Unraveling the processes behind aerosol-cloud interactions: An interplay of population dynamics and phase transition thermodynamics

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Airborne particulate matter is an important component of the atmospheric composition: these aerosol particles are a major factor governing air quality, and play also key role in defining the Earth's radiative balance. A large fraction of aerosol particle populations in various environments is secondary in nature - i.e. formed within the atmosphere from condensable vapors and in a dynamic interaction with the gas phase throughout their lifetime. Therefore, in addition to understanding the large-scale dynamics and chemical reactions of the atmosphere, describing the evolution of the size distribution and chemical composition of aerosol particle populations often boils down to the representation of phase-transition thermodynamics and population kinetics. The same is largely true for understanding the formation and evolution of cloud hydrometeor populations. In my presentation, I will give highlights of recent studies coupling thermodynamics of phase transitions to population dynamics - from understanding the evolution of nanometer-scale cluster populations to studying the sensitivity of aerosol-cloud interactions to the representation of the phase-separation behavior of complex organic aerosol mixtures. Finally, I will reflect on the present key uncertainties related to describing atmospheric aerosol populations and their impacts on climate and air quality.