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Variability of depolarization of aerosol particles in Beijing mega city: implication in interaction between anthropogenic pollutants and mineral dust particles

Yu Tian (1,2), Xiaole Pan (1), Tomoaki Nishizawa (3), Hiroshi Kobayashi (4), Itsushi Uno (5), Xiquan Wang (1), Atsushi Shimizu (3), Zifa Wang (1,2,6)

(1) Institute of Atmospheric Physics, Chinese Academy of Sciences, State Key Laboratory of Atmospheric Boundary Layer Physics and Atmospheric Chemistry, Beijing, China (tianyu@mail.iap.ac.cn), (2) University of Chinese Academy of Sciences, Beijing, China, (3) National Institute for Environmental Studies, Tsukuba, Ibaraki,Japan, (4) University of Yamanashi, Yamanashi, Japan, (5) Research Institute for Applied Mechanics, Kyushu University, Kasuga, Fukuoka, Japan, (6) Center for Excellence in Regional Atmospheric Environment, Chinese Academy of Science, Xiamen, China

East Asia is suffering from both severe air pollution problem due to intensive anthropogenic emissions and natural mineral dust aerosols. During transport, the aerosol particles undergo complex mixing processes, resulting in great impacts on regional air quality, human health and climate. In this study, we conducted a long-term observation using an Optical Particle Counter equipped with a Polarization detection module (POPC) at an urban site in Beijing. Mass concentrations of both $PM_{2.5}$ and PM_{10} estimated from POPC compared well with ground-based measurements. The results revealed that the observed depolarization ratio (DR, termed as the ratio of the intensity of the s-polarized signal to the intensity of the 120 degree backward scattering signal [s/(s + p)]) for aerosol particles in the fine mode was generally much lower in summer than that in spring as a result of predominance of different aerosol types. Mineral dust particles in the coarse mode normally had a large DR value (0.3 ± 0.05) owing to their non-spherical shape; however, particles in the fine mode consisted of large proportion water-soluble compositions, which lead to apparent decrease of their DR values in particular high relative humidity (RH) condition. Because the observation site was subject to frequent impact of dust event in spring, DR value of particle at 1 μm was almost twice as high as that (0.07 ± 0.01) in summer. Based on size-resolved DR values, anthropogenic pollutants, mineral dust and polluted mineral dust particles, and their contribution to local air quality were well distinguished. About 26.7% of substandard days (daily averaged $PM_{2.5}$ concentration larger than 75 $\mu g/m^3$) in Beijing was featured by high atmospheric loading of coarse-mode particles in winter-spring time. In particular during severe pollution episode in winter, the DR values of coarse mode particles decreased by 13%, implies the high possibility of dust-related heterogeneous processes on pollution formation. During dust event, DR values of particle at Dp = 5 μm decreased evidently with increase of $PM_{2.5}/PM_{10}$ ratio as well as RH, indicating of the morphological changes of mineral dust. This study confirmed that high RH tends to promote water absorption processes on the dust surface as well as coating of soluble compounds, and suggested that complex mixing of dust and anthropogenic particles may lead to underestimate impact of dust particles in urban area based on remote sensing technique, and interaction between dust particle and pollutants should be well considered by the optical model.