Distribution of aerosol mixing state revealed by transmission electronic microscopic observations in Japan and its relevance to CCN activity and air quality

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Aerosol particles are ubiquitous in the atmosphere, regardless from natural and anthropogenic sources. Their climatic importance is embodied through many ways. One of the ways is through acting as cloud condensation nuclei (CCN), promoting changes in cloud microphysical properties and subsequently interfering the Earth energy budget. The role as CCN depends on aerosols physicochemical properties, such as size, chemical composition and mixing state. Since those physicochemical properties evolve on the course of the interactions between meteorology and atmospheric chemical processes, it is important to understand how the role of aerosols as CCN evolves accordingly in various environments. In this study, sampling campaigns of atmospheric aerosol particles were conducted in three locations in Japan, Tsukuba, Tokyo and Mt. Kiso-komagatake (Senjyo), and more than 30,000 individual particles were analyzed with the advanced technique of transmission electronic microscopy (TEM). (Electron microscopy particle database of Meteorological Research Institute can be accessed at http://metemadb.kir.jp/) Based on TEM analysis, individual particles size and elemental composition were revealed in great details and hygroscopicity was derived. The TEM analysis of aerosol populations sampled at the three locations showed distinct CCN properties, indicating that the interactions between meteorology, atmospheric chemistry and local emissions shaped the physicochemical and CCN properties of the aerosol populations differently. In addition, based on TEM analysis, the aerosol populations mixing state were characterized using the recently proposed aerosol mixing state metric and the impact on cloud condensation nuclei (CCN) properties was quantified. This demonstrated that the CCN concentrations calculated in most of the atmospheric models assuming internally-mixed aerosol populations are erroneous to various extent. Apart from their climatic importance, aerosol particles are closely related to public health. The deposition efficiency of inhaled particles along human respiratory tract was shown to depend on aerosol mixing state through their hygroscopic growth after inhalation. Simulations by particle-resolved aerosol model and deposition model indicated that not considering mixing state leads to overestimation of deposition efficiency; whereas considering an average mixing state leads to underestimation of 5% to 20% of soot particle deposition efficiency.

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