Ozone Signatures and Frontal Passages at Shenandoah National Park and Richmond, Virginia

J. Calder, George H. Moody Middle School/Henrico High School; Henrico, Virginia

NASA Mentors: M. Pippin and S. Hyater-Adams; LaRC

Ozone Comparisons of Shenandoah National Park and Math Science Innovation Center

Figure 3 presents ozone concentrations for both Shenandoah National Park and the Math Science Innovation Center in Richmond, VA. Ozone concentrations at the Shenandoah National Park represent regional, background air quality as it is a rural site with no major metropolitan areas located nearby. The Math Science Innovation Center in Richmond, VA represents an urban location showing the diurnal variation of ozone. The National Park lacks a diurnal pattern due to its presence above the atmospheric boundary layer. However, the general increase and decrease of ozone concentrations throughout the summer are similar between the two sites despite the difference in land use.

Back Trajectories of Elevated Ozone

Tropospheric Ozone Residual (TOR)

Figure 8: HYSPLIT back trajectories for (a) June 29, 2012 and (b) May 19, 2012 for elevated levels of ozone at Shenandoah National Park. On June 29, 2012, ozone levels reached 85 ppb and on May 19, 2012, ozone levels reached a maximum of 76 ppb. Elevated ozone at the Shenandoah National Park are sourced from two main locations: the Ohio River Valley and the Northeastern seaboard (Figure 8).

Case Study June 29th to 7th, 2013

During the case study, air masses originated from the south and travelled into the Shenandoah National Park and the Math Science Innovation Center (Figure 6). Trajectories were conducted for the study period. The analysis was performed for 500, 1000 and 1500 meters asl using EDA5 40 km (US, 2004 to present).

In early July of 2013, Shenandoah National Park (Figure 4) and Richmond, Virginia (Figure 5) experienced a low ozone event lasting for a few days. Ozone levels in the Park remained below 30 parts per billion (ppb) throughout the event. An investigation into the weather history shows the presence of a stationary front directly west of Virginia (Figure 6) immediately prior to the low ozone event. Once the front passed over the state, high pressure moved in from the south, providing clean air to the region. The low ozone event was also present at the Math Science Innovation Center in Richmond, VA as well as other monitoring stations across the state.

Using NOAA’s HYSPLIT model, back trajectories of air masses at both Shenandoah National Park and the Math Science Innovation Center (Figure 7) were conducted for the study period. The analysis was performed for 500, 1000 and 1500 meters asl using EDA5 40 km (US, 2004 to present). During the case study, air masses originated from the south and travelled over a long distance prior to reaching the sites.

Student Engagement

Students at Henrico High School were provided the opportunity to investigate differences between tropospheric and stratospheric ozone using real data and active research. Initially students were asked to brainstorm previous knowledge about ozone. Student responses focused on stratospheric ozone. The teacher provided students with links to various websites, including the Environmental Protection Agency, to learn about tropospheric ozone. Lastly, students analyzed graphs comparing seasonal ozone levels averaged hourly for a whole month. Two sites were selected for the analysis: Shenandoah National Park and the Math Science Center Innovation Center, located in Richmond, VA. The latter was chosen for its proximity to Henrico High School. Brainstorming, research and analysis was recorded on large sheets of paper for easy visibility. Lastly, students participated in activity modeling the formation and destruction of stratospheric ozone under natural conditions and with the addition of chlorofluorocarbons (bottom right image).

Students became more cognizant of the health and environmental concerns associated with tropospheric ozone. Most students were unaware of how ozone forms at breathing level and ozone’s easily identifiable sweet odor. Many questioned the levels presented to them, why the two areas had such varying ozone signatures, as well as potential health concerns around the school such as in the copier room.

References

Typically, the Big Meadows monitoring station remains above the stable boundary layer. As a result, diurnal fluctuations are not evidenced in ozone data (Figure 3).

Figure 6: Weather maps for the United States identifying locations of fronts, pressures, isotachs, and precipitation from throughout the case study interval: (a) June 28, 2013, (b) July 1, 2013, (c) July 3, 2013, and (d) June 7, 2013.

Figure 7: Back trajectories using NOAA’s HySpit Model for (a) Shenandoah National Park and (b) Math Science Innovation Center for July 3, 2013.

Figure 9: Total ozone residual from January 2000 to December 2005 for Shenandoah National Park.