

**DEVELOPMENT OF AN AIR POLLUTION EVENT DURING
THE NEOPS-DEP 2002 INVESTIGATION**

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1. INTRODUCTION

The study of the evolution of pollution events are becoming increasingly more important because of the generally adverse effects on general public health. The EPA estimates that 5 to 20 percent of the total U.S. population is especially susceptible to the harmful effects of ozone and airborne particulate pollution [1]. Those individuals with pre-existing conditions such as asthma, bronchitis or emphysema may experience an even greater risk. Long-term, repeated exposure to high levels of ozone may lead to inflammations of the lung lining as well as decreased efficiency of the lungs themselves[1]. The NEOPS-DEP study was performed to gain a further understanding of the development and cause of pollution events. The NEOPS-DEP study focused on gathering vertical profiles of ozone and other particulate matter, thereby making it possible to study transport of air masses not only using surface sites, but also adding vertical and horizontal (as the air mass advects past the site) data using radar and lidar to characterize the planetary boundary layer. Through the characterization and investigation of developing pollution events it is expected that their occurrence can be more accurately predicted, thereby making it possible to issue public health warnings and institute regulations to reduce the severity of the event.

2. METHOD

Three major measuring techniques were used for the collection and characterization of the pollution event: Raman Lidar, Radar/Rass, and Tethersonde instruments. The Lidar Atmospheric Profiler Sensor (LAPS) was used as the primary investigation technique to characterize this pollution event. LAPS has the capability of measuring meteorological conditions and atmospheric properties such as vertical profiles of water vapor, ozone and extinction during both the day and night [2].

LAPS uses two methods of Raman scattering to attain its data. Rotational Raman scattering is used to measure temperature and vibrational Raman scattering is used to measure ozone, water vapor and extinction. The LAPS system has the capability of taking atmospheric readings through the troposphere. The measurements have a vertical resolution of 75 meters. Specifically ozone is obtained from a DIAL [Differential Absorption Lidar] analysis of the Raman shift of N₂ (285nm) and O₂ (276nm), which occur on the steep side of the Hartley absorption band of ozone [3,4]. Radar/RASS operates by transmitting electromagnetic energy into the atmosphere at angles relative to the zenith in two different vertical planes and measuring the backscattered energy from refractive index fluctuations. The wind speed and trajectory can be found between the surface and 4.5km in altitude. Virtual temperatures are obtained by using a Radio Acoustic Sounding System (RASS) which measures the speed of sound using the electromagnetic energy scattered from the acoustic wave front. The tethersonde

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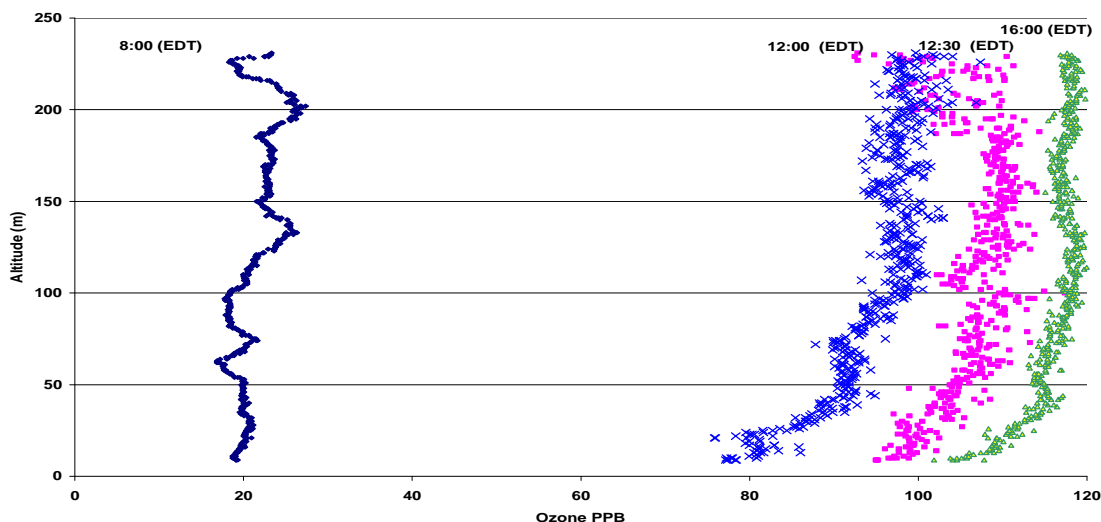


Figure 1. Millersville University tethersonde vertical profiles on July 2nd 2002.

of Millersville University carries ozone, particulate matter and meteorological probes to a height of 300 meters, taking essentially continuous readings during ascent and descent with typically two vertical profiles per hour. The tethersonde was also left at heights of interest for extended periods in order to make time lapsed comparisons with the LAPS and Radar/RASS systems.

3. RESULTS

During the period of June 30th through July 4th 2002 of the NEOPS-DEP investigation in Philadelphia a major air pollution episode occurred. Over the 5 day period, there were extended afternoon periods when the ozone remained above 100 ppb, peaking in the afternoon of July 2nd at 120 ppb.

Shown in Figure 1 are a selection of the vertical profiles taken with the tethersonde of Millersville University on July 2nd at three separate times. Ozone levels rose quickly, this rise can be attributed to the transport into the region of ozone and chemical precursors of ozone formations. When looking at the back trajectories there is a degree of recirculation within the mid-Atlantic region and Philadelphia region allowing for the high ozone air mass to remain within the region. On the night of July 1st the planetary boundary layer descended to approximately 300 as expected. Figure 2 shows a time sequence of ozone which shows that high levels of ozone remained above the nocturnal boundary layer through the night on July 1st-July 2nd. As convective heating and mixing developed on

July 2nd, ozone from the storage/transport layer was mixed downward rapidly towards the Earth's surface. This rapid mixing can be seen in Figure 3 with the rapid increase in the ground ozone levels at 8:00(EDT). At the same time the NO_x components which accumulated within the surface layer decrease as they are diluted by distribution through the boundary layer. As the day progressed, it can be easily seen in Figure 2 with the increase in ground ozone concentration there is a corresponding decrease in the NO_x levels from the surface layers as it contributes to the photochemical production of ozone.

Coupling of a high pressure circulation with the momentum from earlier convective heating produced a low level jet when the nocturnal inversion decoupled the surface friction by forming a stable layer. The observations showed speeds averaging around 10m/s and peaking at around 14m/s as seen in Figure 4. The low level jet signature has been found to be associated with most major ozone events occurring during the NEOPS investigations because of the important role it plays in transport of ozone and precursor materials.

Figure 5 shows the water vapor mixing ratio during the period of July 2nd. On July 2nd the water vapor mixing ratio maintained values near 20 g/kg. As the event progressed the water vapor mixing ratio slowly decreased. July 3rd began a turn around in the event as the ozone levels began to drop. Shown in Figure 6 are the peak ozone levels for July 3rd according to standard color code. Winds changed to the NW gusting at 8-9 m/s.

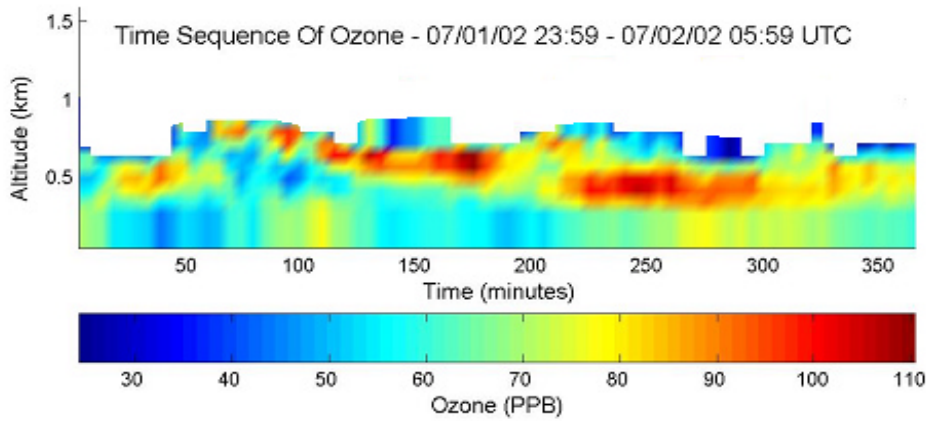


Figure 2. Time sequence of ozone concentration aloft on the morning of July 2nd.

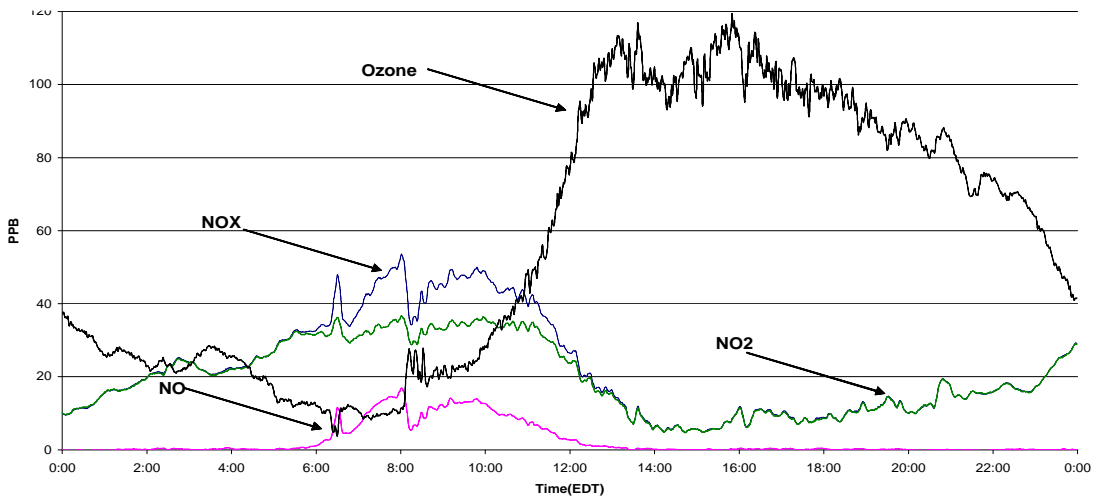


Figure 3. Ozone and NOX Concentrations on July 2nd. The sudden increase in ozone corresponds to the decrease in NOX concentrations.

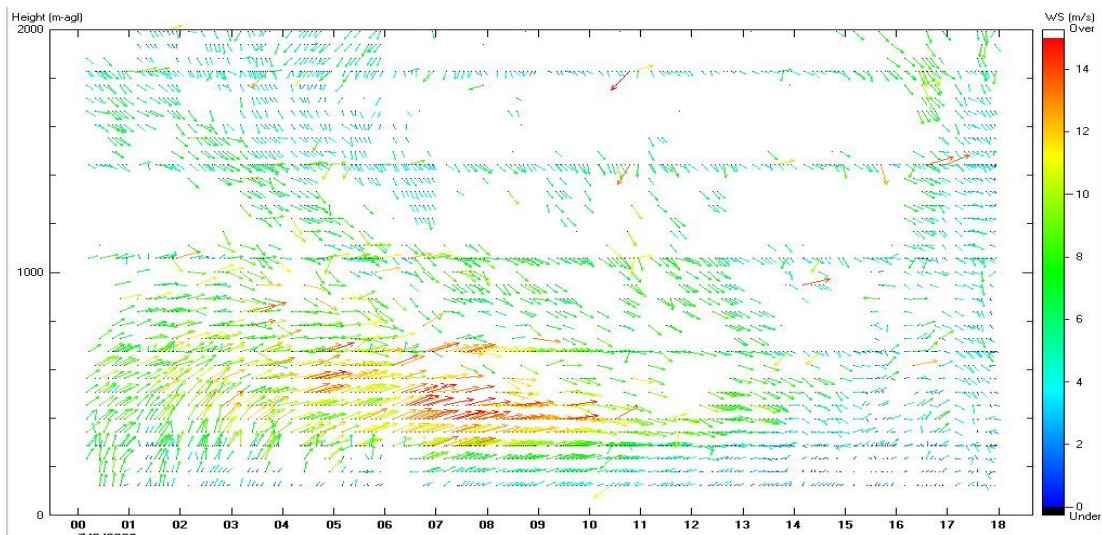


Figure 4. Low Level Jet July 2nd measured by the doppler wind radar.

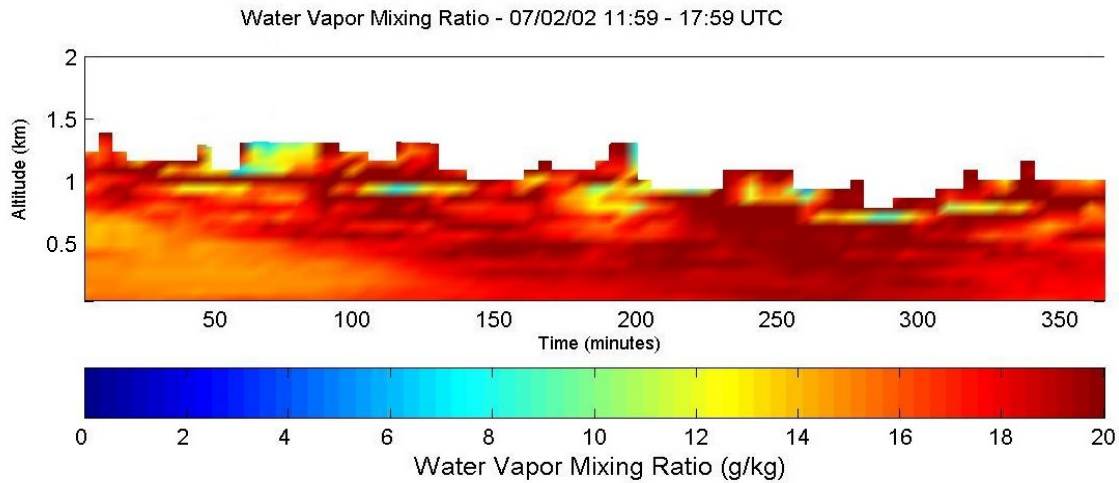


Figure 5. Water vapor mixing ratio on July 2nd, 2002.

Visibility increased from 3km to 15km relatively quickly with the departure of the haze at approximately 12:00 EDT on July 3rd. This new air mass can be seen with the drastic decrease in the water vapor mixing ratio during the period of July 1st-July 4th.

The pollution event ended during the night of July 4th 2002. The end of the event can be attributed to a change in the air mass. Shown in Figure 7 are vertical profiles of the water vapor mixing ratio measured by LAPS. The water vapor is less than 10 g/kg on July 1st and 4th, but was more than 20 g/kg on July 2nd. When looking at the back trajectories for July 1st-July 4th they primarily originated in the upper Midwest. The change in the air mass origin can be seen in Figure 8.

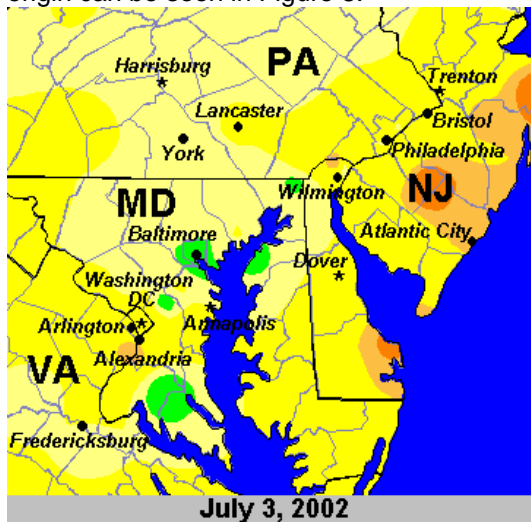


Figure 6. Ozone levels July 3rd according to standard color code warning level.

4. CONCLUSION

The increased level in ground ozone was aided in formation by the transport of precursor materials from the upper Midwest region. In addition to the formation from materials transported into the region, was the ozone storage layer aloft. This ozone rapidly mixed to the surface, thereby creating hazardous levels of ozone at ground level. Exacerbating the situation is the addition of NO_x during the 'rush hour' traffic in the morning hours that can contribute to the photochemical process later in the day. During the NEOPS-DEP 2002 study there were three other major pollution events. These events exhibited similar characteristics including high levels of ground ozone.

Through this and related studies, it may become possible to more accurately predict when sudden increases in ozone may occur. This would make it possible to enact restrictions on commuter traffic and potentially suppress the sudden increase in hazardous pollutant levels.

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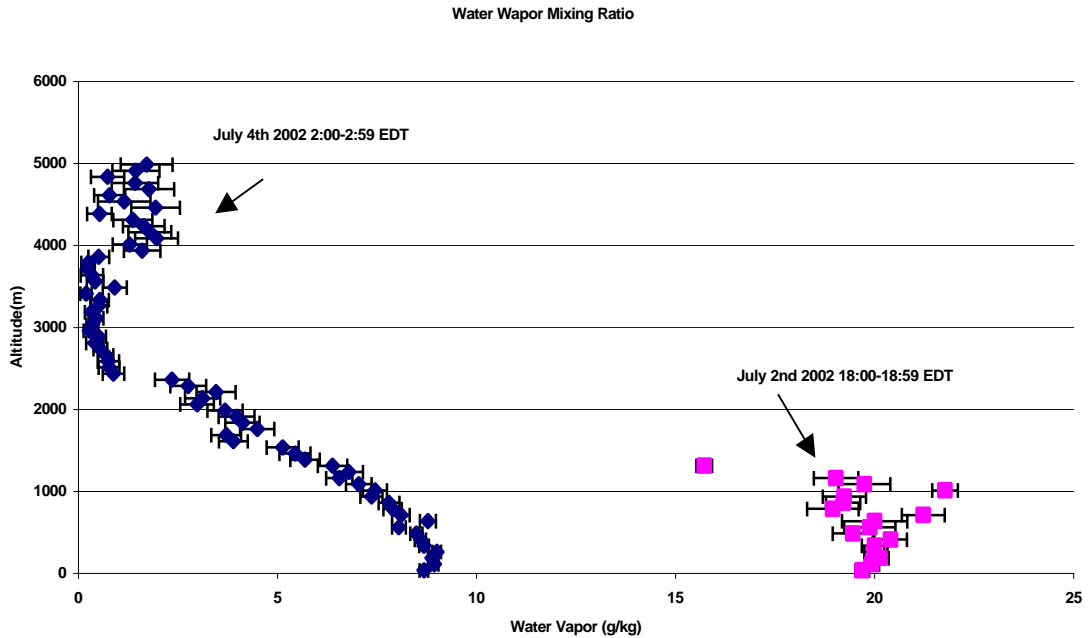


Figure 7. Comparison of water vapor mixing ratio(g/kg) on July 2nd and July 4th 2002.

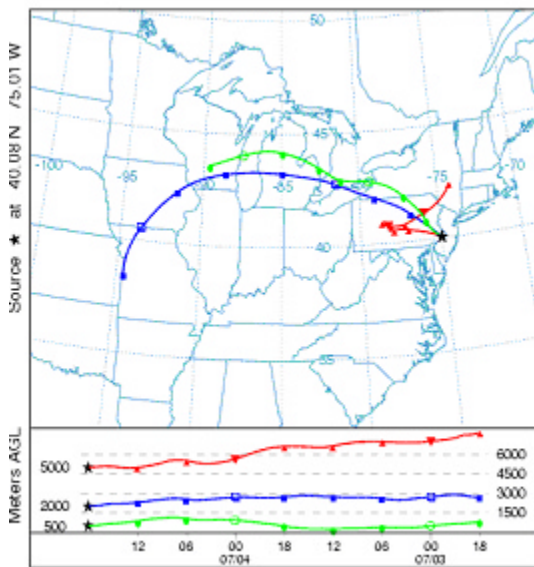


Figure 8. Back Trajectories July 4th (NOAA)

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