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The role of organic compounds in cloud formation: Relative importance of entrainment, co-condensation and particle-phase properties

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The organic fraction of atmospheric aerosols is widely acknowledged to affect the cloud nucleating potential of aerosols. Cloud droplet formation through activation of non-volatile CCN is considered to be relatively well understood, however, there are fewer systematic studies on the activation of aerosols containing semi-volatile organic compounds that co-condense alongside water vapour, thus enhancing CCN activity. Although the significance of co-condensation of organic vapours for cloud droplet number concentration predictions has recently been identified, it remains uncertain how this process may interact with atmospheric dynamics. In addition to co-condensation of existing in-cloud material, additional semi-volatile mass can be entrained from the surrounding environment. Reduced cloud droplet number concentrations are expected as the parcel is diluted with clean air; however, additional soluble mass in the particle phase promotes droplet activation. The extent of increased droplet activation due to co-condensation relies also on the physiochemical properties of the organic compounds, as seen in several other phase partitioning sensitivity studies.

In this work we study the simultaneous impact of entrainment and co-condensation, the relative importance of these two processes at different atmospheric conditions, their interactions with each other, and the particle-phase chemistry in terms of cloud microphysical properties and their parametric sensitivities.

To assess the importance of the entrainment of semi-volatile materials as compared with their co-condensation and chemical properties, a pseudo-adiabatic cloud parcel model with a detailed description of bin microphysics is employed. We have added the co-condensation process to the model such that it is coupled with the parametric entrainment representation. The effects of entrainment and co-condensation are benchmarked independently and simultaneously against a control simulation. Furthermore, we probe the sensitivity of cloud microphysical properties to perturbations in the prevailing meteorology and aerosol physiochemical parameters as well as to the inclusion of different thermodynamic and kinetic processes. Future work is to be focused on the evaluation of coupled atmospheric dynamics and gas-particle phase interactions in global climate models.