



Diurnal evolution of size-resolved soot mixing state in the megacity Beijing: mechanism and parameterizations

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Soot is the most efficient light absorbing aerosol species and has strong climate effect in the atmosphere. The mixing state of soot particles shows a significant impact on its optical and hygroscopic properties and hence on its direct and indirect radiative effects. From this aspect, understanding of soot mixing state and its evolution mechanism becomes an essential task for understanding the climate effects of soot particles.

During the CareBeijing 2006 campaign, we carried out soot mixing state measurements of the regional aerosol south of the megacity Beijing employing a Volatility Tandem Differential Mobility Analyzer (VTDMA). Pronounced diurnal variations were observed for the mixing state of size-resolved soot particles (7 sizes from 30 nm to 320 nm). For Aitken mode particles, the largest fraction of internally mixed soot was observed in 8:00 to 9:00 while for accumulation mode particles the largest fraction values were observed in 12:00 - 13:00. The different behaviors of Aitken and accumulation mode particles implied that the condensable vapors had different uptake coefficients on internally and externally mixed particles. Within the accumulation mode, the number fraction of internally mixed soot were well correlated.

Based on a simplified model study, the evolution of accumulation mode particles can be well explained by competitions of fresh emission and coating processes. The life time of externally mixed (un-coated) soot particles would be about 1.7 to 2.6 hours (corresponding to a conversion rate of 38% h⁻¹ to 59% h⁻¹) indicating a fast decay process. The model study also derived a diurnal profile of condensable vapor pressure, which showed a peak in the afternoon.

The evolution of the soot mixing state was found to be strongly linked to the aging process of air masses. Considering the parameterization of soot evolution in models, we suggested parameterizing the soot mixing state (number fraction of internally mixed soot) at 150 nm by air mass aging indicators (EC/Total Aerosol, EC/(EC+OC), etc) and calculating the soot mixing state of other accumulation mode particles from that at 150 nm. The simplicity and flexibility of this method promise its use in time-consuming climate models though more evidences from other sites are also needed to verify the universality of our results.