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Aerosol optical properties in the mega-cities Beijing and Guangzhou: Measurements and implications for regional air pollution, aerosol sources and remote sensing

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Aerosol optical properties were measured in two mega-city regions in China. The first site (Backgarden) was in a rural area approximately 60 km northwest of the mega-city Guangzhou in south China and was part of the "Program of Regional Integrated Experiments of Air Quality over the Pearl River Delta" intensive campaign in July 2006 (PRIDE-PRD2006). The second site (Yufa) was in a suburban area approximately 40 km south of Beijing and was part of "Campaigns of Air Quality Research in Beijing" (CAREBeijing-2006) in August 2006. Both sites were designed to measure the regional pollution of the mega-cities. The optical parameters determined with a nephelometer and photoacoustic spectrometer include absorption and scattering coefficients, single scattering albedos and Angstrom exponents at multiple wavelengths (450-700 nm).

In both measurement campaigns, we observed pronounced diurnal cycles in absorption and scattering coefficients and single scattering albedo, which can be explained by boundary layer mixing effects and enhanced light absorbing carbon emissions from traffic activity during the nighttime and early morning, respectively (diesel soot from regulated truck traffic). In Beijing both the extensive and the intensive properties were highly dependent upon the origin of the air mass, which indicates that not only does the aerosol concentration change with air mass origin, but so do the chemical composition and sources. When the measured air masses originated in the north and passed over Beijing, the single scattering albedo was generally low (< 0.8), which indicates that the local emissions of air particulate matter in Beijing were dominated by primary particles from combustion sources (e.g., diesel soot from traffic). The southerly inflow to Beijing had typically very high absorption and scattering coefficients (i.e., very high aerosol concentration) and higher than average single scattering albedo and Ångström exponents, suggesting a large proportion of small particles and secondary chemical components (e.g., sulfates and oxidized organics). Overall, the results suggest that a majority of the particle pollution in Beijing is transported into the city from the south. The scattering and absorption coefficients measured in the outflow of the Guangzhou area during PRIDE-PRD2006 were $\sim$2 times smaller than the southerly inflow into Beijing during CARBeijing-2006, which indicates that the sources of particulate pollution south of Beijing are even stronger than those in the Pearl River Delta.

In both mega-city regions the Angstrom exponent exhibited a wavelength dependence (curvature) that was related to the ratio of fine and coarse particle mass (PM1/PM10) as well as the surface mode diameter of the fine particle fraction. The results demonstrate consistency between in situ measurements and a remote sensing formalism with regard to the fine particle fraction and volume mode diameter, but there are also systematic deviations for the larger mode diameters. Thus we suggest that more data sets from in situ measurements of aerosol optical parameters and particle size distributions should be used to evaluate formalisms applied in aerosol remote sensing. Moreover, we observed a negative correlation between single scattering albedo and backscatter fraction, and we found that it affects the impact that these parameters have on aerosol radiative forcing efficiency and should be considered in model studies of Beijing, Guangzhou and similarly polluted mega-city regions.

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