Atmospheric Chemistry and Physics
An Interactive Open Access Journal of the European Geosciences Union

Atmos. Chem. Phys., 8, 5161-5186, 2008
www.atmos-chem-phys.net/8/5161/2008/

Aerosol optical properties in a rural environment near the mega-city Guangzhou, China: implications for regional air pollution, radiative forcing and remote sensing

R. M. Garland[1], H. Yang[1], O. Schmid[2], D. Rose[1], A. Nowak[3], P. Achtert[3], A. Wiedensohler[3], N. Takegawa[4], K. Kita[4], Y. Miyazaki[4], Y. Kondo[4], M. Hu[5], M. Shao[5], L. M. Zeng[5], Y. H. Zhang[5], M. O. Andreae[1], and U. Pöschl[1]

[1]Max Planck Institute for Chemistry, Biogeochemistry Department, Mainz, Germany
[2]Helmholtz Ctr. Munich, German Research Ctr. for Environmental Health, Inst. for Inhalation Biology, Neuherberg, Germany
[3]Leibniz Institute for Tropospheric Research, Leipzig, Germany
[4]RCAST, University of Tokyo, Tokyo, Japan
[5]State Key Joint Laboratory of Environmental Simulation and Pollution Control, College of Environmental Sciences and Engineering, Peking University, Beijing, China

Abstract. The scattering and absorption of solar radiation by atmospheric aerosols is a key element of the Earth's radiative energy balance and climate. The optical properties of aerosol particles are, however, highly variable and not well characterized, especially near newly emerging mega-cities. In this study, aerosol optical properties were measured at a rural site approximately 60 km northwest of the mega-city Guangzhou in southeast China. The measurements were part of the PRIDE-PRD2006 intensive campaign, covering the period of 1–30 July 2006. Scattering and absorption coefficients of dry aerosol particles with diameters up to 10 μm (PM_{10}) were determined with a three-wavelength integrating nephelometer and with a photoacoustic spectrometer, respectively.

Averaged over the measurement campaign (arithmetic mean ± standard deviation), the total scattering coefficients were 200±133 Mm^{-1} (450 nm), 151±103 Mm^{-1} (550 nm) and 104±72 Mm^{-1} (700 nm) and the absorption coefficient was 34.3±26.5 Mm^{-1} (532 nm). The average Ångström exponent was 1.46±0.21 (450 nm/700 nm) and the average single scattering albedo was 0.82±0.07 (532 nm) with minimum values as low as 0.5. The low single scattering albedo values indicate a high abundance, as well as strong sources, of light absorbing carbon (LAC). The ratio of LAC to CO concentration was highly variable throughout the campaign, indicating a complex mix of different combustion sources. The scattering and absorption coefficients, as well as the Ångström exponent and single scattering albedo, exhibited pronounced diurnal cycles, which can be attributed to boundary layer mixing effects and enhanced nighttime emissions of LAC (diesel soot from regulated truck traffic). The daytime average mid-visible single scattering albedo of 0.87 appears to be more suitable for climate modeling purposes than the 24-h average of 0.82, as the latter value is strongly influenced by fresh emissions into a shallow

nocturnal boundary layer. In spite of high photochemical activity during daytime, we found no evidence for strong local production of secondary aerosol mass.

The average mass scattering efficiencies with respect to PM_{10} and PM_1 concentrations derived from particle size distribution measurements were 2.8 $m^2\ g^{-1}$ and 4.1 $m^2\ g^{-1}$, respectively. The Ångström exponent exhibited a wavelength dependence (curvature) that was related to the ratio of fine and coarse particle mass (PM_1/PM_{10}) 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 the PRD and similarly polluted mega-city regions.

Final Revised Paper (PDF, 6085 KB) Discussion Paper (ACPD)

Citation: Garland, R. M., Yang, H., Schmid, O., Rose, D., Nowak, A., Achtert, P., Wiedensohler, A., Takegawa, N., Kita, K., Miyazaki, Y., Kondo, Y., Hu, M., Shao, M., Zeng, L. M., Zhang, Y. H., Andreae, M. O., and Pöschl, U.: Aerosol optical properties in a rural environment near the mega-city Guangzhou, China: implications for regional air pollution, radiative forcing and remote sensing, Atmos. Chem. Phys., 8, 5161-5186, 2008. Bibtex EndNote Reference Manager