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Aerosol hygroscopicity and CCN activity during the AC3Exp campaign: Implications for CCN parameterization

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Atmospheric aerosol particles acting as CCN are pivotal elements of the hydrological cycle and climate change. In this study, we measured and characterized NCCN in relatively clean and polluted air during the AC3Exp campaign conducted at Xianghe, China during summer 2013. The aim was to examine CCN activation properties under high aerosol loading conditions in a polluted region and to assess the impacts of particle size and chemical composition on the CCN AR which acts as a proxy of the total number of aerosol particles in the atmosphere. A gradual increase in size-resolved AR with particle diameter suggests that aerosol particles have different hygroscopicities. For particles in the accumulation mode, values of κapa range from 0.31-0.38 under background conditions, which is about 20% higher than that derived under polluted conditions. For particles in the nucleation or Aitken mode, κ range from 0.20-0.34 under both background and polluted conditions. Larger particles were on average more hygroscopic than smaller particles. However, the case is more complex for particles originating from heavy pollution due to the diversity in particle composition and mixing state. The low R2 for the NPO CCN closure test suggests a 30%-40% uncertainty in total NCCN estimation. Using bulk chemical composition data from ACSM measurements, the relationship between bulk AR and the physical and chemical properties of atmospheric aerosols is investigated. Based on a case study, it has been concluded that one cannot use a parameterized formula using only total NCN to estimate total NCCN. Our results showed a possibility of using bulk κchem and f44 in combination with bulk NCN > 100 nm to parameterize CCN number concentrations.