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Aerosol Liquid Water Driven by Anthropogenic inorganic salts: Implying its key role in the haze formation over North China Plain

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Aerosol liquid water content (ALWC) plays profound roles in air quality and climate change. In this study, ALWC was calculated on a basis of (1) the thermodynamic model (ISORROPIA-II) using long-term filter-based chemical composition data and (2) measured high time-resolution size-resolved hygroscopic growth factor. The simultaneously elevated ambient relative humidity (RH) and anthropogenic secondary inorganic (sulfate, ammonium, and nitrate) mass concentrations resulted in the abundant aerosol liquid water during the haze episodes in the atmosphere of Beijing. Thus, the particles may act as an efficient medium for multiphase reactions and facilitate the gas-particle transformation of sulfur, nitrogen, and organics, thereby, accelerating the haze formation, especially during nighttime with greater ALWC compared to daytime. Unexpectedly, the secondary inorganic fraction in PM2.5 was observed to increase with increasing ambient RH, which is a meteorological parameter independent of anthropogenic activities. This could indicate the presence of a feedback mechanism driven by Henry's law and thermodynamic equilibrium. As a particle takes up anthropogenic compounds such as SO_2 and N2O5, its inorganic mass increased which in turn, will drive increasing water uptake. Then, greater water content reduces the aerosol aqueous solution concentration allowing for greater uptake of inorganic compounds to complete the feedback. The ALWC was well-correlated with both nitrate and sulfate mass concentration, indicating that both nitrate and sulfate salts play the key roles in determining the ALWC. With the significantly reduction in SO_2 emissions in China, the nitrate will become to be a dominant anthropogenic inorganic salts driving ALWC. Thus, the abundance of aerosol liquid water and its effects on aerosol chemistry and climate should be reconsidered.