

How much do various sources and states contribute to ambient ozone amounts over the northeastern U.S.? a source apportionment study with CAMx

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Motivation

- Clean Air Act requires EPA to set NAAQS for nose-level O₃. In 2015, the EPA lowered the 8hrO₃ standard to 70 ppbv. This standard is met if the 3-year average of the annual 4th-highest 8hrO₃ concentration is less than 71.0 ppbv.
- Areas containing sites that don't meet this standard are designated non-attainment areas and must develop State Implementation Plans (SIPs) that document how emissions will be reduced to bring the area into attainment.
- In order to assist with the SIPS, members of the Ozone Transport Commission (OTC) performed a future-year (2023) source apportionment simulation with CAMx to determine the major contributing sources and states to air quality within non-attainment areas.
- Preliminary results of this simulation are discussed in this talk.

What was done?

- Base simulation of 2016 with OTC 2016 v1 emissions (BEIS v3.6.1; ERTAC v16.0) using v7.1 of CAMx with CB6r5 chemical mechanism driven by meteorology from WRF v3.8.
- Source apportionment simulation of 2016 using collaborative projected 2023 (fi) emissions (APCA*; ERTAC v16.1).
- Domain: OTC2 (273 e-w × 246 n-s × 35 vertical)
- Time Period: Apr 1 Sep 30, 2016
- Emissions from various states and clusters of states tagged for 24 emission sectors (322 total tags)
- For each grid point, the contribution of 322 tags to hourly surface layer O₃ under NO_x-limited and VOC-limited conditions was estimated.

*Caveat: While the SA_Use_APCA flag was set to .true. in the job script, the SA_Use_APCA_Ptoverride flag was not set and defaulted to .false. in these simulations. Preliminary analysis suggests that this oversight likely led to an underestimation of the contribution of anthropogenic sources to O_3 , especially during periods of VOC-limited chemistry.



Evaluation of Base Simulation with 2016 meteorology & 2016 emissions Time series of $8hrO_3$ at Westport, CT

090019003.1: Connecticut, Fairfield, Sherwood Island State Park - Westport



Day-to-day fluctuations in 8hrO₃ well captured at Westport, CT.

Overall, 97 (58) % of monitoring sites within the OTR have normalized mean biases (NMBs) of less than 15(5)%, while 98(41)% of sites have normalized mean errors (NMEs) of less than 25(15)%.

Thus, nearly all sites meet the NMB & NME criteria specified in Emery et al. (2017), while ~half meet the goals.

Source: OTC TSD Draft



Seasonal variation reproduced although model biased Scalow April-May and high July-August R²

Boxes show 25th, 50th, and 75th PCTL. Whiskers show 1.5× interquartile range. Circles show outliers. Scatterplot shows reasonable agreement (slope 1.05; R^2 of 0.41), between modeled and obs. 4th highest 8hrO₃ within the OTR (Mid-Atlantic & northeast U.S.)



Jin-Sheng Lin

O3 from All Sector at 3pm EST May 24, 2016

All 24 Sectors May 24



O3 from All Sector at 3pm EST July 21, 2016

July 21 Nonroad-Diesel Biogenic Onroad-Diesel Onroad-NonDiesel BC IC 88 88 max = 49.12 ppb max = 23.21 ppb max = 11.56 ppb max = 7.27 ppb max = 0.00 ppbmax = 10.24 ppb Airport EGU ERTAC NonEGU Peaker Nonroad-NonDiesel Rail 80 max = 14.92 ppb max = 7.95 ppb max = 24.93 ppb max = 16.44 ppb max = 2.99 ppb RWC max = 8.27 ppb Area-Nonpoint Offshore-Rigs Oil-Gas (point + nonpoint) CMV-C1C2C3 Offshore-CMV 22 81 max = 15.78 ppb max = 23.55 ppb max = 0.10 ppb max = 11.36 ppb Agriculture max = 12.44 ppb AgBurn max = 10.33 ppb Others (Run2 Wild-Prescribed Fire Mexico Canada max = 16.58 ppb max = 0.00 ppb max = 20.25 ppb max = 0.72 ppb max = 0.24 ppb max = 14.87 ppb ppb 0.5 1.5 2.5 3.5 4.5 5 0 2 З 4

All 24 Sectors



CAMxv7.1 CB6R5 WRFv3.8 2023fi emissions 20160401-20160929



Beltsville, MD August 2 (2016 Met; 2023 emissions)

CAMx O3: 20160802: 240330030 (Beltsville)



Beltsville, MD June 1 (2016 Met; 2023 emissions)

CAMx O3: 20160601: 240330030 (Beltsville)



Beltsville, MD July 21 (2016 Met; 2023 emissions)

CAMx O3: 20160721: 240330030 (Beltsville)



Beltsville, MD July 16 (2016 Met; 2023 emissions)

CAMx O3: 20160716: 240330030 (Beltsville)



Beltsville, MD July 22 (2016 Met; 2023 emissions)

CAMx O3: 20160722: 240330030 (Beltsville)



Beltsville, MD July 29 (2016 Met; 2023 emissions)

CAMx O3: 20160729: 240330030 (Beltsville)





Hourly Ozone and Sector Contribution (ppbv) at Westport, CT during top 4 high O₃ events

In CSAPR, the EPA used a contribution screening threshold of 1% of NAAQS (0.70 ppbv here) to identify upwind states that may significantly contribute to downwind non-attainment. Using that threshold and various metrics, what states could be significant contributors to 8hrO₃ at Greenwich, CT?

Metric	СТ	DE	MD	NJ	NY	PA	VA	IL	IN	MI	ОН	KY	NC	TN	WV	FL	ТХ	States
1. Contribution on maximum modeled ozone day	X			X	х	Х	X	X	X	X	х	X		X	X			12
2. Avg contribution on top 4 modeled ozone days	Х		х	Х	х	Х	х		х	X	х				X			10
3. Avg contribution on top 10 modeled ozone days	Х		Х	Х	х	Х	х			Х	х				X			9
4. Avg contribution on any day with model $O_3 > 71$ ppb	Х		х	X	х	Х	X			X	х							8
5. Max. contribution on any days with model $O_3 > 71$ ppb	Х	Х	Х	Х	х	Х	х	Х	х	X	х	Х	X	Х	X	Х	X	17
6. Avg of top 4 contributions when O ₃ >71ppb	X		х	X	х	Х	X	X	х	Х	х	Х	X		X		X	14

IL, IN, KY, NC, and TX contributed > 1% to Greenwich, CT 8hrO₃ on at least 4 code orange/red days; however, their contribution is averaged out when a 10-day mean is taken.

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Which states and sectors are "significant" contributors to 8hrO₃ at Greenwich, CT?



Which states and sectors are "significant" contributors to 8hrO₃ at Babylon, NY?



Contributions from Texas, Illinois, Rhode Island, and North Carolina are also significant if average of 4 highest contributions on code orange/red days is used as a metric. Their contributions are averaged out when 10-day mean is used.

Which states and sectors are "significant" contributors to 8hrO₃ at Edgewood, MD?



Dark: Significant contributors by both metrics.

Light Blue: Additional significant contributors if avg. of top 4 code orange/red days is used.

Hatched: Significant contributors if mean of 10 highest days used. Insignificant if avg of top 4 code orange/red days used.

(Note: 71 ppbv threshold only surpassed on 5 days; meteorological variability not captured; NJ & NY contributions not sampled)

Conclusions

- Source apportionment with CAMx was used to estimate the contribution of various emission sectors and states to sfc. layer O₃ over the eastern U.S. in 2023 assuming 2016 met. conditions
- By 2023, 85-90% of model O₃ is formed under NO_x-limited conditions. However, O₃ formed under VOC-limited conditions is still substantial near Long Island Sound and the Great Lakes.
- The most important emission sectors over the OTR were found to be OnRoad-NonDiesel, OnRoad-Diesel, NonRoad-NonDiesel, NonRoad-Diesel, Area, EGU, and NonEGU. Oil & Gas, CMVs, Rail, Airport and at some sites EGU peaking units also contribute > 1%.
- Contribution of various states to local AQ varies greatly from day-to-day. In order to capture this meteorological variability at least ~10 days must be considered when evaluating source contributions. However, 10-day means may "average out" substantial contributions from some states. Therefore, metrics based on 10 or more days that minimize this averaging-out should be used. For example, mean of 4-highest daily contributions on the 10 highest model days or days when 8hrO₃ exceeds 70 ppbv, whichever is largest.