Supplemental Guidance for Ozone Advance Areas Based On Pre-existing National Modeling Analyses

Introduction

The Ozone Advance guidance document (EPA, 2012a) provided by EPA to assist in the development of "paths forward" or action plans to reductions in ozone precursors outlined types of photochemical modeling and/or data analyses that could be done to identify which emissions may be most beneficial to reduce. Specifically, the guidance suggested that areas interested in conducting modeling could target their analyses toward addressing certain key questions:

a) whether it would be more efficient for local Ozone Advance efforts to concentrate on reductions of volatile organic compounds (VOCs), nitrogen oxides (NOx), or a combination of these two basic types of ozone precursors, and
b) what amounts of reductions would be needed to make a difference in ozone concentrations (i.e., what level of emissions reductions will be needed to avoid exceeding the ozone National Ambient Air Quality Standards (NAAQS)).

The guidance also recommends that before beginning any modeling effort, an area should contact the relevant state/tribe or EPA Regional Office for suggestions regarding whether sufficient modeling information for the area already exists, and, if not, what types of analyses are appropriate.

EPA/OAQPS does not currently have modeling results for local areas that are appropriate for use in explicitly developing Ozone Advance paths forward/action plans, however we do have national-scale modeling that may be useful as a general guide to answer the questions posed above. Additionally, recent EPA modeling conducted in support of regulatory actions may be useful in understanding the projected trends in ozone design values over the U.S. in the near future.

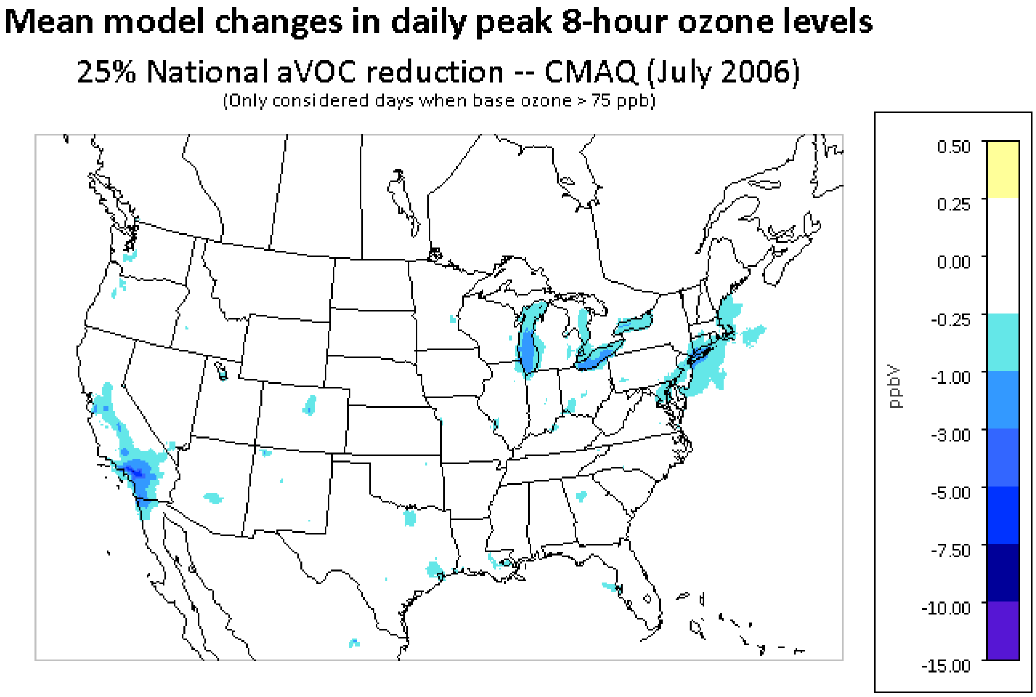
The purpose of this document is to summarize recent EPA/OAQPS national modeling analyses with regard to: 1) NOx vs. VOC sensitivity and 2) future projections of ozone design values. An important caveat with respect to each of these analyses is that the national modeling is done using model inputs and model grids that are not as informative to local policy planners as a local-specific modeling application would be. These results should be considered preliminary indications of potential control impacts until more specific modeling or data analyses can be done to inform the Ozone Advance path forward or action plan.

Ozone Sensitivity to NOx vs. VOC Emissions

The effectiveness of NOx versus VOC controls for the purpose of reducing ground-level ozone depends on the ambient mixture of NOx and VOCs. Studies performed in different regions have shown that the effectiveness of controls depends not only on local emissions but also on the contribution of transported pollution and natural emissions to ambient NOx, VOC, and ozone concentrations. Such studies have suggested that anthropogenic VOC reductions in some areas may not be effective due to the overwhelming contribution of biogenic emissions to ambient VOC levels. However, this response is not necessarily constant and may vary by time of day or throughout the ozone season due to changes in wind direction (affecting direction of pollution transport), temporally varying anthropogenic emissions, and varying biogenic emissions from changes in sunlight, temperature, and precipitation. Additionally, the magnitude of potential ozone changes from VOC emission reductions may be relatively small compared to NOx emission reductions, but anthropogenic VOC emission reductions may still be beneficial on average.

EPA has conducted Community Multiscale Air Quality Model (CMAQ) modeling over a 48-state domain at a grid resolution of 12 km to assess the effects of an across-the-board 25% anthropogenic VOC emission reduction on 8-hour maximum ozone concentrations. The model simulations were completed for a single month in the peak of an ozone season (July 2006). As noted earlier as a caveat, this type of analysis does not give any information about how effective local VOC emissions reductions would necessarily be, but can give general information about where cuts in nationwide VOC emissions will affect 8-hour maximum ozone concentrations.

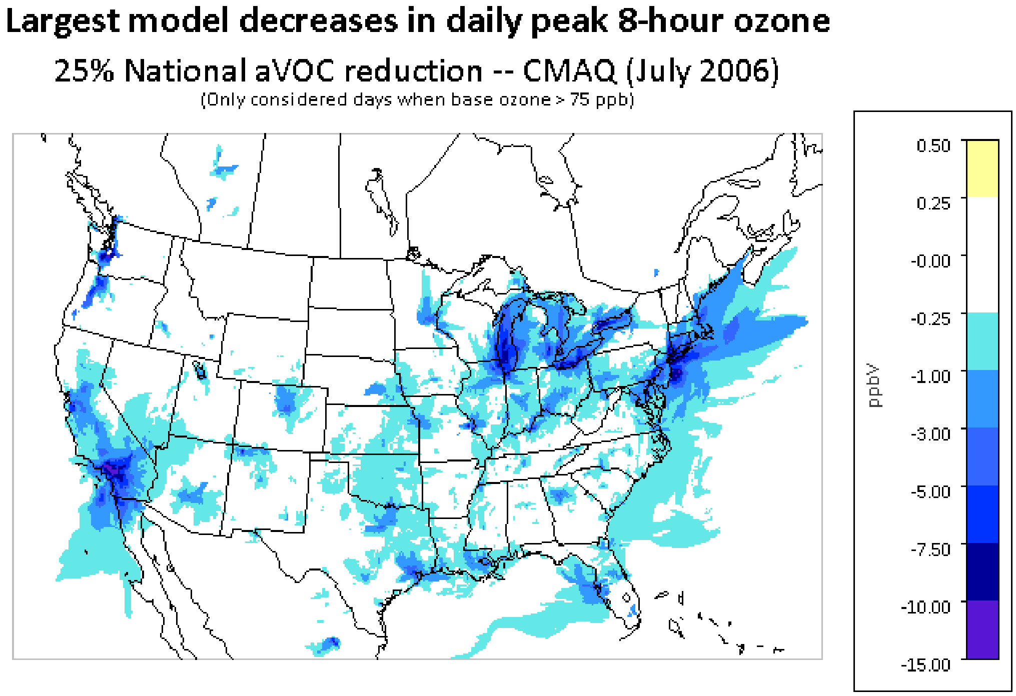
Figure 1a illustrates the model-simulated mean change in daily maximum 8-hour values across the U.S. from the month of July 2006 due to a 25% across-the-board reduction in anthropogenic VOC emissions. Figure 1b shows the single greatest decrease in daily peak 8-hour ozone concentrations from the same national 25% anthropogenic VOC emissions reduction scenario. Because we want to isolate the impacts of controls on days that are potentially relevant to attainment of the NAAQS, both of these figures only consider changes when and where the daily peak 8-hour ozone in the base case simulation is greater than 75 parts per billion (ppb).


Mean model changes in daily peak 8-hour ozone levels

25% National aVOC reduction -- CMAQ (July 2006)

(Only considered days when base ozone > 75 ppb)

Figure 1a: CMAQ July 2006 simulation of mean changes in daily peak 8-hour ozone levels resulting from an across-the-board 25% reduction in anthropogenic VOC emissions nationwide. Only days in which the base simulated ozone was greater than 75 ppb were considered.


Largest model decreases in daily peak 8-hour ozone

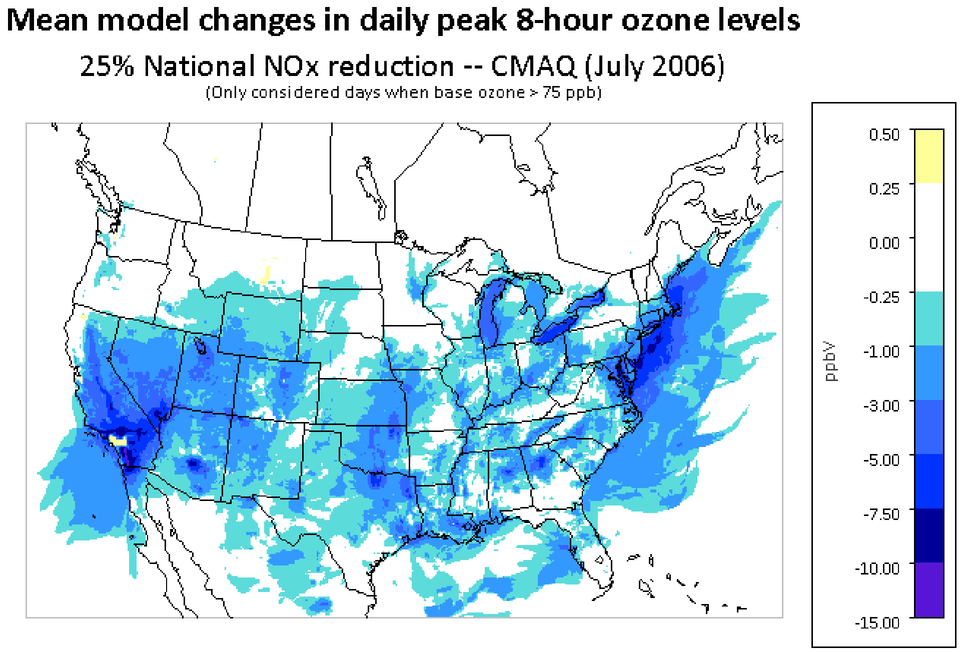
25% National aVOC reduction -- CMAQ (July 2006)

(Only considered days when base ozone > 75 ppb)

Figure 1b: CMAQ July 2006 simulation of largest single daily ozone reductions resulting from an across-the-board 25% reduction in anthropogenic VOC emissions nationwide. Only days in which the base simulated ozone was greater than 75 ppb were considered.

The modeling suggests that large portions of the country could experience reductions in daily 8-hour ozone maxima of at least 0.25 ppb when VOC emissions are reduced nationally by 25 percent. Certain areas are more responsive to VOC controls as evidenced by larger values of greatest possible ozone reduction, as well as by the mean changes over the July 2006 simulation. Areas in southern CA, in the San Joaquin Valley, along the shoreline of the Great Lakes, and in the Northeast Corridor are likely to see the largest and most consistent ozone reductions from VOC controls. However, for many other urban centers, the national modeling suggests some VOC control benefits (e.g., Seattle, Portland, Phoenix, Denver, Dallas, Houston, southern Louisiana, Minneapolis, St. Louis, Cincinnati, Atlanta, and Tampa).

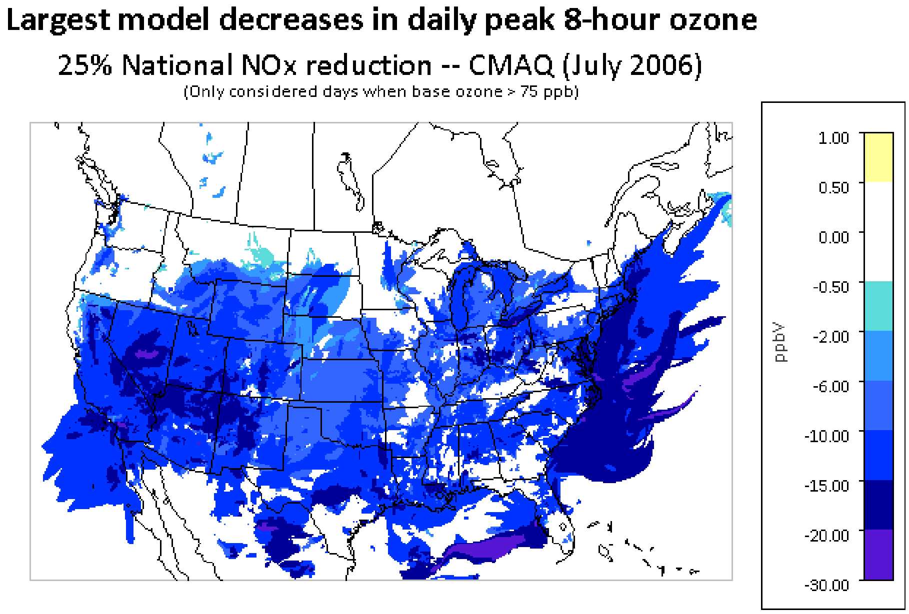
Figures 2a and 2b illustrate the same quantities, but for a scenario involving an across-the-board 25% reduction in anthropogenic NOx (as opposed to VOC) emissions. According to the model results, a much larger area of the country would experience ozone reductions if NOx were to be reduced domainwide. Further, the ozone improvements from NOx emission reductions tend to be larger in magnitude than the ozone improvements from VOC emission reductions.


Mean model changes in daily peak 8-hour ozone levels

25% National NOx reduction -- CMAQ (July 2006)

(Only considered days when base ozone > 75 ppb)

Figure 2a: CMAQ July 2006 simulation of mean changes in daily peak 8-hour ozone levels resulting from an across-the-board 25% reduction in anthropogenic NO_X emissions nationwide. Only days in which the base simulated ozone was greater than 75 ppb were considered.


Largest model decreases in daily peak 8-hour ozone

25% National NOx reduction -- CMAQ (July 2006)

(Only considered days when base ozone > 75 ppb)

Figure 2b: CMAQ July 2006 simulation of largest single daily ozone reductions resulting from an across-the-board 25% reduction in anthropogenic VOC emissions nationwide. Only days in which the base simulated ozone was greater than 75 ppb were considered. *(Note: scale is different from the previous figures to capture larger reductions.)*

Figure 3 shows the ratio in the largest model-simulated decreases in 8-hour peak ozone between the two scenarios (i.e., 25% NOx reduction / 25% aVOC reduction). Ratios greater than one indicate that ozone was reduced more effectively by similar percentage reductions in NOx emissions. Ratios less than one indicate that ozone was reduced more effectively by similar percentage reductions in VOC emissions. Ratios near one indicate generally equivalent effectiveness between the two sets of ozone precursors.

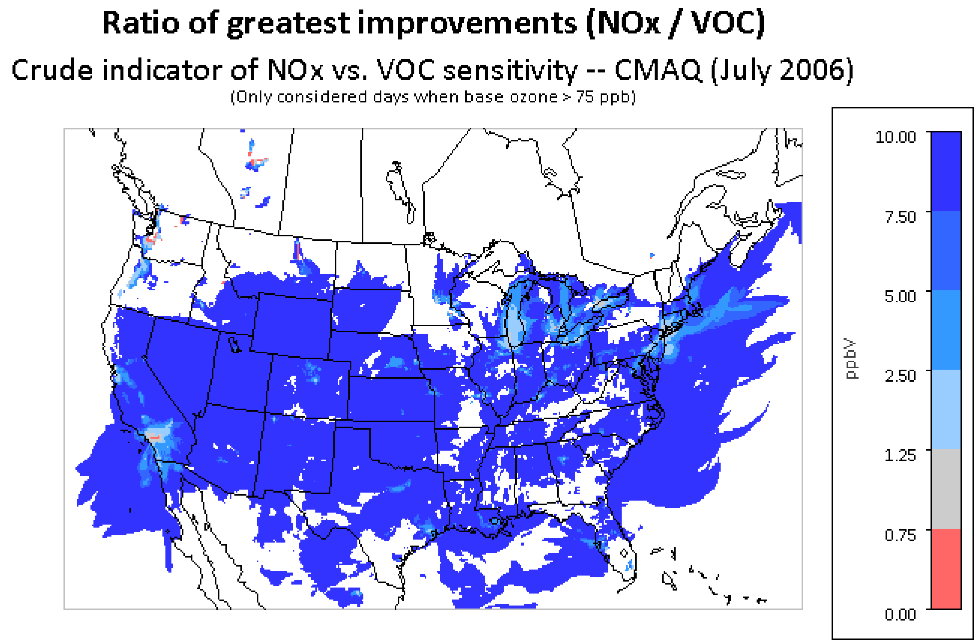


Figure 3: CMAQ July 2006 simulation of the ratio (NOx/VOC) of daily peak 8-hour ozone reductions resulting from an across-the-board 25% reduction in the two sets precursor emissions nationwide. Areas shown in white are locations in which there were no days greater than 75 ppb in the modeling period.

For most of the country, NOx controls have the potential to reduce high ozone concentrations more effectively than a similar percentage reduction in VOC emissions. Over a large geographic expanse of the country, NOx reduction impacts outdo VOC reductions by a factor of 10. The primary exception to this finding is the Los Angeles area, but there are also smaller areas where VOC control impacts are also greater than or equivalent to their NOx counterparts, including: a portion of the San Francisco Bay area, Seattle, and portions of some major metropolitan areas in the Great Lakes and Northeast Corridor. Based on the limited analyses described in this guidance document, most Ozone Advance areas would be wise to focus their initial ozone path forward or action plan efforts on NOx reductions. Again, Ozone Advance participants should consult with their EPA Regional Office point of contact to confirm whether any existing analyses that may be more specific to their local area may be available. Ozone Advance participants may also opt to conduct their own local modeling or data analyses to confirm the signal from the national modeling.

National Modeling Projections of Future Year Ozone

According to EPA's Trends Report (EPA, 2012b), ozone air quality has improved over the past decade. Nationally, 8-hour ozone concentrations declined by 13 percent over the 10-year period between 2001 and 2010. These declines were coincident with large reductions in NOx emissions resulting from EPA rules like the NOx State Implementation Plan (SIP) Call, preliminary implementation of the Clean Air Interstate Rule and Tier 2 Light-Duty Vehicle emissions standards, along with additional local measures to reduce NOx and VOC. Over 80 percent of monitoring sites in the U.S. have experienced an ozone design value improvement of at least 5 ppb over that time period. This trend is expected to continue over the near future as additional Federal, state, and local measures take effect or are newly promulgated.

Recent EPA modeling (EPA, 2010; EPA, 2012c) forecasts continued ozone reductions between now and 2020. The projected design values vary by location, but average ozone design value reductions of approximately 1 ppb/year are common, independent of interannual variations in meteorological effects. As with the rest of the U.S., ozone concentrations are expected to continue to decline in Ozone Advance areas as regional EGU NOx emissions continue to be lowered and mobile source NOx and VOC emissions decline with fleet turnover. These forecasts are clearly contingent upon accurate emission projections. Ozone Advance participants should carefully assess any growing emissions sectors that may not have been adequately accounted for in the national projection modeling.

References:

EPA (2010): Counties projected to Violate Primary 8-hour Ground-Level Ozone Standard in 2020, http://www.epa.gov/airquality/ozonepollution/pdfs/CountyOzoneLevels2020primary.pdf.

EPA (2012a): Ozone Advance Guidance, Office of Air Quality Planning and Standards, RTP, NC, http://www.epa.gov/ozoneadvance/pdfs/2012404guidance.pdf.

EPA (2012b): Our Nation's Air: Status and Trends through 2010, Office of Air Quality Planning and Standards, RTP, NC, EPA-454 / R-12-001. http://www.epa.gov/airtrends/2011/index.html.

EPA (2012c): Average and maximum design values by monitoring site for 8-hour ozone, annual PM2.5, and 24-hour PM2.5 for the 2003-2007 base period, the 2012 base case, and the 2014 base and CSAPR control scenario, http://www.epa.gov/airtransport/techinfo.html.