# Optical and hygroscopic properties of long-range transported haze plumes over the Korean Peninsula under the Asian continental outflows

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Keywords: Optical property, hygroscopicity, Single scattering albedo, long-range transport.
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The objective of this study is to characterize the aerosol optical and hygroscopic properties of different haze plumes originating from the Chinese continent. Integrated in-situ measurements of atmospheric aerosols were performed at Deokjeok Island during spring 2009 to characterize the optical and hygroscopic properties of LRT aerosols. From identified Asian continental outflow cases, we investigated the wavelength dependence of the light absorption coefficient and the humidity-dependent light scattering enhancement factor of $PM_{2.5}$ as a function of aerosol composition. Two haze episodes occurred during March 31 - April 1 (N China) and April 5 – 13 (E China) with $PM_{2.5}$ mass concentrations as high as 104 μg $m^{-3}$ and 101 μg $m^{-3}$, respectively. The N China episode was characterized by relatively low CO and $SO_2$ concentrations and high OM concentration under relatively strong wind speed when air masses originated from the northern part of China. However, the E China episode was characterized by relatively high CO, $SO_2$, and $SO_4^{2-}$ concentrations under relatively weaker wind speed when air masses originated from the eastern part of China. A slightly high wavelength dependence of light absorption coefficient, α of 1.6 ± 0.05 (average ± 1·standard deviation), and a low humidity-dependent light scattering enhancement factor at 80% relative humidity, *f*(80%) (2.0 ± 0.2), were obtained when air masses originated from the northern part of China (N China), compared to those obtained when air masses originated from the eastern part of China (E China) (α = 1.4 ± 0.1; *f*(80%) = 2.4 ± 0.2). The relatively high α and low *f*(80%) during the N China compared to those during the E China were consistent with a relatively high mass ratio of organic aerosol to sum of $SO_4^{2-}$, $NO_3^-$ and $NH_4^+$ during the N China (1.01 ± 0.17) compared to the E China episode (0.25 ± 0.13) (Fig. 1). This result indicates the importance of organic aerosol on aerosol optical and hygroscopic properties of haze plumes. Single scattering albedo (SSA) of dry $PM_{2.5}$ (0.92 ± 0.01) and mass scattering efficiency (MSE) of dry $PM_{2.5}$ at 550 nm wavelength during the E China episode (3.6 ± 0.3 $m^2$ $g^{-1}$) were higher than those previously obtained at the air mass source regions in China (SSA = ~0.8; MSE = ~3.0 $m^2$ $g^{-1}$) (Fig. 2), implying that optical properties of $PM_{2.5}$ were significantly altered during long-range atmospheric transport.

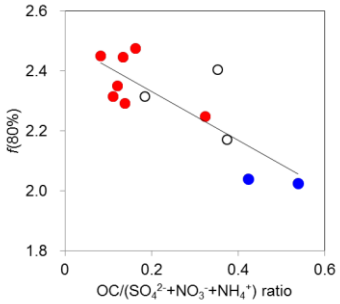


Figure 1. Scatter plot between mass ratio of OC to sum of the major inorganics and *f*(80%). Filled red and blue circles represent the E China and N China episodes, respectively.

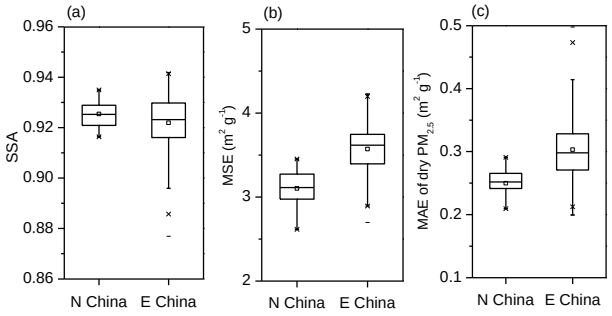


Figure 2. Box-and-whisker plots of (a) dry single scattering albedo (SSA), (b) dry mass scattering efficiency (MSE), and (c) dry mass absorption efficiency (MAE) of $PM_{2.5}$ at 550 nm during the N China and E China episodes. The lower and upper ends of the box and the lower and upper bars show the quartiles at 25% and 75% and the whiskers at 10% and 90%, respectively, and the cross bar in the box and open circles show the median and outliers, respectively.

This work was funded by the Korean Meteorological Administration Research and Development Program under grant KMIPA 2015–5020