SEPARATION OF AEROSOL LIGHT ABSORPTION TO BLACK CARBON, BROWN CARBON, AND MINERAL DUST

—

INTERPRETATIONS OF ATMOSPHERIC MEASUREMENTS NEAR BEIJING

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By
Mingxi Yang

Thesis Committee:

Barry Huebert, Chairperson
Antony Clarke
Vaughan Phillips

ABSTRACT

A key component of the Earth's radiative balance is the aerosols, or particles suspended in the atmosphere. While all particles scatter some of the incoming radiation, aerosol that absorbs light can cause climate-warming and has been a subject of intensive studies over the last few decades (Jacobson, 2001). Black carbon, brown carbon, and mineral dust are three of the most important absorbing aerosols in the atmosphere. Their absorption cross-sections differ greatly and are variably functions of the wavelength of light. Optical instruments that quantify light absorption, however, are unable to distinguish one type of absorbing aerosol from another. Thus, in order to gain a better understanding of the optical properties of the atmosphere, it is instructive to attribute total absorption to corresponding light absorbers. Such inferences, coupled with estimates of aerosol mass concentration, will enable the quantification of light absorption per unit mass, or the mass absorption efficiency.

With the objective of optically and chemically characterizing the China aerosol emission, during the March of 2005, we participated in the multi-national EAST-AIRE (East Asian Study of Troposphere Aerosols: an International Regional Experiment) campaign in Xianghe – a county ~70 km East of Beijing, China. In the past, few experiments had focused on particles emitted from the combustion of coal, which is still the most common source of energy used in northern China, including in Xianghe. We measured light scattering using a nephelometer, and light absorption using an aethalometer and a particulate soot absorption photometer (PSAP). The aethalometer measured absorption over a broad range of

wavelengths (370~950 nm), though its raw data required corrections for apparent absorption (scattering), loading, and multiple scattering artifacts. The loading correction for the aethalometer, while derived from previous published methods, was improved by our inclusion of simultaneous scattering measurements. We also measured the particulate mass concentrations of carbonaceous (elemental and organic carbon) and inorganic species, as well as aerosol number. Using mostly chemical and physical information, we identified periods during the campaign that were dominated by dust, biomass burning, fresh chimney plumes, other coal burning smoke, and relatively clean (background) air. Each of these air masses has its own distinctive optical properties, including the single scatter albedo and Ångstrom exponents. Based on basic assumptions on the wavelength dependence of absorption and refractive index, we were able to infer light absorption due to black carbon (BC), brown carbon, and dust and then estimate the mass absorption efficiency for each type of aerosol from 370 to 950 nm. While agreeing with common consensus that BC is the most important light absorber, we demonstrate that brown carbon and dust can both have significant absorption too, especially at short wavelengths, as reflected by their elevated mass absorption efficiencies in the ultraviolet. This scheme of separating and apportioning total light absorption to appropriate aerosols can be applied to other ambient measurements to explain the sources and causes of light absorption.