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Enhanced hydrophobicity and volatility of submicron aerosols under severe emission control conditions in Beijing

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A series of strict emission control measures were implemented in Beijing and the surrounding seven provinces to ensure good air quality during the 2015 China Victory Day parade, rendering a unique opportunity to investigate anthropogenic impact of aerosol properties. Submicron aerosol hygroscopicity and volatility were measured during and after the control period using a hygroscopic and volatile tandem differential mobility analyzer (H/V-TDMA) system. Three periods, namely, the control clean period (Clean1), the non-control clean period (Clean2), and the non-control pollution period (Pollution), were selected to study the effect of the emission control measures on aerosol hygroscopicity and volatility. Aerosol particles became more hydrophobic and volatile due to the emission control measures. The hygroscopicity parameter (κ) of 40–200 nm particles decreased by 32.0%–8.5% during the Clean1 period relative to the Clean2 period, while the volatile shrink factor (SF) of 40–300 nm particles decreased by 7.5%–10.5%. The emission controls also changed the diurnal variation patterns of both the probability density function of κ (κ-PDF) and the probability density function of SF (SF-PDF). During Clean1 the κ-PDF showed one nearly-hydrophobic (NH) mode for particles in the nucleation mode, which was likely due to the dramatic reduction in industrial emissions of inorganic trace gases. Compared to the Pollution period, particles observed during the Clean1 and Clean2 periods exhibited a more significant non-volatile (NV) mode throughout the day, suggesting a more externally-mixed state particularly for the 150 nm particles. Aerosol hygroscopicities increased as particle sizes increased, with the greatest increases seen during the Pollution period. Accordingly, the aerosol volatility became weaker (i.e. SF increased) during the Clean1 and Clean2 periods, but no apparent trend was observed during the Pollution period. Based on a correlation analysis of the number fractions of NH and NV particles, we found that a higher number fraction of hydrophobic and volatile particles during the emission control period.