptor and for each day, the 8-hr average ozone contribution was calculated for each source tag using the averaging period corresponding to the period of highest modeled 8-hr average concentration at the receptor location. Although this analysis approach may not capture the largest ozone contributions modeled during the day, it does reflect contributions during time periods when modeled ozone concentrations are highest. This analysis approach also ensures that ozone contributions from all source tags[9] sum to total modeled 8-hr ozone concentration each day. The post-processed OSAT results along with relevant metadata were compiled into a web-based shinyapps.io dashboard application to facilitate future data mining and analysis.

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[9] Including a leftover residual contribution from all untagged sources calculated by CAMx.

OSAT outputs can also be used in a "relative sense" (rather than a "absolute sense") to apportion an ozone observation (e.g., a monitor concentration or design value) into modeled contributions from individual source tags. One advantage to such an approach is that the modeled contribution can be tied to an observed ozone concentration, rather than tied strictly to a modeled ozone concentration that may be biased. Anchoring the modeled apportionment results to ambient monitoring data can help mitigate uncertainty associated with imperfect model performance (Foley et al., 2015; Jones et al., 2005).

For receptors tied to air quality monitoring sites, ozone contributions were calculated using OSAT results in a "relative sense". For the base year (2016), relative contribution fractions for each tag on a daily basis were calculated by multiplying the absolute modeled source contribution by the ratio of the monitored MDA8 ozone concentration and the total modeled MDA8 ozone value. For the future year, the ratio of the total modeled MDA8 ozone concentration between 2023 and 2016 is used to estimate projected future year (2023) observed ozone concentrations, and this projected observed ozone is used to apportion the modeled ozone. These approaches have been used in past ozone source apportionment modeling analyses (e.g., Craig et al., 2020) and are similar to methods used by EPA to calculate ozone source contributions from a photochemical grid model (U.S. Environmental Protection Agency, 2022b).

Model Performance Evaluation

EPA evaluated its 2016 modeling platform using statistical assessments of modeled ozone predictions versus observations paired in time and space. A summary of model performance statistics from the 2016v2 platform is shown in **Table A-3**. Generally, the modeling platform underpredicts MDA8 ozone concentrations for days when the MDA8 ozone is greater than or equal to 60 ppb. But overall, EPA found that "the ozone model performance results for the CAMx 2016fj (2016v2) simulation are within or close to the ranges found in other recent peer-reviewed applications (e.g., Simon et al., 2012 and Emery et al., 2017)" and that "the model performance results demonstrate the scientific credibility of the 2016v2 modeling platform." Additional details on the ozone model performance evaluation for EPA's 2016v2 platform can be found in the Technical Support Document (TSD) for the modeling platform (U.S. Environmental Protection Agency, 2022b).

Table A-3. Summary of ozone model performance statistics from the EPA 2016v2 modeling platform for days with MDA8 ozone ≥ 60 ppb for the period May through September. 'MB' is mean bias, 'ME' is mean error, 'NMB' is normalized mean bias, and 'NME' is normalized mean error. From U.S. Environmental Protection Agency (2022c), Table A-3.

Climate Region	Number of Site-Days ≥ 60 ppb	MB (ppb)	ME (ppb)	NMB (%)	NME (%)
Northeast	2997	-4.1	7.1	-6.2	10.7
Ohio Valley	3211	-7.1	8.7	-10.9	13.3
Midwest	1134	-12.7	13.0	-19.1	19.5
Southeast	1477	-2.9	6.1	-4.5	9.4
South	993	-7.8	9.1	-12.0	14.1
Southwest	3054	-8.8	9.7	-13.6	15.1
Northern Rockies	215	-11.9	12.4	-19.0	19.8
Northwest	84	-5.8	10.8	-9.0	16.6
West	8279	-9.7	11.4	-13.8	16.2

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