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Project Summary

Ozone Behavior in the Combined Baltimore-Washington, DC Plume

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An extensive air quality monitoring program was carried out in the Washington, DC-Baltimore region from July 14-August 15, 1980. This field study included data collection at numerous ground stations and two aircraft sampling platforms. Measurements included ozone, oxides of nitrogen, individual hydrocarbons (C_2-C_{10}), condensation nuclei and visual distance, and numerous meteorological parameters. Specific areas of interest in this study included the acquisition of air quality data for (1) development and testing of a regional air quality simulation model and (2) gaining a better understanding of oxidant production and transport in plumes emanating from Washington, DC, and Baltimore. This summary describes oxidant behavior downwind of these two cities in cases in which plume interaction was observed. Seven days during the 1980 study period when southwesterly winds carried the Washington, DC, plume into the region occupied by the Baltimore plume were selected. A case study analysis was performed for each of these days. General conclusions are presented regarding oxidant patterns in the regions where plume interactions occurred.

This Project Summary was developed by EPA's Atmospheric Sciences Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

During July and August of 1980, the U.S. EPA sponsored a large air quality monitoring program in the northeastern United States. This program is referred to as the Northwest Regional Oxidant Study (NEROS). Federal, state, and private research organizations worked together to acquire a comprehensive data base that includes numerous meteorological measurements and gaseous pollutant information. Primary objectives of the study were to establish a data base that could be used for development and testing of a regional-scale photochemical air quality simulation model and to provide states in the northeastern United States with data useful for State Implementation Plan revisions.

Because one of the primary objectives of the 1980 NEROS study was to obtain a data base for photochemical modeling purposes, it was essential that the physical and chemical characteristics of urban plumes in the region be well understood. Consequently, a great deal of effort was put into characterizing the plumes from Baltimore, Washington, DC, New York City, and Boston. Four fixed wing aircraft and a helicopter were used to monitor the chemical composition and dispersion behavior of these plumes. In Baltimore, Lagrangian plume tracking experiments were performed with the aid of tetroons. On one occasion, a tetroon released near Baltimore allowed tracing of an air parcel as far as New York City. Many Eulerian-type studies were conducted in which aircraft flight paths crisscrossed the Baltimore and Washington, DC, plumes at fixed distances upwind and downwind of the cities.

A great deal of the collected data can be used to improve understanding of photochemical oxidant production in urban plumes. The close proximity of the Bal-

timore and Washington, DC, urban centers provided a unique opportunity to examine the effects created when the plume from one large city impinges on that of another. This summary describes plume behavior in instances in which the Baltimore and Washington, DC, plumes overlapped. Seven days during the 1980 study period when southwesterly winds carried the Washington, DC, plume into the region occupied by the Baltimore plume were selected. A thorough case study analysis was performed for each of these days. General conclusions are presented regarding oxidant behavior in regions where plume interactions occurred.

Results

General conclusions relating to oxidant production and transport in the region downwind of Baltimore and Washington, DC, are listed below.

1. Ambient non-methane hydrocarbon (NMHC) concentrations measured during the 0600-0900 period at ground-level urban sites in Baltimore and Washington, DC, were very similar in magnitude. The mean NMHC concentrations were 659 and 671 parts per billion carbon (ppbC) for Baltimore and Washington, DC, respectively. The NMHC concentration frequency distributions were also very comparable; the majority of readings fell within the 450 to 750-ppbC range. The class distribution of individual hydrocarbon species was approximately 60% paraffins, 30% aromatics, and 10% olefins in each city. Assuming sampling sites were representatively placed, these results imply that hydrocarbon emissions are nearly the same in Baltimore and in Washington, DC.
2. The mean hydrocarbon/NO_x ratios were not significantly different for the two cities. The downtown Baltimore site exhibited a ratio of 7.0 ± 2.9; the corresponding mean ratio at the ground-level Washington, DC, station was 9.5 ± 7.2 The Washington, DC, ratio appeared to be more variable than the Baltimore ratio.
3. Because of the close proximity of the two cities, meterological factors that influence oxidant production in each city are normally the same. Because oxidant precursor levels are similar, ozone production in the two plumes would be expected to be nearly the same. Aircraft measurements verified this assumption.
4. Southwesterly winds in the Washington, DC-Baltimore region can lead to direct overlap of the two urban plumes or to varying degrees of partial overlap. In the one instance of direct overlap recorded during the 1980 study period, a single oxidant plume was observed downwind of the two cities. Lagrangian measurements obtained with aid of a tetroon traveling at altitudes between 2300 and 3600 ft showed no evidence of ozone production in the air parcel departing Baltimore at 11:00 a.m. Ozone concentrations were about 70 ppb within the air parcel and to the north and south of the plume. After two hours of travel, ozone levels in the plume were elevated by 40 ppb compared to ozone concentrations outside of the plume boundaries. At 5:00 p.m. this same air parcel, which at that time was located 190 km downwind of Baltimore, exhibited peak ozone concentrations of 170 ppb. Thus, ozone levels in the plume increased from 70 ppb on the outskirts of Baltimore to 170 ppb 6 h later at a distance of 190 km downwind of Baltimore. Because oxidant precursor concentrations and atmospheric dispersion conditions on that day were typical of those encountered during the study period, it seems reasonable to assume that ozone concentrations will increase by approximately 100 ppb in an air parcel that passes directly over both Washington, DC, and Baltimore during the morning hours.

   In situations in which partial overlap of the urban plumes occurred, highest ozone levels were observed in the region of maximum plume overlap. Because of the geographic location of the two cities, the northern portion of the combined plume contained the region of greatest overlap. Consequently, a crossplume ozone gradient usually existed; concentrations were highest in the northern portion of the plume and lower to the south. When west southwest wind flow created a side-by-side overlap of the individual plumes downwind of Washington, DC, and Baltimore, a biomodal crossplume ozone profile was observed. Ozone concentrations in the interaction region between the two plume centerlines were commensurate with an additive contribution from each of the individual plumes.
5. A combined Washington, DC-Baltimore plume with enhanced ozone concentration was documented on seven days during the 1980 field study program. On these days. ozone concentrations in the plume ranging from 120 to 220 ppb were measured in the region between Baltimore and Philadelphia. Background ozone levels to the north and south of the plume generally ranged from 90 to 110 ppb during the afternoon. Elevated ozone levels in the Washington, DC-Baltimore plume were observed as far as 190 km downwind of Baltimore. In the region 60 to 80 km downwind of Baltimore, crossplume ozone profiles at 1500 ft often differed from those recorded at higher altitudes. The low-altitude profiles exhibited relatively high ozone concentrations over Chesapeake Bay and along its northern shoreline. The enhanced ozone concentrations are probably the result of limited precursor dilution (shallow mixing layer) and minimal ozone losses due to scavenging over the water.

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***William A. Lonneman** is the EPA Project Officer (see below).*
The complete report, entitled "Ozone Behavior in the Combined Baltimore-Washington, DC Plume," (Order No. PB 86-120 664/AS; Cost: $16.95, subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650

The EPA Project Officer can be contacted at:

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