DEPARTMENT OF THE ENVIRONMENT

Summary 2006 Air Quality Summary

Air quality in Maryland continued to show significant improvements during the summer of 2006 (May-September) despite meteorological conditions which favored poor air quality. Listed below are several highlights from the season:

- Benefits of the NO_x ($NO + NO_2$) control program implemented in 2003 include sustained conspicuous and widespread improvements in ground-level ozone observed across the Northeast, Mid-Atlantic, and portions of the Midwest.
- Maryland observed only 20 ozone exceedance days in comparison to 31 days on average during the period of 1996-2005. An exceedance day is defined as a day when the daily maximum 8-hour ozone levels reached Unhealthy for Sensitive Groups or above on the Air Quality Index (AQI)
- There was also good news concerning fine particles during the summer of 2006. Maryland observed only 2 days in which fine particle pollution reached USG or above as compared to 6 days on average during the summers of 2000-2005.

Ground-Level Ozone

Ground-level ozone during the summer of 2006 (May-September) will be remembered for its low number of 8-hour exceedance days (days in which the daily maximum 8-hour ozone levels reached USG or above). During the course of the summer, Maryland observed a total of 20 exceedance days, which was much lower than the historical average of 31 days during the ten-year period of 1996-2005. A detailed look at the historical 8-hour ozone exceedance days since 1980 shows Maryland has been making continuous progress towards lowering bad air quality days (**Figure 1**).

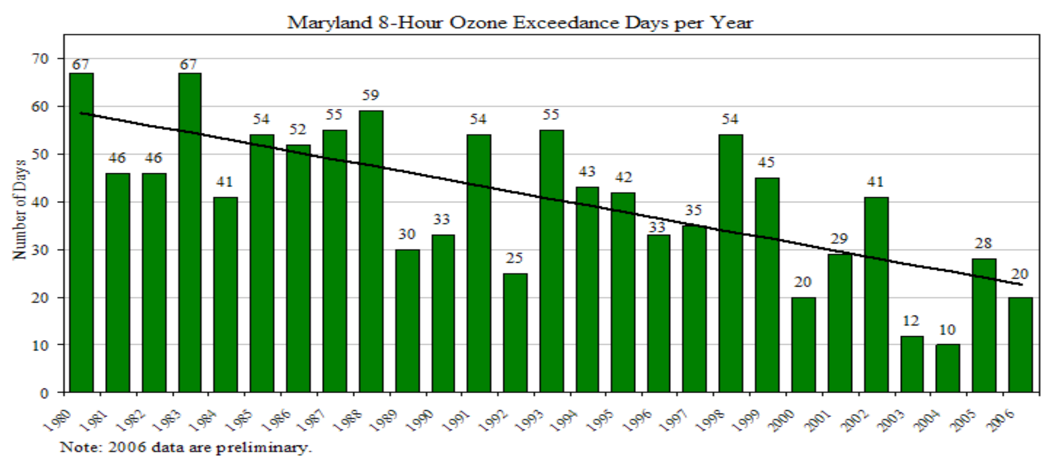

Figure 1: Maryland 8-hour ozone exceedance days per year. Black line indicates the 27-year linear trend.

The first ozone exceedance day occurred on Memorial Day (May 29th) and the last ozone exceedance day occurred on August 25th. There were a couple of four-day episodes and other one-to-two day episodes. The first four-day episode occurred during the Memorial Day weekend (May 29-June 1) and the other occurred between the 22nd and 25th of August. One difference between 2006 and the historical ozone seasons is that the highest seasonal 8-hour ozone levels of 2006 were not observed during 3 to 4 day episodes. The highest 8-hour ozone reading for the season occurred on the 18th of July (during a two-day episode) in which daily peak 8-hour ozone level reached 110 ppb (Unhealthy) at Essex. In comparison, during the worst summer ozone season in recent years, the highest 8-hour ozone levels occurred on June 24th, 2002 in the middle of a five-day episode (June 21-25, 2002), with a peak of 128 ppb (Very Unhealthy) at Edgewood. Two longer episodes of six and eight days each were also observed during the summer of 2002.

How did ground-level ozone in Maryland compare to ozone in the Northeast/Mid-Atlantic, and various major Metropolitan Areas across the United States? **Figure 2** shows a count of exceedance days for 14 states and the District of Columbia that make up the Northeast/Mid-Atlantic region. Both Maryland and North Carolina ranked first for the poorest air quality with a total of 20 8-hour ozone exceedance days. Overall it was a good year for air quality for the entire region.

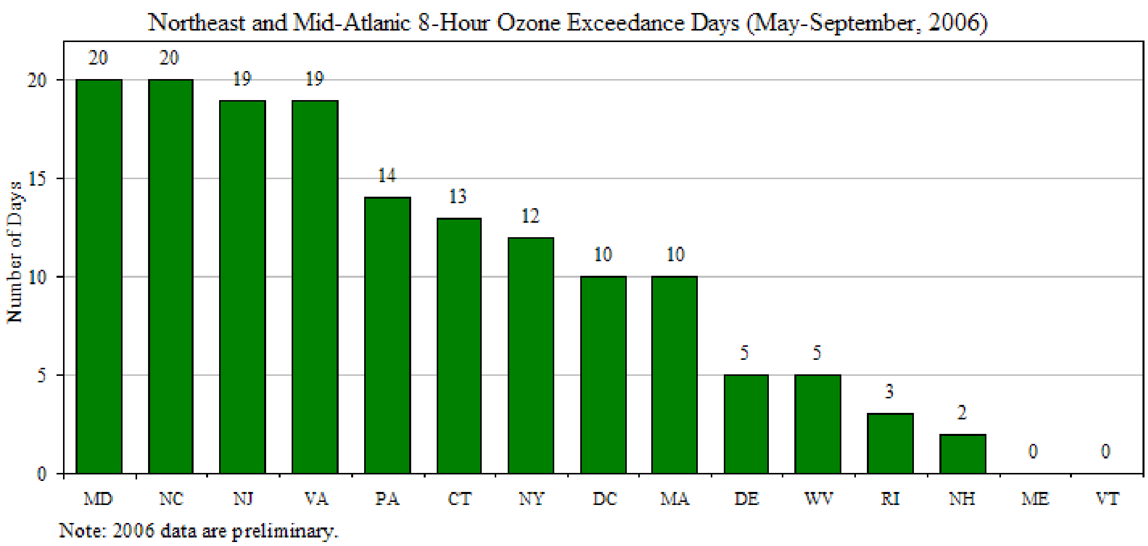

Figure 2: Northeast and Mid-Atlantic 8-hour ozone exceedance days during the summer of 2006 (May-September).

An illustration from the EPA AIRNow program shows a sharp decrease during the summer of 2006 in the number of days in which ozone levels reached USG or above in the upper Midwest, Mid-Atlantic, and Northeast (**Figure 3**). In particular, the Baltimore region observed 17 days in 2006 in comparison to 23 days in 2005 and 27 days for the historical ten-year average during 1996-2005. The Washington D.C. region on the other hand, did not observe a decrease in the number of days with USG or above between 2005 and 2006. Both years tied at 19 days. This number was still lower than the historical ten-year average of 24 days. The widespread improvement in ozone levels across the Northeast, Mid-Atlantic, and portions of the Midwest was a possible result of the large-scale NO_x control program fully implemented during 2003 and 2004. This will be discussed in further detail in the *Weather and Air Quality* section.

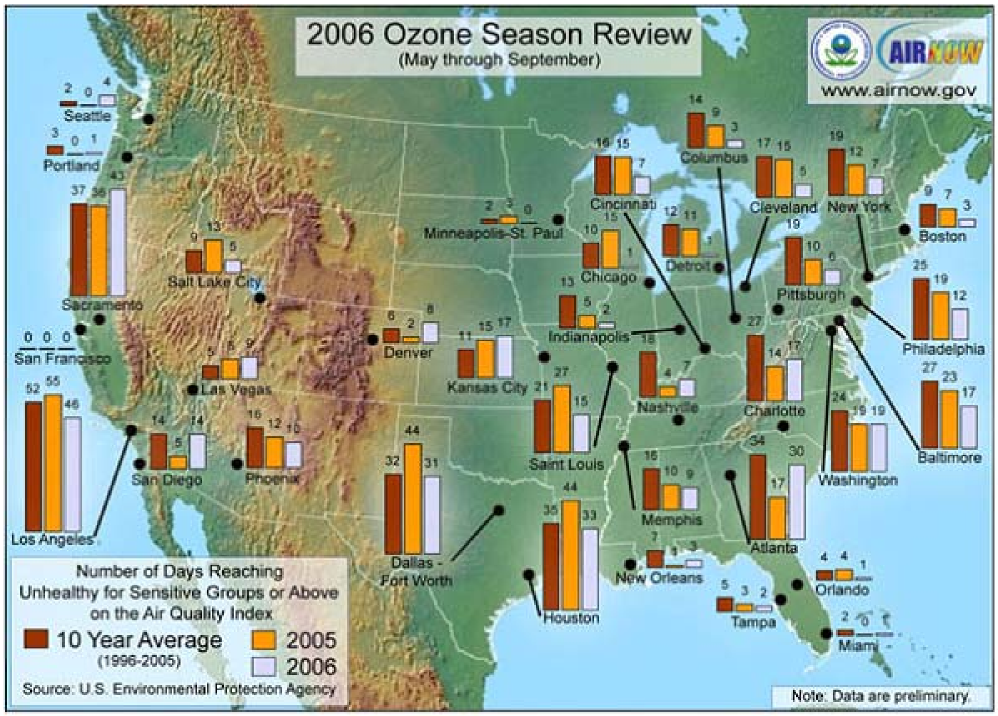

Figure 3: The contiguous United States ozone season review for 2006. Graphic courtesy of EPA AIRNow program. Visit the AIRNow website at http://www.airnow.gov for further information.

Fine Particle Pollution ($PM_{2.5}$)

Fine particle pollution ($PM_{2.5}$) is a year-round problem in Maryland with levels typically peaking during summer months, like the ozone levels. Under the existing standards, particle pollution usually is not the primary pollutant on high pollution events. That is, the $PM_{2.5}$ AQI is rarely higher than the ozone AQI when USG conditions for ozone occur. Maryland observed a total of 2 days in which particle pollution (non-FRM, continuous data) reached USG or above on the AQI. This was a notable improvement compared to the historical average of 6 days based on both FRM and non-FRM continuous data for the months of May through September during 2000-2005.

How did particle pollution influence the overall AQI distribution for the summer? Particle pollution was not the primary pollutant during high pollution events; however, on Moderate days (Code Yellow), particles are a crucial consideration. The AQI distribution for particle pollution (**Figure 4**, center pie chart) shows that Moderate AQI occurred on 56.2% of summer days, a majority percentage of the pie. USG days occurred at only a small fraction of 1.3%. In contrast, the AQI distribution for 8-hour ozone (Figure 4, left-side pie chart) reveals that Moderate AQI occurred on 34.6% of the days and USG or above AQI occurred on 13.1% of the days. When the approach is expanded to consider both 8-hour ozone and particle pollution, the AQI distribution is very different (Figure 4, right-side pie chart). Moderate days occurred on approximately 50% of the days and USG or above days occurred on approximately 14% of the days.

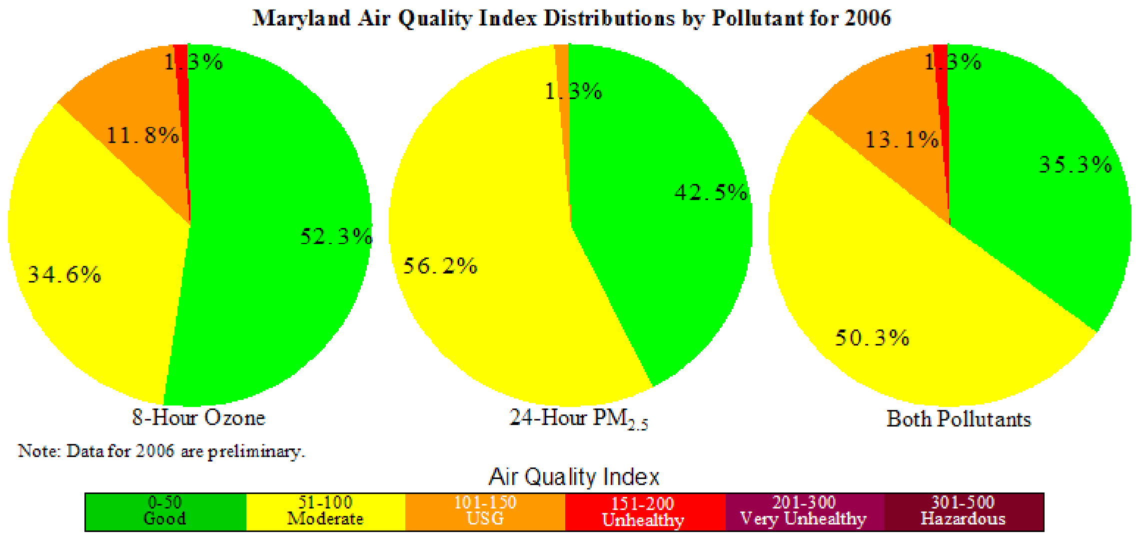

Figure 4: A comparison of Air Quality Index (AQI) distributions for 8-hour ozone and 24-hour particle pollution ($PM_{2.5}$) during the summer of 2006 (May-September).

A monthly comparison AQI days for each pollutant also confirms the importance of particle pollution on Moderate days. In certain months, particle pollution completely changes the overall picture of air quality in Maryland. For instance, there were more Good days than Moderate or above days during May, June, and September for ground-level ozone (**Figure 5**, left-side bar chart). When the approach is expanded to consider both 8-hour ozone and particle pollution, there were fewer Good days than Moderate or above days during May, June, and September (Figure 5, right-side bar chart). Thus, particle pollution is an important part of the overall air quality in Maryland, especially on Moderate days.

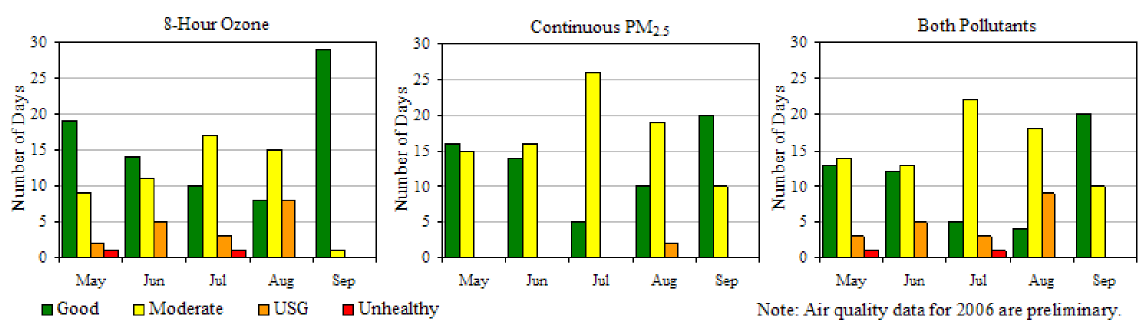

Figure 5: A monthly comparison of Air Quality Index (AQI) distributions for 8-hour ozone and particle pollution ($PM_{2.5}$) during the summer of 2006 (May-September).

EPA recently tightened the standards for 24-hour particle pollution after reviewing scientific evidence in recent years relating the exposure of particle pollution to public health, in particular respiratory and heart diseases. The new standard will become effective on December 18, 2006. The current 24-hour standard of 65.5 ug/m^3 will be replaced by a more stringent standard of 35 ug/m^3. The annual $PM_{2.5}$ standard will remain unchanged. While this change is important for protecting public health, it will have many implications related to regulatory and air quality forecasting activities. Maryland is currently in non-attainment for only the annual standard. The new standard would put Maryland in non-attainment for both the annual and 24-hour $PM_{2.5}$ standards. The U.S. EPA plans to revise the AQI in 2007 to reflect the change in the standard previously described. Speculation indicates particles will become equally, if not more important than ground-level ozone in determining the daily AQI.

Weather and Air Quality

Background

Weather conditions during the summer of 2006 were conducive to ground-level ozone formation. However, regional ground-level ozone this summer was low in portions of the Midwest, Mid-Atlantic, and Northeast. The general weather pattern during the summer of 2006 provided a substantial test of the effectiveness of the regional NO_x program in reducing regional ozone levels. The meteorological departure from normal height patterns in the middle troposphere (500-millibar level, typically is at 18,000 feet or ~5-6 kilometers) is compared to the departure from normal 8-hour ozone exceedance days. An examination of these patterns can provide insight to Regional Planning Organizations (RPOs) in regards to whether regional collaborations and pollution controls are effective.

Why compare height patterns aloft instead of at the surface? Typically, day-to-day fluctuations in weather are observed at the surface. However, these changes are driven by variations in atmospheric conditions aloft in conjunction with those at the surface. Meteorologists typically begin studies by looking at the 500-mb level and construct weather maps for levels above and below 500-mb. Since examining all heights of the atmosphere at any given time is not feasible, it is logical to choose a particular height that best represents the atmosphere at any given time.

What does a departure from the normal 500-mb height pattern tell us? A higher than normal height pattern at the 500-mb level typically represents regions at the surface in which higher pressure and warmer temperatures tend to occur. Likewise, a lower than normal height pattern at 500-mb level typically represents regions at the surface in which lower pressure and cooler temperatures tend to occur. For simplicity, higher and lower than normal height patterns will be referred to as higher and lower pressures respectively. In an absence of controls, these regions typically indicate either an area of substantially more or fewer counts of 8-hour ozone exceedance days.

Methodology

500-mb height data were obtained from the Earth System Research Laboratory and 8-hour ozone exceedance days were obtained from the EPA AIRNow. Ozone data and 500-mb height data were aggregated by Metropolitan Statistical Areas (MSAs) and averaged over the 11-year period of 1993-2003. The 11-year average is defined as the normal pattern. Departures from the normal pattern for individual years during 1993-2006 were computed for both variables. Eight-hour ozone data were then broken into bin/class based on the 11-year average and year-to-year fluctuation (**Table 1**). Regions with fewer averaged 8-hr ozone exceedance days were treated slightly difference than regions with higher averaged 8-hr ozone exceedance days. For instance, an average count of 8 days was classified into bin 2, and the departure from normal of 4 would be considered as "Well Above Normal". Departures from normal data for both variables are plotted together for this analysis.

Table 1: 8-hour ozone exceedance classification scheme based on 11-year average and year to year fluctuation. Data are in counts of 8-hour exceedance days. Negative counts indicate below normal conditions.

Eight-Hour Ozone Exceedance Classification Scheme based on 11-Year Average and Year to Year Fluctuation						
Bin	**11-Year Average**	**Well Below Normal (WBN)**	**Below Normal (BN)**	**Normal (N)**	**Above Normal (AN)**	**Well Above Normal (WAN)**
1	**0 to 5**	**≤ -4**	**-(1 to 4)**	**±1**	**+(1 to 4)**	**≥ 4**
2	**6 to 10**	**≤ -4**	**-(2 to 4)**	**±2**	**+(2 to 4)**	**≥ 4**
3	**11 to 20**	**≤ -6**	**-(3 to 6)**	**±3**	**+(3 to 6)**	**≥ 6**
4	**> 20**	**≤ -7**	**-(3 to 7)**	**±4**	**+(3 to 7)**	**≥ 7**

Results and Discussion

Historically, above normal pressure patterns during June-August have resulted in "Above Normal" to "Well Above Normal" counts of 8-hour exceedance days for MSAs in Northeast, Mid-Atlantic, and portions of the Midwest. This relationship has been true for all years from 1993 through 2004 (except 1997). An example plot for 2002 is shown in **Figure 6** to illustrate the significance of meteorology and the relationship between regional ground-level ozone to an above normal pressure pattern. Starting in 2005 this relationship became less pervasive and continued into 2006. Aggregated ozone for these years showed "Below" to "Well Below Normal" counts of 8-hour exceedance days despite an above normal pressure pattern observed in those regions.

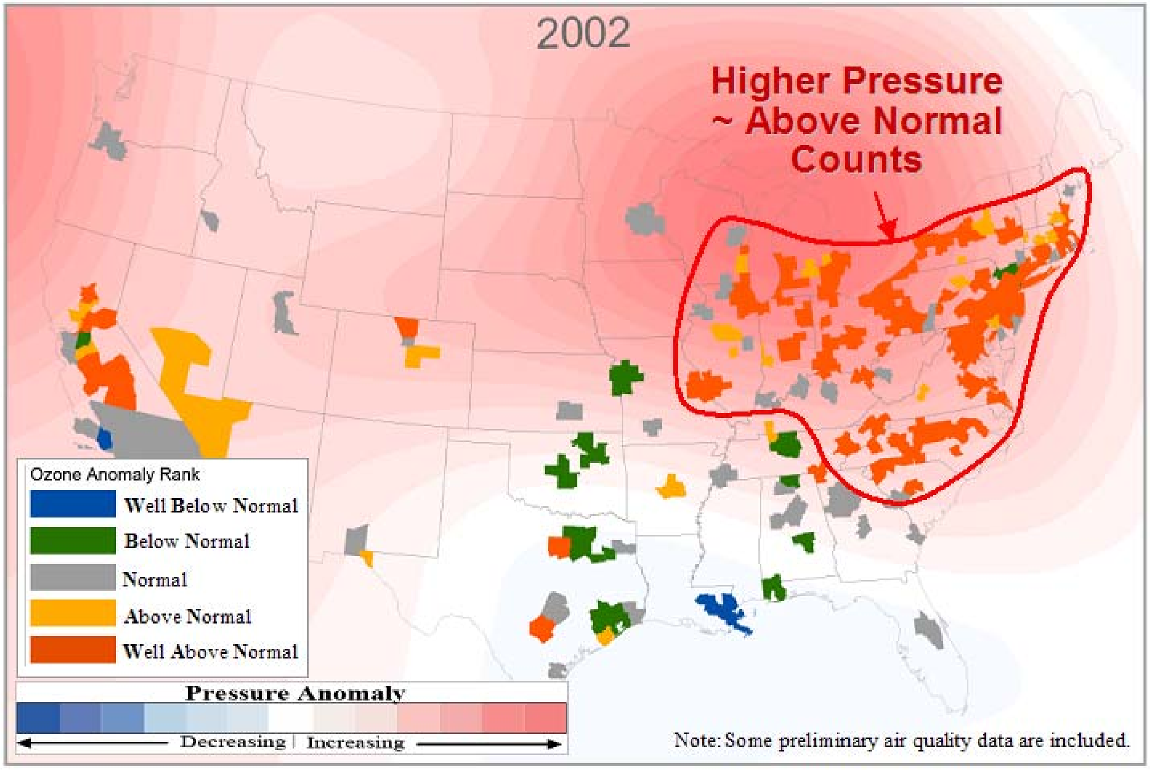

Figure 6: A comparison between the ground-level ozone anomaly and the pressure anomaly during the summer of 2002 (Jun-Aug) across the U.S. Portions of the Midwest, Mid-Atlantic, and Northeast observed "Above Normal" to "Well Above Normal" counts of 8-hour ozone exceedance days (shaded in orange and red). These regions were observed where higher than normal pressure patterns (contoured shades of pink and red) were also observed. The meteorological data courtesy of ESRL/PSD/CDC Interactive Plotting and Analysis website at http://www.cdc.noaa.gov/cgi-bin/PublicData/getpage.pl. The air quality data courtesy of AIRNowTech website as part of the EPA AIRNow program at http://www.airnowtech.org.

During the summer of 2006 (Jun-August), departure from the normal height pattern indicates much of the contiguous United States (CONUS) experienced above normal pressures (shown as contoured shades of red in **Figure 7**). At the same time, aggregated 8-hour ozone exceedance days for Metropolitan Statistical Areas (MSAs) across the CONUS showed "Below Normal" to "Well Below Normal" counts (shaded green and blue in Figure 7) for the Northeast, Mid-Atlantic, and portions of the Midwest.

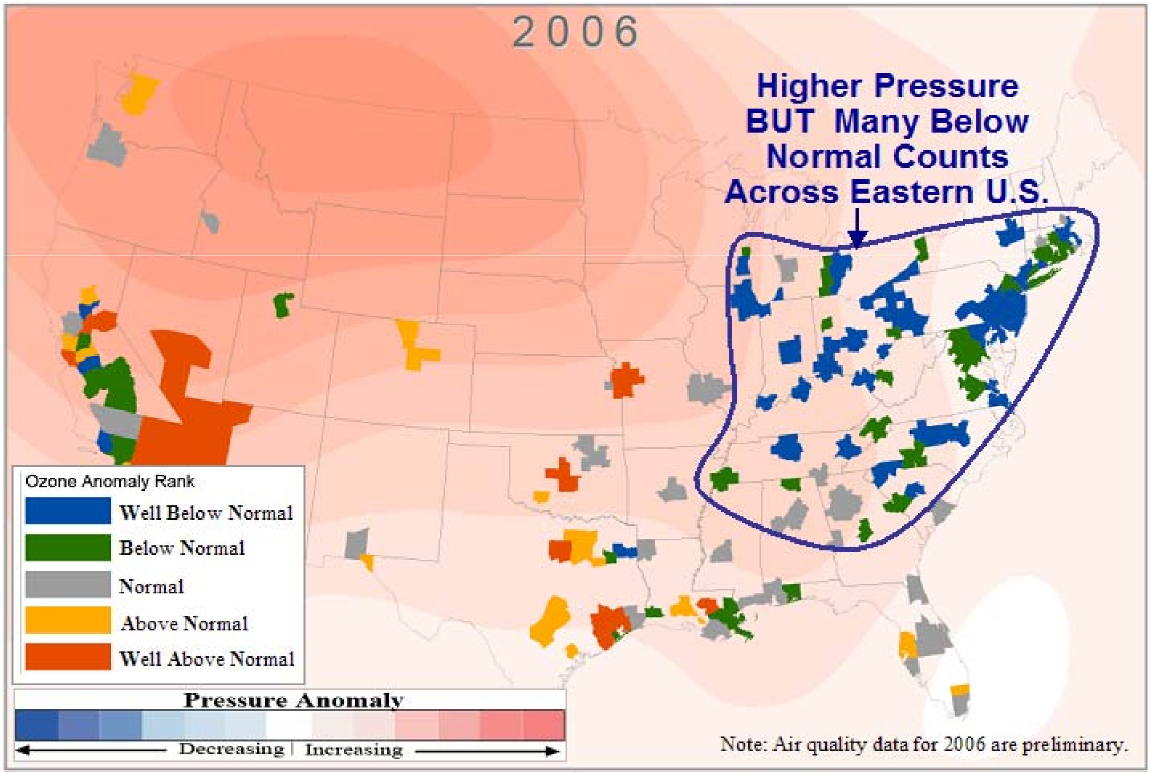

Figure 7: A comparison between the ground-level ozone anomaly and the pressure anomaly during the summer of 2006 (Jun-Aug) across the U.S. Much of the Northeast, Mid-Atlantic, and portions of the Midwest observed improvements in ozone levels (below normal ozone exceedance days, shaded by green and blue) despite above normal pressure patterns (contoured shades of pink and red), favoring poor air quality. The meteorological data are courtesy of the ESRL/PSD/CDC Interactive Plotting and Analysis website at http://www.cdc.noaa.gov/cgi-bin/PublicData/getpage.pl. The air quality data are courtesy of the AIRNowTech website as part of the EPA AIRNow program at http://www.airnowtech.org.

The improvements are closely related to the regional NO_x control program over the Eastern United States. During 2003 and 2004, installations of expensive Selective Catalytic Reduction (SCR) units (over 100 units according to the Institute of Clean Air Companies [ICAC]) occurred at major power plants to reduce NO_x emissions, an important ozone precursor. Major NO_x point sources and total number of SCR unit installations are shown in **Figure 8**. The majority of NOx point sources are located along the Ohio River Valley, portions of the Southeast, and Southern Mid-Atlantic regions. It is also important to note that SCR units were installed where the controls are needed the most (i.e. the Ohio River Valley). An illustration from the U.S. Department of Energy (DOE) indicates a sharp decrease in NO_x emissions from electrical generation units (EGUs) was observed from the 1990s into the early 2000s, in particular a decrease from 6.4 million short tons in 1995 to 3.7 million short tons in 2004 where emission inventory data were available (**Figure 9**). That was almost a 50% decrease in total NO_x emissions from EGUs. It is logical to conclude that the large reductions in NO_x emissions were the result of regional NO_x control program. If the NO_x control program is effective, regional improvements in ground-level ozone should occur in those local areas and especially in downwind states such as Maryland.

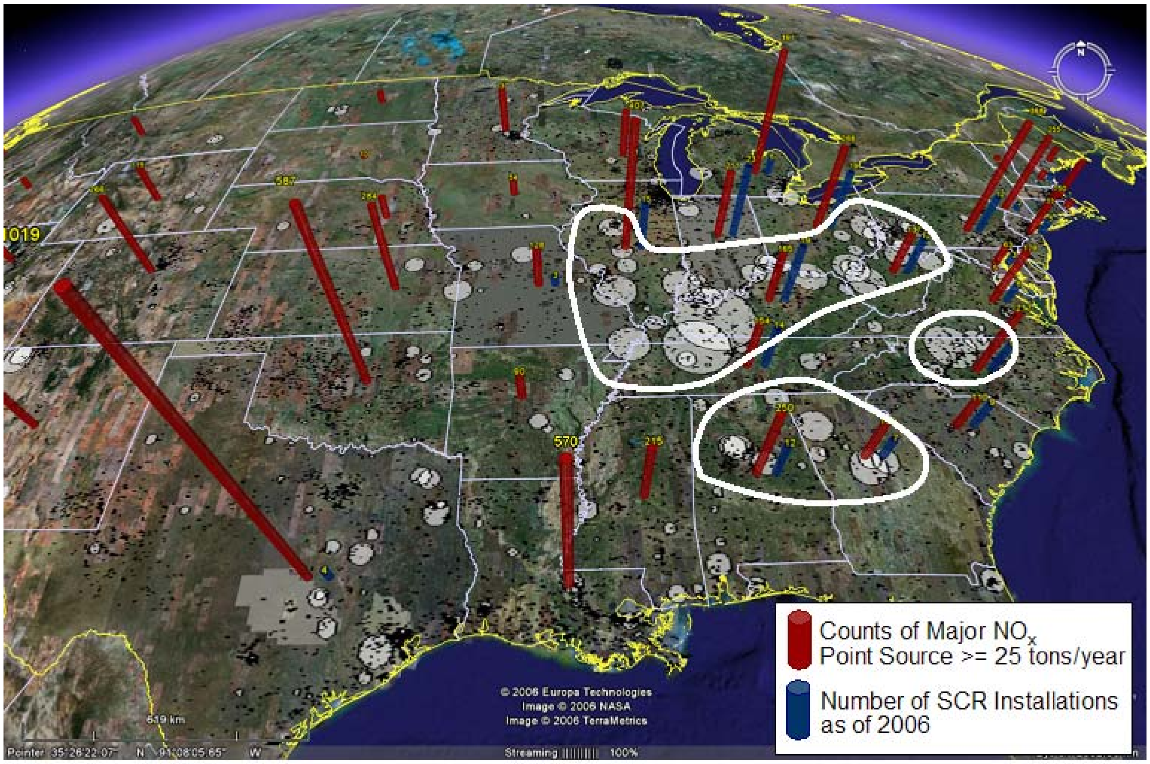

Figure 8: Major NO_x point sources (white circles) shows relative magnitude of yearly NO_x emissions at each electrical generation unit (EGU) using the 1999 EPA's National Emission Inventory (NEI) database. The EGUs are located along the Ohio River Valley, portions of the Southeast, and Southern Mid-Atlantic regions. Major SCR units (as of 2006 according to the Institute of Clean Air Companies (ICAC) are deployed where the controls are needed the most (i.e. the Ohio River Valley). For information relating to emissions, visit EPA NEI website at http://www.epa.gov/air/data/neidb.html. For information relating to SCR units, visit ICAC website at http://www.icac.com/.

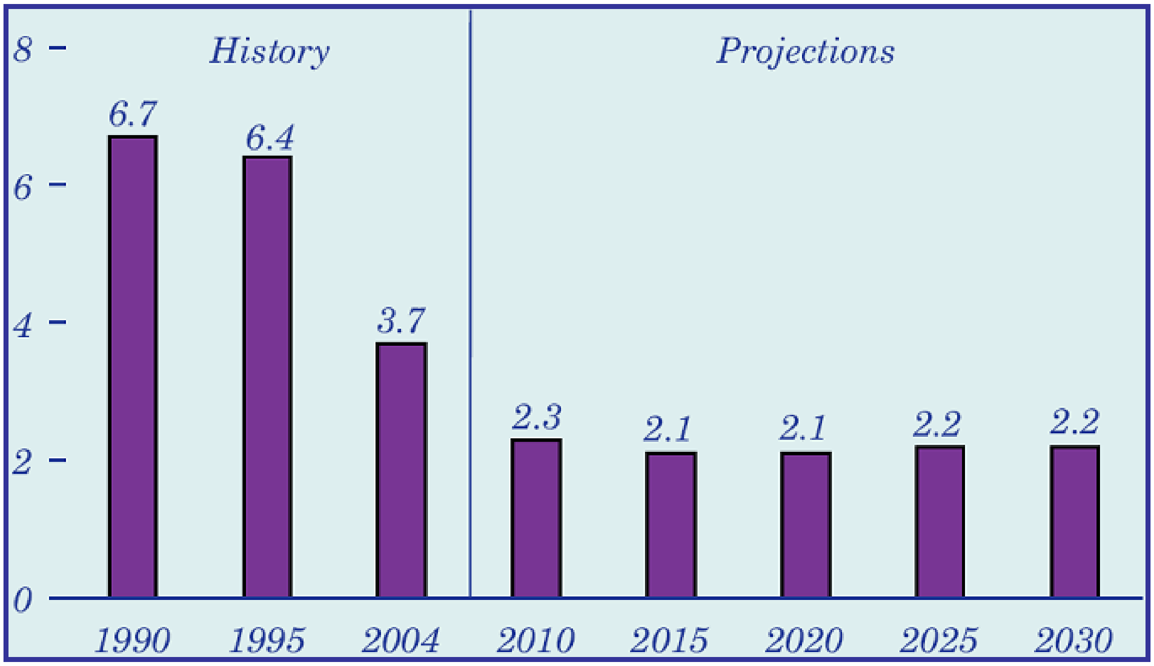

Figure 9: NO_x ($NO+NO_2$) emissions from electrical generation in million short tons. Graphic from the DOE Annual Energy Outlook 2006 with Projections to 2030 report. Additional information can be found at Energy Information Administration (EIA) website at http://www.eia.doe.gov/oiaf/aeo/.

An analysis by the EPA AIRNow program during the summer of 2006 (Figure 3) showed a sharp decrease in the number of days in which ozone levels reached USG or above in the upper Midwest, Mid-Atlantic, and Northeast. Additional preliminary analysis performed by the MDE Ambient Air Monitoring Program also showed dramatic improvements despite meteorological conditions conducive to the formation of ground-level ozone (Figure 7). Eventually the effectiveness of regional NO_x control program will be tested in the future by a typical summer of hot weather. At this point in time, the observed data clearly indicate improvements in ground-level ozone in portions of the Midwest, Mid-Atlantic, and Northeast between 2005 and 2006 are the result of the regional NO_x control program.

Disclaimer: (a) All statistics for 2006 are preliminary. (b) Particle pollution data displayed in this report include both continuous and FRM where available. Statistics may be different for regulatory purposes since only FRM data are considered.