Source apportionment of fine aerosol mass and chemical composition in the Baltimore-Washington corridor

L.-W. Antony Chen, Presenter
Department of Meteorology, University of Maryland, College Park
E-mail: antony@meto.umd.edu; Tel: (301) 405-7724; Fax: (301) 314-9482

Bruce G. Doddridge and Russell R. Dickerson, Co-author
Department of Meteorology, University of Maryland, College Park
E-mail: bruce and russ@meto.umd.edu

Summary

As the primary field experiment for the Maryland Aerosol Research and CHaracterization (MARCH-Atlantic) study, chemically speciated $PM_{2.5}$ and trace gases (NH_3, HNO_3, CO, SO_2, NO_y, etc) have been sampled at Fort Meade (39.10°N, 76.74°W; elevation 46 m MSL), Maryland, since July 1999. FME is suburban, located in the middle of the Baltimore-Washington corridor, and generally downwind of the highly industrialized Midwest. The $PM_{2.5}$ at FME is expected to be of both local and regional sources. The goal of this study is to investigate the origins of $PM_{2.5}$ mass based on the daily/seasonal variation of $PM_{2.5}$ chemical compositions. 24-hr average $PM_{2.5}$ data acquired over a 2-year period, including 8 season-representative months, are presented here. Major mass contributing species in $PM_{2.5}$ includes sulfate, nitrate, ammonium, and carbonaceous material. Ammonium sulfate dominates in summer (> 50%) but its fraction decreases to ~ 30% in winter when more ammonium nitrate is formed due to lower temperatures. Carbonaceous material, including elemental carbon (EC) and organic carbon (OC), accounts for 25 – 35% of the $PM_{2.5}$ mass. Good correlations are observed between EC, CO, and NO_y, EC and a large fraction of OC likely result from mobile emissions in the B-W corridor. Crustal material (Al, Si, Ca, Fe, K, etc) and sea salt (Na^+ and Cl^-) aerosols are minor, contributing to < 5% of the $PM_{2.5}$ mass. Reconstructed $PM_{2.5}$ mass is calculated, and it generally agrees with the gravimetric mass except a deficit probably resulting from the unaccounted H_2O.

An innovative factor analysis model, UNMIX, is used to apportion the $PM_{2.5}$ mass and components to possible sources. Besides major species, Br, Se, and Cu are included as the model inputs, but elements of crustal or sea salt origins are excluded to simplify the problem. A six-factor solution is resolved with their compositions and contributions calculated. Most of sulfate is apportioned to two factors, which contributes strongly in summer and winter respectively. It is suggested that one represents the formation of secondary sulfate while the other represents a more 'primary' source. The solution also includes a factor containing OC, Br, and K that implies wood burning and a factor rich in Cu and Fe implying metal processing plants. The last two factors apportion significant EC, OC and CO so that it is thought to be mobile emission related. The two factors are distinguished by their nitrate content and seem to be complementary in the seasonal variation. The implication is that a source with its composition varying temporally may be represented by two or more factors in the factor analysis modeling.

To investigate the source locations of the six factors, we employ an ensemble back trajectory (EBT) method that calculates the difference between probability fields of air back trajectories on 'normal' and 'dirty' days. The factor of secondary sulfate is more regional in character, resulting from emissions in the Midwest, while the factor of 'primary' sulfate is localized in the northern neighborhood of FME, suggesting emissions from utility plants in Baltimore or Philadelphia. Wintertime wood burning occurs more likely in rural areas of Virginia and West Virginia. The suspected source region for the Cu factor is the highly industrialized corridor between Philadelphia and New York. The EBT analysis also supports that the two mobile-related factors originate from traffic in the Baltimore-Washington corridor. The $PM_{2.5}$ mass contributions, by season, from the six factors are estimated. Summertime fine PM is dominated by the regional sulfate source, and the fraction of local contribution, mobile sources plus local 'primary' sulfate, increases from < 25% in summer to > 65% in winter. Though high $PM_{2.5}$ episodes were observed in both summer and winter, they could be completely different in nature. This finding can imply control strategies for the fine PM and haze pollution.

Mr. Chen is a Ph. D candidate in Chemical Physical Program, University of Maryland, College Park, under directions of Dr. Bruce Doddridge and Dr. Russell Dickerson, and a graduate research assistant in Department of Meteorology. Mr. Chen's research interest ranges from chemistry and meteorology of small-scale air pollution to global climate change. From 1999 to 2002, Mr. Chen has been involved in the Maryland Aerosol Research CHaracterization study, conducting fine aerosol measurements in the Baltimore-Washington suburban area. Mr. Chen expects to graduate in 2002 with 4 - 5 publications, and pursue a postdoc study in this field.