# **Empirical Estimates of Summer Background Ozone Levels in New York State**



## Abstract

Background concentrations for a certain region are usually defined as concentrations that would be observed in the absence of local anthropogenic emissions. They are important because no amount of local controls can reduce average ozone concentrations below the background values.

In this study we first estimate O3 backgrounds by using ozone precursors and pollutant markers following the method of Lin et al. (Geophys. Res. Lett., 2000). The method is verified against independent data which then allows a simple estimation technique to be used in cases where precursor or marker data is not available. We then apply the method at 28 New York sites and find that summer background ozone levels are estimated to range from 30 to 45 ppb, with median value of 37 ppb.

Second, we modeled ozone background concentration using EPA CMAQ model (Byun and Schere, Appl. Mech. Rev., 2006), based on 2007 emission inventory over East of U.S. By gradually reducing ozone precursor emissions, the model ozone background is reached as the photochemical formation of ozone ceases (in this case, at 90% NOx and 23% VOC reduction) The modeled background concentrations in the Northeastern region of U.S. cluster around 35 ppb.

The monitor specific background levels in New York allow for some preliminary discussions of the spatial distribution of the background levels and its relationship to control strategies.

## **Analysis of observations: Method**

Background ozone cannot be measured directly. However, when the local ozone production is low, we can consider associated ozone concentrations to have background character. This happens when ozone precursors NO<sub>x</sub>, NO<sub>y</sub> and pollution makers such as CO are low. For example, Lin et al. (2000) use daily maximum 8-hr averages of O<sub>3</sub> for Harvard Forest, MA to estimate background as median value for the subset of data with CO or NO<sub>v</sub> concentrations below 25<sup>th</sup> percentiles.

We have applied this method to three sites with available data, in and outside of New York state. Beltsvile, MD site data are obtained from the CASTNet database (http://java.epa.gov/castnet). Pinnacle State Park, NY database is described by Schwab et al. (2009), and Harvard Forest. MA database is described by Munger and Wofsy (1999). We report results in Table 1 only for the summer period (Jun-Aug)

#### Table 1. Summer O3 background concentrations estimated by CO, NOy

The third column presents results using the precursor and marker method while the last column of the table reports 25<sup>th</sup> percentile of the ozone distribution for the same summer periods. As Lin et al. (2000) note, lower part of  $O_3$  distributions must have a strong background signal. They have found that for 1980-1998 Harvard Forest summer background estimate corresponds to the 25<sup>th</sup> percentile of ozone distribution. We have confirmed their result, and found that for the period in question this simple methodology also holds for New York and Maryland sites. In effect, for the geographic area considered, we can use 25<sup>th</sup> percentile of summer ozone distributions

as surrogate of background estimates.

This allows us to estimate backgrounds for much larger number of sites that have only ozone measurements. The method is applied to all New York sites with adequate

Site		Period	Background O3	25th percentile O3	
	Beltsville, MD	2008-2010	48 ppb	45 ppb	
Pinn	acle State Park, NY	1995-2010	40 ppb	38 ppb	
Harvard Forest, MA		1990-2002	39 ppb	39 ppb	

CountyID	SiteID	County	Address	O3 [ppb]
1	12	Albany	LLoudonville, Albany	36
5	83	Bronx	200th St. and Southern Blvd,	33
5	110	Bronx	IS 52, New York	33
13	6	Chautauqua	Dunkirk	45
13	11	Chautauqua	Westfield	44
15	3	Chemung	Elmira	39
27	7	Dutchess	Millbrook, Inst of Ecosystem S	37
29	2	Erie	Amherst	41
31	2	Essex	Whiteface summit	42
31	3	Essex	Whiteface base	34
41	5	Hamilton	Piseco Lake	35
43	5	Herkimer	Nicks Lake	33
45	2	Jefferson	Vaadi Rd, Perch River	36
53	6	Madison	Crumb Hill Rd, Camp Georgeto	38
63	1006	Niagara	Middleport	38
65	4	Onondaga	Camden	33
67	1015	Onondaga	East Syracuse	36
71	5001	Orange	Montgomery Valley Central HS,	40
79	5	Putnam	NYSDEC HQTRS GypsyTrail Rd	39
81	98	Queens	15TH AVE, New York	30
85	67	Richmond	Susan Wagner HS,, New York	41
91	4	Saratoga	Saratoga Nat Hist Park	35
93	3	Schenectady	Mt.Pleasant HS, Schenectady	33
103	2	Suffolk	East Farmingdale	40
103	4	Suffolk	Riverhead	39
111	1005	Ulster	Belleayre Mountain	37
117	3001	Wayne	Williamson	35
119	2004	Westchester	White Plains	39

Background concen Gaomputercamodeling Confirmation ve used EPA CMAQ model version 4.71, on the domain covering East USA for the 2007 base case ozone season (April through October). In this experiment, we gradually reduce NO<sub>x</sub> and VOC emissions until

ozone concentrations reach a plateau which means limited local ozone formation.

We have simulated the 2007 base case and three reduction cases:

•Case N48V23: NOx emissions reduced by 48%, VOC emissions reduced by 23%

•Case N68V23: NOx emissions reduced by 68%, VOC emissions reduced by 23%

•Case N90V23: NOx emissions reduced by 90%, VOC emissions reduced by 23% Results are shown on the graph with modeled (y-axis) versus observed (x-axis) ozone concentrations. Of course, observed concentrations and their spread remains the same, but modeled spread along vertical axis falls with reduced emissions. At 90% reduction of NOx emissions, the modeled ozone concentrations tightly cluster around 34.9 ppb (red points on the graph). This is very close to estimates obtained by data analysis.

Fig. 1. Modeled vs.

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### **Analysis of observations: Results**

 
 Table 2. Summer O3 background concentrations estimated by 25<sup>th</sup> percentile of O3
 for DEC Monitoring Sites 1995-2010

Summer background ozone is in the range 30-45 ppb, with median value of 37 ppb.



on reduction scenarios. round 35 ppb.



The estimates of median background levels at the New York monitors were then used to determine whether control strategies and influx of ozone into the state can be discerned by the method used. To that end, background data were separated into the pre and post "NOx SIP call" periods and plotted in the following graph for the monitors in Table 2. It is seen that in essentially all cases, the median background values have reduced in New York after

NOx emission reductions took effect in 2002/3 era.

Another example of verifying the method's usefulness is in depicting the median ozone background distribution in New York. Using the results for the period 2003-10 and the corresponding average 8 hour ozone design values (defined as the averages over rolling three years from 2003-10), the ratio of the backgrounds to design values are presented in the following figure for the same monitor locations. It is seen that in general background values are a bigger percentage of the design values at the monitors closer to the border of the state which implies a clear transport into the state. The low value noted in NY City appears to be an anomaly based on an assessment of precursor data at the

NYBG monitor.

A simple method has been used to estimate median background ozone values in New York state based on verification of the technique against more rigorous methods using observed data. A CMAQ modeling analysis confirms the usefulness of the method in providing rough estimates of background levels. The technique is then used to project median background ozone levels at 28 monitor locations in the state. Preliminary review of the results indicate that the method correctly identifies the effects of previous regional NOx emission reductions, as well as the importance of influx of ozone into New York. Further testing of the method is necessary for urban locations.

#### References

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# **Application of Method and Discussion**





# Conclusion

Lin, C. Y., D. J. Jacob, J. W. Munger, and A. M. Fiore 2000: Increasing background ozone in surface air over the United States, Geophys. Res.