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

EPA Office of Air Quality Planning and Standards, Air Quality Modeling Group
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Introduction

The Ozone Advance guidance document (EPA, 2016) provided by EPA to assist in the development of successful plans ("paths forward") to reduce ozone precursors, outlines 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 suggests conducting modeling to address certain key questions, including:

a) whether it would be more effective for Ozone Advance efforts to concentrate on reductions of VOCs, NOx, or a combination of the 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 NAAQS.)

The guidance also suggests 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 local Ozone Advance plans/paths forward, 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 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 local plan/path forward.

Ozone Sensitivity to NOx vs. VOC Emissions

It has been understood for many years that 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 anthropogenic 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 emissions reductions may be relatively small compared to potential ozone changes from NOx emissions reductions, but anthropogenic VOC emissions reductions may still be beneficial.

EPA has conducted CMAQv5.1 modeling over a 48-state domain at a grid resolution of 12 km to examine the overall response of peak 8-hour maximum ozone (MDA8 O_3) to an across-the-board 50% reduction in anthropogenic VOC emissions and, separately, a 50% reduction in anthropogenic NOx emissions, nationwide. (The modeling simulations are described in Appel et al., 2016). This modeling was performed for a single summer month in the peak of an ozone season (July 2011), and results may vary to some extent for other time periods. As noted earlier as a caveat, this type of analysis does not give any information about how effective local VOC or NOx emissions reductions would necessarily be, but can be informative in identifying which areas would see a benefit in terms of lower ozone concentrations from additional reductions in VOC or NOx emissions.

Figure 1 illustrates the modeling-based change in July monthly maximum MDA8 O_3 values across the U.S. to a 50% across-the-board reduction in anthropogenic VOC emissions for the month of July 2011. Because we want to isolate the impacts of controls on days that are potentially relevant to attainment of the NAAQS, we show the change in the single maximum MDA8 O_3 value in July. However, there are some locations where modeled MDA8 ozone values never approached the NAAQS during this time period and the changes shown in figure 1 may not be relevant for planning purposes in those locations. Figures 2a and 2b show locations where modeled July maximum MDA8 O_3 values were at least 60 ppb and 70 ppb respectively to provide context for the changes shown in Figure 1.

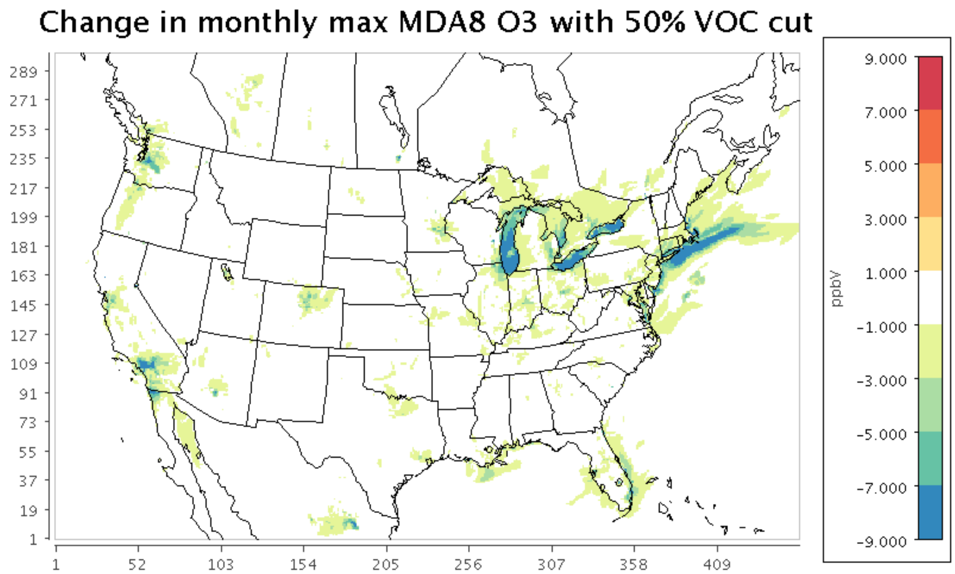

Figure 1: Change in the CMAQ-estimated monthly maximum MDA8 O_3 values (July 2011) resulting from an across-the-board 50% reduction in anthropogenic VOC emissions nationwide.

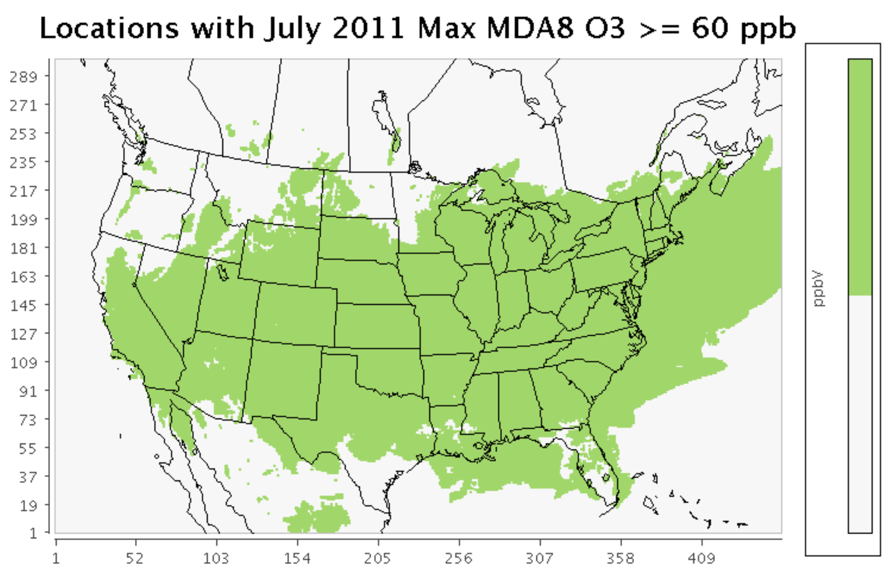

Figure 2a: Locations where the highest modeled July 2011 MDA8 O_3 value was greater than or equal to 60 ppb shown in green.

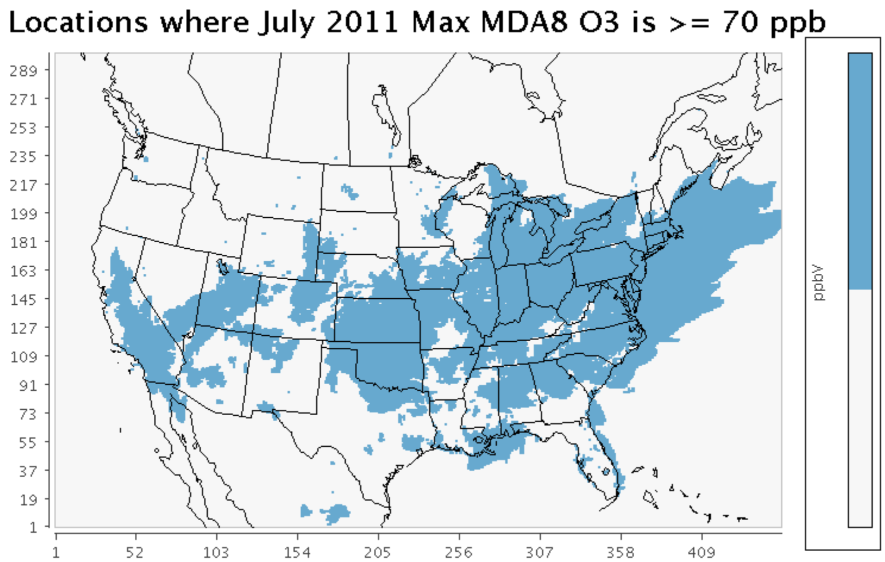

Figure 2b: Locations where the highest modeled July 2011 MDA8 O_3 value was greater than or equal to 70 ppb shown in blue.

The modeling suggests that the benefits from across the board VOC reductions are most prominent mainly close-in to a subset of urban areas and in nearby areas downwind. The reduction in monthly maximum MDA8 O_3 reductions greater than 3 ppb are generally restricted to urban areas while reductions of 1-3 ppb occur in some outlying areas as well. That is, VOC impacts tend to be fairly localized to the vicinity of urban areas.

Figure 3 illustrates the changes in July 2011 monthly maximum MDA8 O_3 for a scenario involving an across-the-board nationwide 50% reduction in anthropogenic NOx emissions. The model results suggest that a much larger area of the country would experience ozone reductions with NOx emissions reductions compared to an equivalent percentage reduction in anthropogenic VOC. Further, the ozone improvements from NOx emissions reductions tend to be larger in magnitude than those shown for VOC emissions reductions. Ozone increases (disbenefits) from NOx reductions were predicted to occur in a few areas where modeled NOx/VOC concentration ratios were high but in most cases were limited locations over water or locations with peak modeled monthly MDA8 O_3 below 70 ppb.

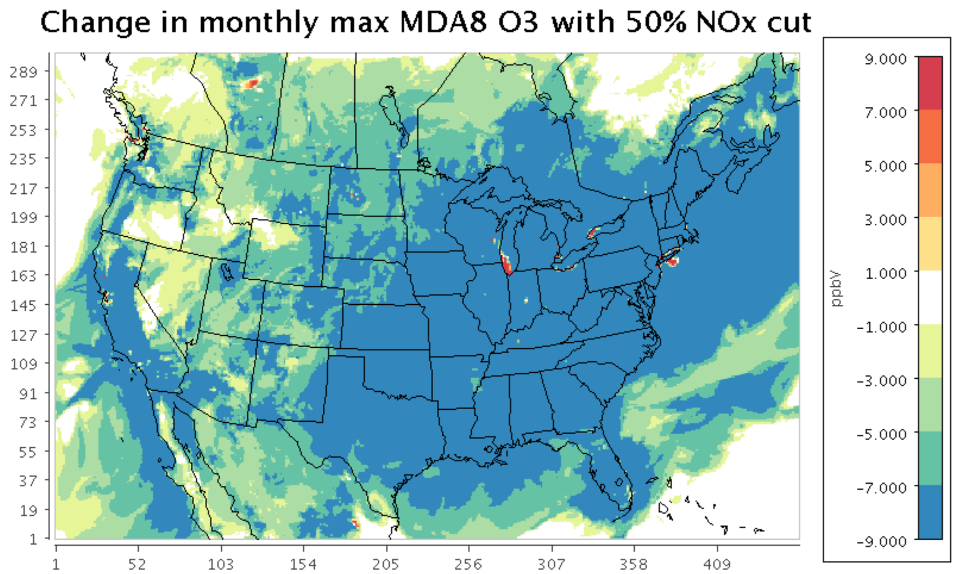

Figure 3: Change in the CMAQ-estimated monthly maximum MDA8 O_3 values (July 2011) resulting from an across-the-board 50% reduction in anthropogenic NOx emissions nationwide.

Figure 4 shows the ratio of the change in monthly maximum MDA8 O_3 resulting from across the board NOx reductions to the change in monthly maximum MDA8 O_3 resulting from across the board VOC reductions. Ratios greater than one (shown in purple) indicate that ozone was reduced more effectively by similar percentage reductions in NOx emissions. Ratios less than one (shown in green) 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. Outside of urban areas, the impacts of NOx cuts were more than 10 times higher than the impacts of VOC cuts. In most cities the impacts ranged from 1.5-5 times larger with NOx compared to VOC cuts. There were very limited areas of urban Los Angeles, Seattle, San Francisco, Miami, Cleveland and New York where VOC reductions resulted in a larger drop in monthly maximum MDA8 O_3 values than NOx reductions.

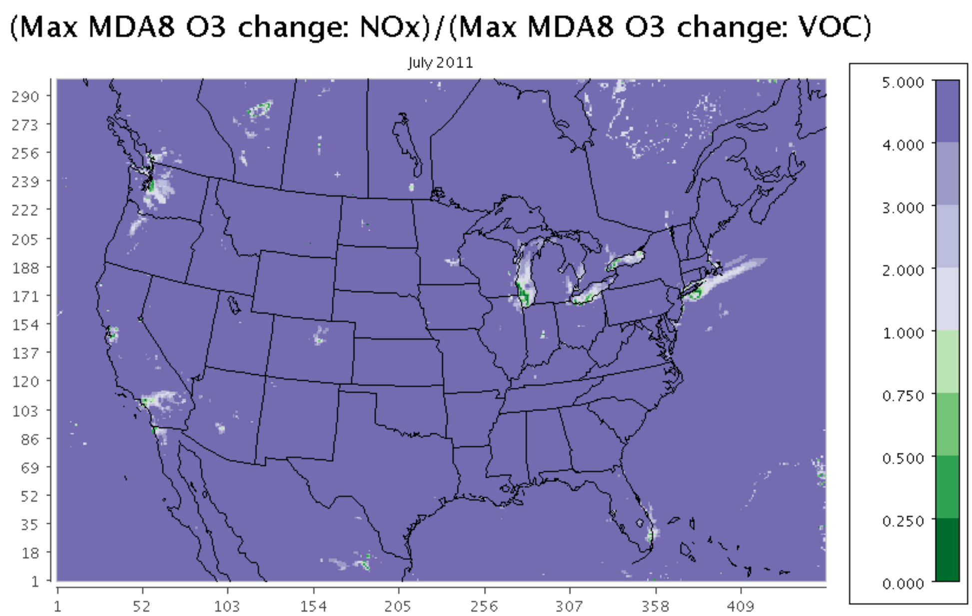

Figure 4: The ratio of the change in monthly peak MDA8 O_3 from the 50% reduction in NOx to the change in monthly peak MDA8 O_3 from a 50% reduction in VOC. *Ratios greater than one (shown in purple) indicate that ozone was reduced more effectively by similar percentage reductions in NOx emissions. Ratios less than one (shown in green) indicate that ozone was reduced more effectively by similar percentage reductions in VOC emissions.*

Based on the limited analyses herein, outside of a few urban areas, most Ozone Advance areas would be wise to focus their initial ozone planning efforts on NOx reductions. Again, Ozone Advance program participants can conduct their own local modeling or data analyses to examine impacts of specific local controls under consideration.

<u>National Modeling Projections of Future Year Ozone</u>

According to EPA's Trends Report (EPA, 2016), ozone air quality has improved over the past two and a half decades. Nationally, the annual 4th highest 8-hour ozone maximum declined by 22 percent over the 25-year period between 1990 and 2015. These declines were coincident with large reductions in NOx emissions resulting from EPA rules like the NOx State Implementation Plan (SIP) Call, implementation of the Cross State Air Pollution Rule, and Tier 2 Light-Duty Vehicle emissions standards; along with additional local measures to reduce NOx and VOC. These trends are also consistent with published studies which show that peak MDA8 ozone values declined across the United States between 1998 and 2013 (Simon et al., 2015).

Recent EPA modeling-based projections for 2025 (EPA, 2015) indicate that ozone reductions will continue in the future.[1] The projected reductions vary by location, but the reductions in ozone design value are on the order of 1 ppb/year in most areas. As with the rest of the U.S., ozone concentrations are expected to continue to decline in Ozone Advance areas as NOx emissions continue to decline as a result of existing control programs. These projections are contingent upon representative emissions projections and continued implementation of current on-the-book federal and state regulations. Ozone Advance areas should carefully assess expected local-specific changes in various emissions sectors.

References

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Simon, H., Reff, A., Wells, B., Xing, J., Frank, N.: Ozone trends across the United States over a period of decreasing NOx and VOC emissions, *Environmental Science & Technology*, 2015, 49, 186-195.

Contact

For more information on how existing national modeling efforts can inform an Ozone Advance plan/path forward, please contact: Heather Simon (simon.heather@epa.gov).

[1] This modeling does not consider the effects on ozone of possible variations in weather conditions that might be associated with inter-annual variability in meteorology and other factors, nor does it consider the potential impacts on ozone in the U.S. of future changes in international transport.